CASE STUDY

Numbas as an engagement tool for first-year Business Studies students

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Abstract

In this paper we report on the implementation of e-assessment in mathematics with a large cohort of Business Studies students in their first year at Cork Institute of Technology, Ireland. The assessment tool used was Numbas, a freely available e-assessment tool for mathematics developed at Newcastle University. The main motivation in introducing Numbas for this course was to increase attendance and engagement at tutorials but also to make regular assessments with feedback a practical possibility for large groups. In this paper we discuss the effect the introduction of Numbas had on student engagement, in particular on student participation, attendance, and on the student experience.

Keywords: Numbas, student engagement, online assessment, computer aided assessment, formative assessment.

1. Introduction

Historically, attendance and engagement in mathematics modules were reported as low among first year Business Studies students at Cork Institute of Technology (CIT). Moreover, students' feelings about mathematics were often negative. Attendance at tutorials in particular was poor, especially among those students most likely to need the help offered by tutorials. In CIT, the average teaching load for a lecturer is 18 to 20 hours per week with lecturers often teaching five or more modules concurrently. With this heavy workload it is difficult to have regular assessment with timely and constructive feedback. As a result of these time and workload restrictions, this cohort of students traditionally had only one exam during the semester together with the final exam. Other written homework sheets were assigned for the students to work through for tutorials but these were not incentivised with marks so many students did not always attempt them. Hence, students lacked regular formative feedback on how they were doing and what they needed to improve on.

We wished to investigate if using Computer Aided Assessment (CAA) would help alleviate some of these problems. In particular, we focused on increasing attendance and engagement at tutorials. We also wanted to understand if using CAA would improve the students' experience of mathematics. Here we report on the use of Numbas as a tutorial and assessment tool for the first year Business Studies students over two semesters. We settled on the use of Numbas because it has a strong reputation, is user friendly and is compatible with the Virtual Learning Environment used at the CIT campus.

The remainder of this paper is organised as follows. First we discuss the background underpinning our research, then we go on to describe the methodology we used to implement e-assessment and collect data, then we describe the results of our research and finally we draw our conclusions.

2. Background

2.1. Engagement

While student engagement is central to Higher Education there is not, however, general consensus in the literature on a definition of the term. For example, Trower and Trowler (2011) define student engagement as follows:

"Student engagement is concerned with the interaction between the time, effort and other relevant resources invested by both students and their institutions intended to optimise the student experience and enhance the learning outcomes and development of students and the performance and reputation of the institution"

In this paper, we follow Warwick (2008) and Linnenbrink and Pintrich (2003) where student engagement is divided into three components: behavioural engagement, cognitive engagement and motivational engagement. They describe behavioural engagement as

"the observable behaviour we see as teachers in the classroom. This relates to the efforts students are putting into mathematical tasks and how students relate to each other and to the teacher in terms of their willingness to seek help, attendance at the classes etc.".

We focus on this definition and use attendance, participation and student enjoyment as indicators of engagement with the modules.

2.2. Assessment and Feedback

Regular assessment and quick feedback improves learning (Black & Wiliam, 1998). Students tend to be very judicious in where they focus their efforts and can be 'selectively negligent' when there is no assessment associated with a topic (Gibbs & Simpson, 2004-5). Assessment and feedback, although widely accepted as increasing engagement, are difficult and time consuming in practice. The idea of automating (or partially automating) these processes seems attractive as students derive the benefits without the substantial increase in workload involved. It would seem that e-assessment makes it possible for the practitioner to synthesise best practice in encouraging engagement. There is a long history of e-assessment in mathematics back to the 1980s when WeBWorK, the online homework system, was developed by Michael Gage and Arnold Pizer at the University of Rochester. Feedback is also well documented as increasing engagement (Cairini, et al., 2006). Bearing this in mind and in an effort to increase engagement for students of first year Business studies modules we introduced the mathematics e-assessment tool Numbas.

2.3. Numbas

Numbas is a freely available e-assessment tool for mathematics developed at Newcastle University. It generates random variations of uploaded questions and interacts with Learning Management Systems such as Blackboard and Moodle. It allows students to input mathematical formulae easily and creates a similar but different question for each student. It is an excellent formative assessment tool giving students instant feedback with features such as 'try another question like this one', 'show steps' and an 'advice' section which gives the solution to the question, as shown in figure 1. One can also add images, video, graphs and embed GeoGebra in a question. Since Numbas is an open source tool with a global community of users, expertise and experience can be shared nationally and internationally. It is actively maintained at Newcastle and is easy for lecturers and students to work

with. The Numbas system has a proven record of accomplishment and a strong reputation (Foster, et al., 2012 and Perfect, 2015). It is currently being used in Cork Institute of Technology and University College Cork as well as in Newcastle University, University of Leicester, Kingston University, London (Denholm-Price & Soan, 2014) as well as at universities in Norway and South Africa.

