

# Online Students' Perceptions of Interactive Tools to Support Postgraduate Learning of Mathematics

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With the advent of new technologies, methods of blended learning are used in online mathematics classrooms to facilitate interactions and provide a richer experience for students. This paper analyses data obtained from practising teachers during their participation in two postgraduate mathematics courses. We conclude that discussion forum interactions are students' preferred way of online learning. Also, although high levels of interaction do not necessarily correlate with success, they are essential for some students to persist with difficult content.

Emerging technologies are increasingly enabling new ways of interacting in both the physical and the virtual classroom, allowing higher education instructors to redesign their delivery methods. Planning instruction using a variety of delivery modes is often referred to as 'blended learning' (Bonk & Graham, 2012). In a blended learning environment, learners can access course content and activities in a variety of ways, for example, videos, blogs and online assessments, while interacting with each other and with the instructor in synchronous and/or asynchronous fashion (Holmes, 2005).

The project we report on in this paper was designed to evaluate the impact of methods of blended learning and assessment in a series of online courses, part of a postgraduate retraining program for teachers. The student cohort we focused on for this study consisted of a group of 60 practising teachers re-training to be high school mathematics teachers. The backgrounds of the students were diverse, but generally they were secondary school teachers who specialised in areas other than mathematics during their training but found that re-training in mathematics would provide better career prospects.

The project concentrated on two concurrent semester-long courses in the postgraduate program. These courses had traditionally been taught online asynchronously by sending students material to work on and asking to submit two written assignments and sit a final exam. Students were able to communicate via email and online discussion boards with the university educators to ask questions and request feedback. With this project we aimed to provide a wider range of blended learning experiences for students, including frequent targeted online assessment, which we thought could steer the asynchronous nature of the online teaching of these courses from a traditional self-directed approach to one in which interaction with the university educators and other students was more akin to face-to-face. The ultimate goal of the project was to ascertain which factors contribute to a quality learning environment in online mathematics teaching. In this paper we aimed to answer the following research question:

*What factors do postgraduate students identify as contributing to a quality online learning environment?*

## Review of Literature

The question of how to determine the quality of our teaching in the online environment is central to recent theoretical and empirical research (Anderson, 2008; Graham, Cagiltay, 2014. In J. Anderson, M. Cavanagh & A. Prescott (Eds.). *Curriculum in focus: Research guided practice (Proceedings of the 37<sup>th</sup> annual conference of the Mathematics Education Research Group of Australasia)* pp. 525–533. Sydney: MERGA.

Lim, Craner, & Duffy, 2001). It is often argued that the best way to ascertain the quality of online teaching is through interactions occurring online and these interactions have been experimentally proven to be associated with increasing student achievement (Bernard et al., 2009). However, many different instruments and measures for analysing the content of online interactions are available, and concerns about their validity and reliability have been raised (De Wever, Schellens, Valcke, & Van Keer, 2006).

The work we present in this paper contributes to the body of literature on online teaching of mathematics and builds on Engelbrecht and Harding's (2005) desirable attributes for teaching online mathematics. In mathematics, as in many other disciplines, the ease, convenience, cost-effectiveness and asynchronous nature of online interactions lend themselves to distance education. However, it is of utmost importance for mathematics distance educators to be aware of the different affordances of the online environment, in particular, issues such as online computerised assessment may play a major role in how the courses are ultimately designed and delivered (Threlfall, Pool, & Homer, 2013).

## Methodology

Mathematics courses are amongst the most difficult to teach online due to issues with notation and the highly structured nature of the content. Perhaps, for this reason, the teaching of mathematics in online environments has traditionally centred on the content to be delivered. To facilitate the delivery of mathematics content this project focused on the production of two types of online learning activities. On the one hand, and to enable students' self-regulation and engagement, a series of resources were either specifically created for the course or externally sourced from the Internet. Externally sourced tasks comprised two open-source text-based mathematics books, and many short videos and interactive demonstrations covering most of the topics in the course. Our internally produced lessons included a set of highly structured course notes, an interactive blog and discussion forums. The interactive blogs were delivered every week, and the forums were open to students and frequently involved answers to mathematical problems raised in the course notes. Due to the nature of mathematical notation, it was sometimes difficult to answer mathematical questions using the interface available with our content management system. To solve this problem we often posted answers as pencasts, or interactive documents containing both written text and voice. On the other hand, designed to enable student direction, we created a series of assessment tasks. All tasks were available to students from the beginning of the course. Some tasks were due fortnightly, some had to be completed within a very strict timeframe, and some involved giving feedback to other students.

