Are Online Quizzes an Effective Tool for Mastering Basic Algebra?

Wayne Read
James Cook University
<wayne.read@jcu.edu.au>

Patrick Higgins
James Cook University
< patrick.higgins@jcu.edu.au >

On-line quizzes are used to help first year University Mathematics students identify weaknesses in their basic skills and improve them. Quizzes developed as a formative tool have been utilised at JCU for eight years. However, before this research no-one has questioned the effectiveness of quizzes for this task. We present a description of the quizzes used in a core first year Mathematics subject at JCU and provide a statistical overview of their usage and efficacy for the intended task.

Quizzes are a ubiquitous part of the assessment regime in tertiary education centres throughout the world. The advent of the web and Information Learning Technology (ILT) has transformed the traditional paper based quiz into a means of electronically assessing students and providing formative feedback. Several studies have shown positive correlations between student motivation, engagement and attitude and the online quiz environment, both in numerate (Angus and Watson, 2009) and literate (Johnson and Kiviniemi, 2009) disciplines. However, in the Mathematical disciplines there appears to have been little research that studies the direct relationship between the quiz questions and the student's ability to reproduce the specific techniques that the quiz questions are based on at a later date. There also appears to be little available data on the way that students use this type of quiz.

The online quizzes at James Cook University (JCU) were set up to provide a formative learning environment where first year Mathematics students could practise basic skills in their own time and pace, and allow students to develop mastery of basic building blocks in a specific subject. Online quizzes were provided in two traditional core Algebra and Calculus courses, as well as a Discrete Mathematics subject for IT students. These subjects have run for eight years, and student surveys reinforce the positive feedback reported in the literature. In particular, students believe that on-line quizzes increase their basic skill set and are a motivating factor in their Mathematical studies. However, the MathsART have raised several questions about the quiz environment. For example, 'Do students help each other?', 'Do students guess multiple choice questions?', 'Are we encouraging rote learning rather than understanding?', 'Are students mastering the basic skills required?'.

The MathsART tried to answer some of these questions, and our initial investigations revealed how little we actually knew about the learning environment that students used with the online quizzes, so we decided to take a step back and collect basic data on the quiz environment at JCU. In this paper, we provide a statistical summary of the student usage of the on-line quizzes in one of the core Mathematics subjects. We present a basic statistical analysis of student's performance on specific questions, presented both in the online quiz environment and in an invigilated environment. Students were asked to sign consent forms at the start of the subject, and 150 out of a cohort of 201 consented to the use of their data. One student did not complete any assessment leaving 149 students in the study. All the analyses presented in this paper are based on the results obtained for the consenting students that completed assessment.

The rest of this paper is organized as follows. In the next Section, we describe the structure of the subject and the nature of the quiz environment. Next, we provide a basic

In J. Dindyal, L. P. Cheng & S. F. Ng (Eds.), Mathematics education: Expanding horizons (Proceedings of the 35th annual conference of the Mathematics Education Research Group of Australasia). Singapore: MERGA.

statistical analysis of the results for the quizzes and finally, discussion of these results and recommendations for future study.

Quizzes and MA1000 at JCU

The online quizzes that are the focus of this paper form part of the learning and assessment environment for the first year, core Mathematics subject MA1000: Mathematical Foundations. MA1000 is a one semester subject on Algebra, Analytic Geometry, Trigonometry and Introductory Calculus, and is worth 12.5% of the points required for the first year of a Science or Engineering degree. The assessment consists of nine on-line quizzes, three on-course tests and an end of semester exam. A student can pass the subject and avoid the end of semester exam, if they pass the on-course tests. Consequently, most students take the on-course assessment very seriously. Although the quizzes form part of the summative assessment for the subject, they are only worth 10%, which is given for encouragement and does not have any significant effect on the marks for the subject.

Students are expected to access the online quizzes via LearnJCU, the Blackboard interface that JCU uses for online learning and reporting. Quizzes can be attempted from the JCU campus or remotely, and are not invigilated. The ten questions that comprise each of the nine quizzes are drawn randomly from a database of quiz questions. Students are encouraged to attempt a quiz as many times as they wish, and the highest score (out of ten) is recorded.

A quiz is generated automatically when a student accesses the system, by randomly drawing ten questions from the database. The questions are of two basic types: multiple choice and numeric answer. For the multiple choice questions, a student is given a choice of four answers. For example, a multiple choice quiz question is

Simplify: $\frac{2^{n+2}4^{n-1}}{8^{n-1}}$
Which of the following expresses the answer with positive indices?
(a) 2^3 (b) 2^2 (c) 2^{n+2} (d) $n-4$

The numeric questions were generated using “template” questions; a new quiz question is obtained by simply changing the numeric constants or the variable names in the template question. For example, a numeric quiz question is

Determine the value of x that satisfies

$$\frac{2^{x+1}}{4^{4-3x}} = 1$$

Each of these questions had sixteen variations, so each ten question quiz was randomly drawn from 160 possible choices. The questions on the quizzes are drawn from two categories, “simple drill” (SD) and “complex drill” (CD). Simple drill questions correspond to material that the student should be able to answer correctly 95% of the time, once they have completed that component of the subject, and these types of questions will be the main focus of this paper.

Figure 1 is a plot of the average number of attempts that students make on each of the quizzes, assuming the student attempted the quiz. We note that fifty percent of the class attempted the quiz at least twice, with the exception of quiz six, which was attempted at least once. The maximum number of attempts was thirty, for quiz eight. Fifty percent of the class attempted quiz four at least three times.