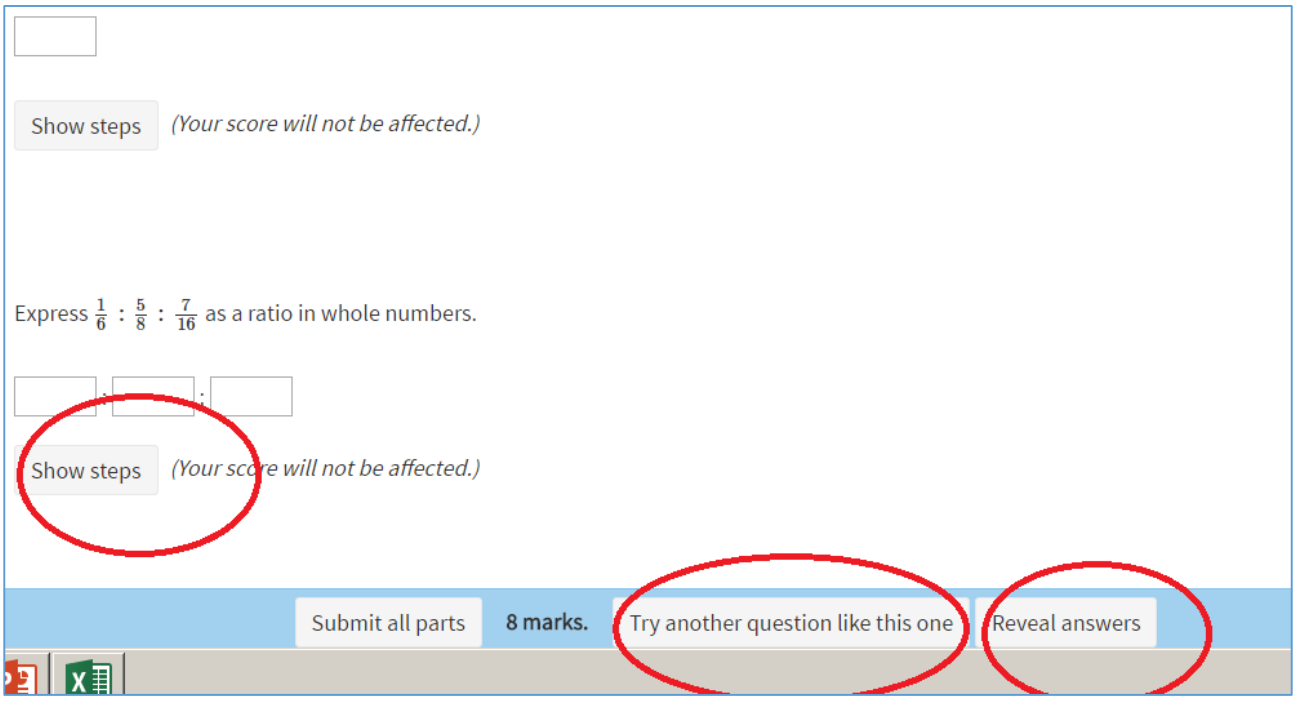

Figure 1. Numbas as a formative assessment tool

3. Methodology

3.1. Implementation

Prior to the introduction of Numbas, students had three hours of lectures each week and a one-hour pen and paper tutorial every second week. Assessment consisted of a mid-semester exam (20%) and an end of semester summative exam (80%). Following the introduction of Numbas, the schedule of lectures and tutorials stayed almost the same but the format of the tutorials changed. Under the new system students still had 3 lecture hours per week and they now had a tutorial every week, but the format of the tutorial varied depending on the week (see table 1).

The final mark for the module was now made up of three Numbas assessments (20%), a statistical software package exam (20%) and an end of semester summative exam (60%).

The Numbas tutorials were very structured. The relevant questions for a given tutorial were available for students to practise for at least one week before the tutorial. The students were given an opportunity to work through the questions in the tutorial for 40 minutes with the tutor available to give help and guidance. The practice 'tests' were designed to make the most of the medium of formative assessment. Students got instant feedback on whether their answer was correct or not, had unlimited attempts and had access to hints, answers and fully worked solutions as well as tutor support. Each student worked at their own pace but students could help each other with the method of how to do a question. The last 15 minutes of the tutorial were devoted to the Numbas assessment. The assessment questions were a subset of the questions that the students had been working on for the previous week and in the tutorial. Assessments were set up so that students could only submit one attempt at an answer and there was a fixed time limit.