Alongside the fortnightly tasks we created a set of surveys in which we asked students to give a brief overview of their views and perceptions of courses, encouraging suggestions for improvement. We also incorporated in the surveys a Likert-type frequency scale asking about their engagement with the different resources created for the courses. The analysis of these surveys was of particular interest, as in previous iterations of these courses students had submitted handwritten mathematical work covering all topics at the end of the semester, whereas this time we opted for two different forms of assessment: a timed multiple-choice test to check for basic understanding of the topics presented in the preceding two weeks, and a more challenging long response question to ensure deep understanding of the topics. The second task, different from previous years, was to be typed

(and plotted if necessary) with mathematical typing software we provided to all of our students prior to the beginning of the course. It was important for us to see if students felt that the resources we created helped them with these tasks.

All data collection occurred in the first semester of 2013. Our university content management system allows the running of analytics concerning the frequency of student access to the course and the number of posts made on the discussion board. We collected this data for the 60 students enrolled in two courses and correlated it with student achievement.

A subsample of students (n=15), gave consent to participate further in the study and completed the fortnightly surveys providing us with information about their level of engagement with the different technological innovations introduced in the courses. This allowed us to conduct a deeper analysis of the learning environment, as opposed to only observable and potentially biased interactions between teachers and students. The analysis of the discussion board interactions, the assessment tasks, and the survey responses, enabled us to assess the quality of the learning environment as it correlates to the technological innovations introduced.

## Results

The data obtained in this project will now be presented in three sections. Firstly we will briefly provide a breakdown and analysis of students' grades, the number of times they proactively intervened in classroom discussions and the time spent online in the courses' pages. This analysis was produced using the analytic tool present in the university's content management system, Blackboard<sup>®</sup>. Secondly, we will analyse the data obtained from the students who actively participated in the research project by providing a detailed analysis of their activities and the comments they made in the surveys. Lastly, the same analysis will be provided about the open discussion forums.

### *Relationship between Course Grades, Access Time and Frequency of Discussion Board Posts*

For the two courses examined in this study, analytics were sourced from Blackboard<sup>®</sup> to reveal the relationship between students' grades and their time spent within the course and discussion board post frequency. Overall 60 students were enrolled in either or both of the two courses under consideration. In Course 1 (focussed on introductory calculus) 41 students were enrolled, and 50 students were enrolled in Course 2 (focussed on higher level mathematics topics for the most part not covered in the high school curriculum). Table 1 displays the descriptive statistics related to course grades, time spent on course and frequency of discussion board posts for each course.

Table 1

*Course grades, time spent on course and discussion board course frequency*

	Course 1 (n=41)	Course 2 (n=50)
Course grade – mean (sd)	78.1(10.9)	81.6(8.8)
Time spent on course – mean (sd)	176(146)	144(92)
No. of discussion posts – mean (sd)	9.7(11.8)	11.0(12.3)

Students in both courses were invited to participate in the research project by completing regular surveys and allowing access to their final grades, discussion and blog

comments. Of the sixty (60) unique students enrolled in either or both courses, fifteen (15) provided consent to participate further in the study, with eight students completing one or more of five regular surveys throughout the semester. T-tests were conducted to compare the mean scores of the fifteen consenting students with the remaining enrollees in each course for each of the three measures: course grades, time spent on course and discussion board post frequency. The t-test results are displayed in Table 2.

Table 2

*Comparison study participants and non-participants in relation to course grades, time spent on course and frequency of discussion posts*

	Participant students Mean (sd)	Non-participant students Mean (sd)	T-tests
Course grade: Course 1	81.7(11.8)	76.9(10.5)	t(39) = - 1.21, p = 0.233
Course grade: Course 2	85.8(7.0)	80.1(8.9)	t(39) = - 2.09, p = 0.043
Time (hours) spent in course: Course 1	257(188)	150(122)	t(39) = - 3.04, p = 0.000
Time (hours) spent in course: Course 2	190(127)	128(72)	t(48) = - 2.08, p = 0.043
No. of discussion posts: Course 1	22.8(17.8)	5.5(3.9)	t(48) = - 2.16, p = 0.036
No. of discussion posts: Course 2	18.7(15.6)	8.3(9.8)	t(48) = - 2.80, p = 0.007

The 15 participant students in this study were significantly different, as a group, in comparison to the remaining students in several ways. The participating cohort, on average, achieved a higher course grade, with the difference being statistically significant in Course 2. In both courses, the participant students spent significantly more time accessing and interacting with the online components of the course and posted significantly more discussion board posts than the remaining students. Specifically, in Course 1, the participant students, on average, posted four times as many posts as the non-participant students, and in Course 2, more than twice the number of posts. Therefore, the self-selected students were significantly more likely to engage in the online environment than their colleagues in each of the courses and they tended to achieve a higher course grade, significantly so in Course 2.