Students are expected to receive close to full marks for the quiz component of the course, and are expected to use the quizzes to master the material covered. Figure 2 is a plot of the average marks obtained for the class for each quiz, with 95% confidence intervals

marked. We note that the average mark is between 85% and 95%, except for quiz four, which was 80%. Quiz four was on the Binomial Theorem and the Binomial Series, which students found difficult.

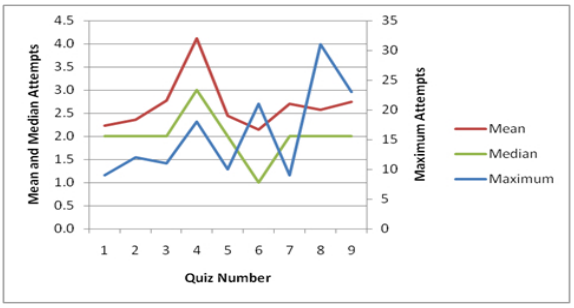

Figure 1. Number of attempts for each quiz.

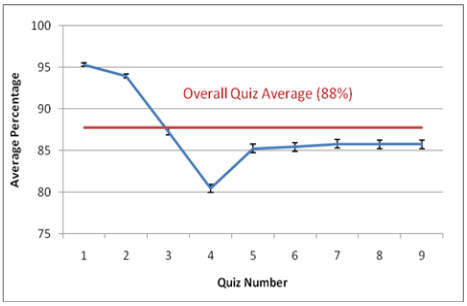

Figure 2. Average % obtained for each quiz.

The Quiz Data and Analysis

The data collected for the analyses presented in this paper is summarised as follows. Nine SD questions were selected and then examined in the oncourse tests. Four of these questions were also included in the end of semester examination. Each quiz question was worth one mark in the online quizzes. However, in the tests and examination the number of marks varied between two and three, so the averages presented are given in two ways: first, with the test and examination marks normalised so that they are out of one and secondly, with their original weighting. As noted in the previous Section, most students get close to full marks for each quiz, so we have calculated the average score for each question, where the average is taken over all of the student's attempts.

Table 1 presents the overall average marks (i.e., including SD questions) obtained in quizzes and the invigilated assessment for the subject. The subject is divided into three sections, each concluding with an on-course test. The quizzes for each section are completed before the test. The examination is at the end of the semester, for those students who do not elect to accept their grade on the oncourse assessment. Of the 149 students in our study, 37 did not sit the final exam.

Table 1

Overall Average Percentages for the Questions in the Quizzes and the Tests/Examination

Quiz Average	Normalised Test/Exam Average	Actual Test/Exam Average
71.6%	71.4%	67.6%

We note here that the quiz average and the normalised Test/Exam average are almost identical, with the actual Test/Exam average slightly smaller. Note that these results are significantly less than the target value of 95% and the average results for each quiz.

Next, we examine the average marks obtained for each of the nine quiz questions used in this study. Figure 3 is a plot of the normalised Test/Exam average and the quiz average for each question. We haven't included the actual Test/Exam averages, as they follow the same trend noted for the overall results: that is, approximately 5% less than the normalised results. Confidence intervals were not included, as the 95% intervals were almost too small to be seen on the plot.

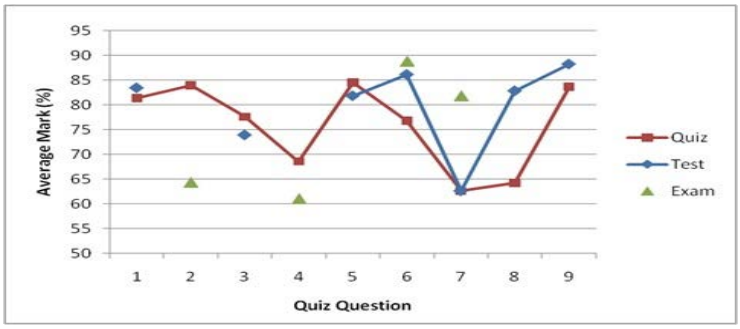

Figure 3. Average marks for the quiz questions on the quizzes, tests and exams

Close examination of Figure 3 reveals a different picture to the aggregated results presented in Table 1. First, the average scores for the quizzes are significantly higher than the overall averages for the tests and exams for most of the quiz questions. The lower averages for the overall results are probably due to the inclusion of the results for CD questions. The exceptions are the exam questions that were taken from quizzes completed earlier in the semester, and quizzes four, seven and eight. The average score for the quiz questions are a good predictor of the results for the tests for almost all the quiz questions. The only real exception is question eight, which significantly underestimates the test result.

Discussion

The analyses presented in this paper suggest that the overall quiz statistics (such as the quiz average) can be misleading. It would be easy to conclude from Figure 2 that the goal of 95% correct for the SD questions was within reach, whereas the individual quiz question data reveals that it is not. Also, the performance on the examination for quiz questions that were taught early in the semester (questions two and four in Figure 3) suggest that students are forgetting material that they have dealt with successfully earlier in the subject. The results for individual questions also suggest that the distinction between SD and CD needs to be revisited, as the average marks for questions four, seven and eight imply that these are not SD questions. These results are only preliminary, and more research needs to be carried out on the relationship between the average score per question and performance on test and exam results.

Acknowledgement

We thank Jo Balatti and Shaun Belward for their help and critical review of this paper.

References

Angus, S.D., & Watson, J.(2009). Does regular online testing enhance student learning in the numerical sciences? Robust evidence from a large data set. *British Journal of Educational Technology*, *40*, 255-272.

Johnson, B.C., & Kiviniemi, M.T. (2009). The effect of online chapter quizzes on exam performance in an undergraduate social psychology course. *Teaching of Psychology, 36*, 33–37.