Table 1. Tutorial schedule

Week	Type of Tutorial	Description
1	Numbas	Getting started with Numbas and a practice Numbas test
2	Statistical software	Computer Lab
3	Pen and Paper	Traditional pen and paper tutorial, working through students' questions on assigned homework
4	Numbas	Tutorial and a 15 minute assessment
5	Statistical software	Computer Lab
6	Pen and Paper	Traditional pen and paper tutorial, working through student's questions on assigned homework
7	Pen and Paper	Traditional pen and paper tutorial, working through students' questions on assigned homework
8	Numbas	Tutorial and a 15 minute assessment
9	Statistical software	Computer Lab
10	Numbas	Tutorial and a 15 minute assessment
11	Statistical software	Computer Lab
12	Statistical software	Statistical Software exam

In the academic year 2015/16, the modules in question had 459 registered students and were delivered by a teaching team of ten lecturers/tutors. As CIT does not currently have a large electronic exam hall and occupancy of each computer lab is limited to 22 students, the group needed to be split into 25 different tutorial groups, which occurred at 21 different times. This complexity posed some logistical challenges and required careful preparation and planning. A number of copies of printable versions of the assessment were also available as a back up.

Once created, the Numbas tests were uploaded to the virtual learning environment Blackboard. Students in CIT are familiar with using Blackboard for other learning and assessment purposes and so adapt very easily to doing their mathematics assessments through this system. This integration with Blackboard allows their results to be automatically tracked and recorded. The adaptive release feature available on Blackboard was used to control the times that students could access the Numbas assessment.

3.2. Data Collection

An online survey was emailed to all 459 first year Business students at the end of Semester 1 of the 2015/2016 academic year. In total, 83 responses were received. We asked students to respond to statements on a 5-point Likert scale with the five options: strongly disagree, disagree, neutral, agree and strongly agree. The survey also included some open-ended questions. The most apparent limitation to this survey study is the response rate of 18%. However, despite this low response rate, valuable insight was gleaned in that the students that did respond gave a full and detailed response. In addition to the student survey, 10 lecturers/tutors involved in the modules were asked to complete a survey anonymously. Seven responses to the lecturer survey were received. The authors applied both qualitative and quantitative methods to the data collected. Attendance records were available for six tutorial groups in Semester 1 and four tutorial groups in Semester 2.

4. Analysis and Results

In relation to engagement, the themes emerging from our research are increased student participation, increased attendance and improved student experience in terms of enjoyment. As expected, instant feedback was a popular feature for students. The main barrier we expected was usability but this was not reported as an issue.

4.1. Student Participation

We found that students like to the get the 'green tick' to say that they have answered a question correctly. This seemed to be a key motivation and students were *"more likely to try again than in traditional pen and paper tutorials",* according to one of the lecturers. *S*tudents interacted more with the material being taught and lecturers/tutors felt that the students were more engaged in tutorials then they had been in previous years. The students asked more questions and took more control of their own learning. In the lecturer/tutor survey, 6 out of 7 said they agreed or strongly agreed with the statement *"Numbas has changed the manner in which students engage with Mathematics in college."* One lecturer commented that students "*do more revision*" since the introduction of the Numbas system. Other comments by lecturers included that Numbas *"gets the students working on material"* and *"encourages student participation."*

4.2. Attendance

We found that attendance at the Numbas tutorials was higher than at traditional tutorials. Figure 2 shows the average attendance at tutorials (both Numbas and non-Numbas tutorials) in Semesters 1 and 2 of academic year 2015/16. In both semesters attendance at Numbas tutorials was about 20% higher than at the tutorials where Numbas was not used.