Given that our participant students appeared to be highly active in the online environment, in comparison to their peers, an analysis of their survey responses and discussion posts was conducted to determine their perceptions of the effectiveness of the various online tools and strategies employed throughout the two courses.

### *Analysis of Students' Experiences with Blended Learning: Survey Responses*

Eight students also responded to up to five surveys throughout the semester seeking information about how frequently and in what manner the students were using particular tools: reading the course blog, watching links to external videos, watching instructor

developed pencasts, reading and/or participating in discussion forums and using online tools to contact and interact with the instructors. The mean scores representing the weekly frequency of access for each of the tools are displayed in Table 3.

Table 3  
*Students' Time Spent in Different Resources Created for the Courses*

	Course 1	Course 2
Read the course blog – mean (sd)	3.7 (0.6)	1.7 (0.1)
Watched the external video links provided (YouTube, etc.) – mean (sd)	2.8 (0.2)	2.1 (0.2)
Read the discussion forums – mean (sd)	4.9 (1.1)	4.6 (1.2)
Participated in the discussion forums – mean (sd)	2.1 (0.3)	2.9 (0.8)
Had contact with the lecturer (directly or through the forums) – mean (sd)	2.2 (0.1)	1.9 (0.2)

In both courses the most frequently accessed components was to read the discussion forums. In this case, students accessed the discussion forums more than four times each week. In Course 1 the blog was the second most accessed resource. On average, students contacted the lecturers twice a week, either on the discussion board or via email.

In general the comments from students participating in the research project about both courses were very positive, and most students thoroughly enjoyed their experience. However, students expressed opinions in the form of comments in the surveys about parts of the courses that they particularly liked. Furthermore, they provided constructive advice for improvement in some topics. As discussed in the introduction, to help us frame these comments and feedback, we have used the seven categories specified by Engelbretch and Harding (2005) about teaching undergraduate mathematics on the internet:

1. *Instructor facilitation:*

In general our students were very happy with the way the instructors facilitated the communication in the online environment. They made comments such as “I really like the blog, both the informal dialogue from the lecturer and the external video links provided. [Instructor 1] did a great job, thank you” (Student 13).

2. *Communication opportunities:*

The discussion forums created for the courses were the main means for students to communicate with the instructors and each other. Their reflection shows they found them very helpful: “I enjoy the discussion forums as a great way to feel connected” (Student 7).

3. *Collaboration opportunities:*

One of the tasks in the course involved a graded discussion in which students were to present their thoughts about a topic and then comment and give advice to other students about their work. This form of asynchronous online collaboration elicited a positive response from students: “Really enjoyed the interaction with other students in both courses” (Student 8). However, students felt that synchronous collaboration and communication would have been very beneficial: “In other courses I have completed through [the university], there have been scheduled in live chat sessions before major assignments. This was helpful” (Student 7).

#### 4. *Cognitive tools:*

Some students pointed out the fact that the use of interactive books would have been of great help: “more interactive course notes, where they are embedded with links to video or pencasts” (Student 13). It has become apparent to us that this is an area in the courses where we need to place emphasis.

#### 5. *Internet resources:*

Most comments students made were very positive “I enjoy the blog and youtube links provided. It makes learning so much more interesting and I felt less in the dark - especially when the topics were new to me” (Student 8, different week). Several students, however, pointed out that externally sourced internet resources were not enough and suggested to “have videos created from the lecturer” (Student 15).

#### 6. *Appropriate interface:*

The university content management system, Blackboard©, and our use of it, was the object of many students’ comments. In the earlier surveys students expressed feelings such as: “I’ve had trouble finding my way around in blackboard” (Student 20). Another point they argued for was more structure in the discussion forums: “It would be great if there were discussion topics for each individual topic/chapter so we knew where to look for specific information as sometimes a LOT of time is wasted searching for something or asking a question that has actually already been answered” (Student 10).

#### 7. *Online assessment:*

We found discrepancies in students’ preferences as to what the best method of assessment was. Although some students preferred the timed online tasks: “For [both courses], I love the on-line test component. The feedback is pretty much instant and the long responses are marked in a timely manner and the feedback has assisted me in my learning” (Student 8). The timed tasks presented challenges for some students, who mentioned issues with the length of time allocated for their completion saying they needed “more time multiple choice” (Student 8).