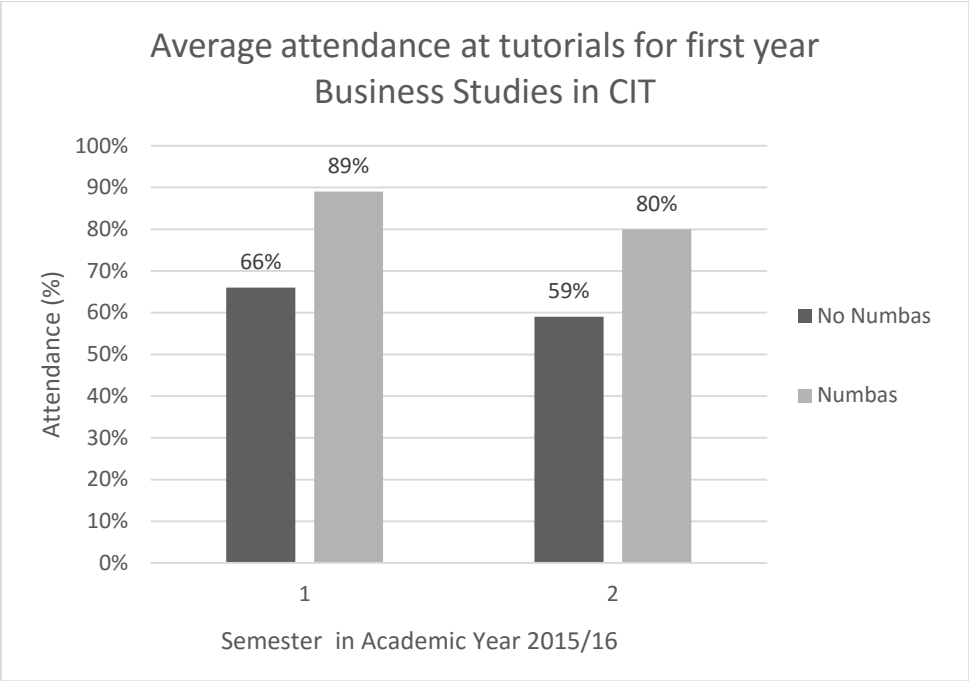

Figure 2. Average attendance at mathematics tutorials for students of first year Business Studies.

Of those that replied to the lecturer/tutor survey, 6 out of 7 said that they agreed or strongly agreed with the statement "The use of Numbas has increased attendance at tutorials." One lecturer commented, *"When (pen and paper) tutorials are the only thing scheduled, less students turn up and they are less inclined to work even if they do turn up".*

4.3. Student Enjoyment

Numbas tests gave rise to a more positive feeling about mathematics and the students found it enjoyable to use. In the survey, students were asked, *"Do you feel that Numbas Assessments have allowed you to enjoy maths more in college?"* When the answers were coded, the result was that 64% answered positively, 31% answered negatively with 5% giving a neutral answer. Some negative comments included:

"No, I hate maths full stop."

"No. under too much time pressure when completing assessments."

"Not at all. I found it quite draining"

The majority of students, however had positive responses:

"It is definitely more enjoyable than normal maths."

"A bit yes I'll never enjoy maths but Numbas really helps"

"Yes it's a change to listening to a lecturer all day and gives you the opportunity to work on maths."

"Yes, definitely. It is something I really didn't mind practicing at home in my own time."

"Yes, it was a new way of learning maths then before and it's much easier."

"Yes, you are more engaged with assessments than versus a class and it is more enjoyable."

"Yes. The interactive section of Numbas helped me to enjoy maths more in college. I looked forward to practicing my Numbas at home in preparation for Numbas assessments."

4.4. Feedback

Figure 3 shows student responses to the statement *"Feedback given by the Numbas program is useful to me"*. One student commented, *"You get constructive feedback on your work"* while another said *"I found it the more interesting and helpful way to study certain topics and it's a good way to challenge yourself in your own time"*. Backing this up, when lecturers were asked to rate the statement *"Feedback given by Numbas is useful for the students"*, they unanimously agreed with the statement.

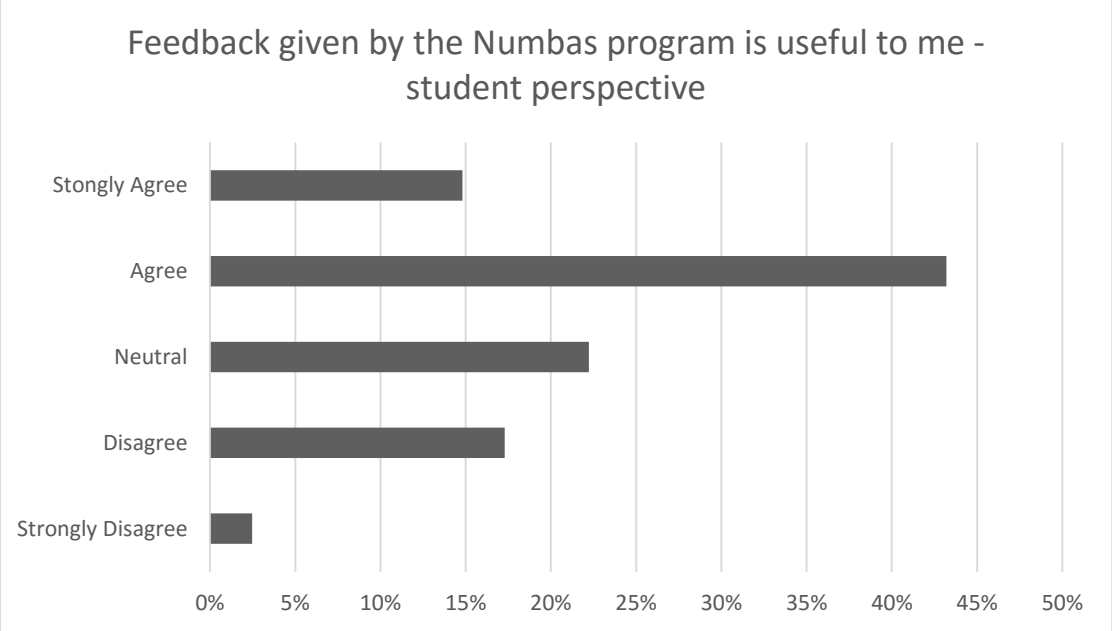

Figure 3. "Feedback given by the Numbas program is useful to me" - student perspective.

4.5. Usability

User experience (UX) refers to the quality of the user's interaction with and perceptions of a system. We expected the inputting of mathematical expressions to be a key issue particularly with a cohort of students not familiar with inputting mathematics into a computer. Sangwin (2013) refers to notation and syntax as "*the most significant barrier to CAA use*". However, inputting mathematics did not seem to be a problem for students when they were using the Numbas system. Students were asked to rate their agreement or otherwise with the statement "*The Numbas system is straightforward for me, as a student, to use"*. As shown in figure 4, the majority of students found Numbas straightforward to use.

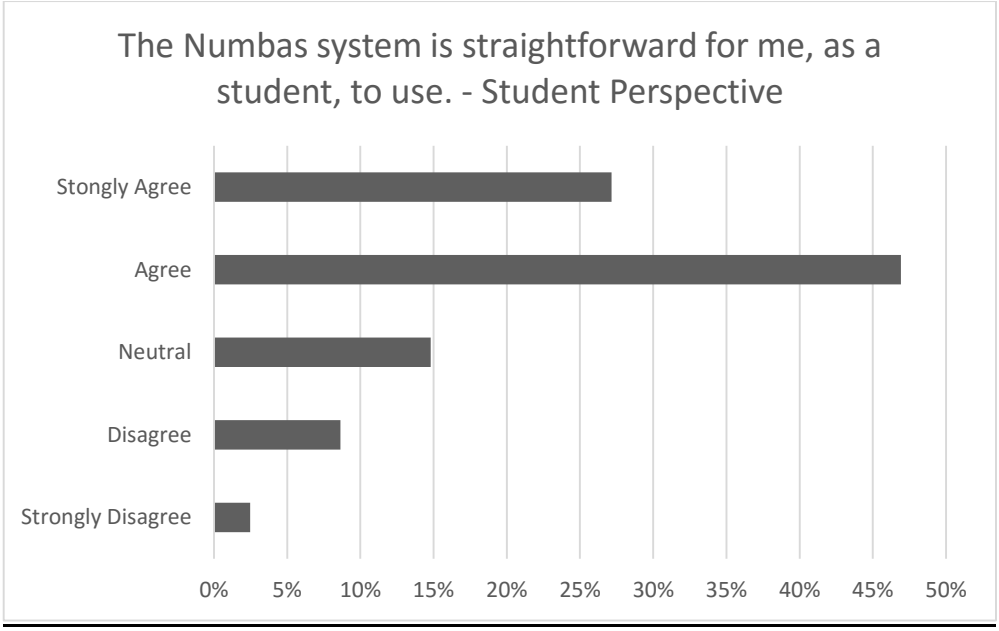

Figure 4. "The Numbas system is straightforward for me, as a student, to use." - student perspective.

Even though initially there was some apprehension among the teaching team to the introduction of a CAA to the modules, after using Numbas in their classes the lecturers/tutors all either agreed or strongly agreed with the statement "*The Numbas system is straightforward for me, as a lecturer or tutor, to use.*" One lecturer commented that *"it is a very good system"* and other said *"There were minor details that I needed to work out myself but overall very user friendly."*

5. Conclusion

In order to address low attendance at tutorials and low engagement at all classes we introduced the online mathematics e-assessment system Numbas as a tutorial and assessment tool. This improved the student experience and increased engagement by increasing attendance, student participation and student enjoyment. It made regular assessment with timely feedback a practical possibility for a large group of students. Usability did not prove to be the barrier that we expected it to be. Through the feedback it gave to students, Numbas proved to be a very successful formative assessment tool. We conclude with a comment from one of our teaching team, which summarizes much of this paper

"I think Numbas is a good thing, useful for getting students engaged."

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