### *Analysis of Students’ Experiences with Blended Learning: Discussion Forums*

Over the course of the semester, students in both courses actively participated in online discussion forums. In many cases, students provided clues as to how they were experiencing the course(s) in relation to all aspects of blended learning. To classify their work, we will use again Engelbrecht and Harding (2005) categories:

#### 1. *Instructor facilitation.*

Here our students expressed gratitude for interaction with instructors: “This is great, thank you. I appreciate you taking the time to answer this question.”(Student 8). Students also expressed appreciation for the instructor-created blog, which provided additional support throughout the semester: “I would like to thank you for all of the blogs you have done this semester. I know they helped me and I am sure others to understand the topics.” (Student 15).

#### 2. *Communication opportunities:*

Students often took the opportunity to seek out support from fellow students expressing feelings such as “How did everyone find the multiple choice test for [this course]. I don’t

know if I like this method of testing. I get a bit flustered. I found it hard. Any comments?” (Student 17).

### 3. *Collaboration opportunities.*

The students appreciated the opportunity to collaborate and assist their peers online. For example, “I’ve printed off [a particular document]. [...] Has saved me heaps of time. I’ve attached it for you” (Student 7). Over time, students became more willing to share their work with others, but some reticence was evident in their comments: “Yes, that confused me too. [...]. I am attaching some working out that I have done. (I am a bit nervous putting this up and hope I don’t embarrass myself).” (Student 8)

### 4. *Cognitive tools:*

Most of the comments elicited about cognitive tools appeared when students were asked to reflect on their teaching as part of one of the assessment tasks: “Applications such as Wolfram Alpha, Geogebra, Efofex and other online content make a teacher’s preparation time enhanced by providing quality educational tools.”(Student 13).

### 5. *Internet resources:*

Students sometimes commented in the appropriateness of certain resources: “I like the way that Khan Academy often gives more than 1 way to think about a solution.”(Student 6).

### 6. *Appropriate interface:*

While the participant students generally appreciated the tools available within the learning management system, some found it challenging at first: “Sorry if this sounds dumb, but this is all new to me really. The last assignment I handed in at uni I had a mac classic and no internet.” (Student 13)

### 7. *Online assessment:*

Students expressed some frustration with the online assessment tools: “Yes, I too found this test challenging [...]. Unfortunately in this type of testing, the working is not included, which limits the ability to demonstrate some level of understanding; it is either right or wrong. Thank goodness for the long response section.”(Student 8).

## Conclusions

From the results above we can infer that students spent most of their online time reading the discussion forums and really valued the insight and feedback they obtained from them. External links to videos were also an important part of the learning experience for students. Our findings corroborate the usefulness of Engelbrecht and Harding’s (2005) framework for mathematics online learning. However, we believe that their classification could be extended by using well established pedagogical approaches to improving quality teaching (NSW DET, 2003).

It is important to note that students who responded the surveys were above average in terms of their interactions in the discussion forums and their time spent online in Blackboard©. This would perhaps indicate that the frequency of use of other resources, such as reading the course blog or watching externally sourced videos, is probably higher than the rest of the student cohort, as would be their interaction with the lecturers. The analysis of data of students who did not actively participate in the research project (i.e. those who didn’t do the surveys) indicates success in the course is not necessarily

dependent upon high levels of interaction with online tools, however, for some students, this interaction is absolutely essential to their levels of persistence with difficult content.

### Further Investigations

With this project we tried to move from an online asynchronous delivery of mathematical content to a blended approach where our interactions with students were virtually face to face. To do so, we utilised a range of digital resources available for online teaching focusing on creating a Quality Learning Environment. This type of environment is one of the dimensions of the Quality Teaching framework (NSW DET, 2003). It is known that the appropriate use of innovative technologies for online delivery of courses positively enhances the learning experience of students. It has also been shown how an approach to teaching using the QT framework can lead to improved results in student achievement and satisfaction (Gore, Ladwig, Griffiths, & Amosa, 2007) and is applicable to assessment in higher education (see ALTC project- <http://www.olt.gov.au/project-quality-assessment-linking-assessment-uon-2007>). What has not been investigated to date is how the QT framework could be used to enhance the quality of eLearning in an online or blended environment in higher education. We will further the study in this paper by analysing in detail using the QT framework all interactions that occurred during the two courses.

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