

# A Study of the Application of Weekly Online Quizzes in Two Courses of Mathematics for Engineering Students – Is it a Fair and Effective Strategy to Increase Student Learning?

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## Abstract

While the application of quizzes has been the subject of research there is still not consensus regarding the best strategy to implement them or if they effectively increase students' learning. This study investigated the application of weekly online quizzes in two courses of mathematics for engineering students to determine if it is a fair and effective strategy to increase students' learning. Two sets of quizzes were applied to Single and to Multivariable Calculus, each with around 100 students. The quizzes were not mandatory, questions were the same for every student (not randomised) and the students could resubmit without penalty. It was expected that all students would achieve the total quiz grades, which represented 10% of the final grade, but only if they got more than 45% in their regular assessments. It was made clear to students that the quizzes were relevant for them as formative assessment. The conclusions were that students strongly adhere to quizzes, and that they make students study more and become more aware of their level of understanding. Very few students classified quizzes as unfair. Nearly all students answering the surveys found quizzes useful and believed that it helped them to achieve better grades. Course grades also increased in those semesters.

## Introduction

The use of quizzes has been studied substantially, however, there is no consensus in the literature regarding the best strategy to apply quizzes nor even if it really increases students' understanding of subjects, particularly in the study of mathematics by Engineering students.

Frequent online quizzes have been suggested as a strategy to enhance learning by several institutions and researchers. The National Centre for Public Policy and Higher Education in the U.S.A (Twigg, 2005) considers computer based continuous assessment and feedback to be a key strategy for quality improvement in learning. According to Gibbs (2000), student assessment is an effective way to increase understanding and online quizzes force students to spend more time working productively outside of class. Tuckman (1998) refers to this as being especially valuable to procrastinators. One method that can be used to address the crisis in college mathematics is to 'provide regular assessment of progress' which includes 'online homework and quizzes with online grading to provide students with immediate feedback, the opportunity to correct their homework mistakes, and ongoing assessment of their success in the course' (Thiel, Peterman, & Brown, 2008). Booth (1998) considers that homework should be given out at regular times, over regular intervals, on a weekly basis;

proposing that learning is work and students should develop regular work habits in order to succeed. Feedback is crucial for student success but giving adequate feedback with large class sizes is difficult, and therefore automated systems are a useful solution to the large class size problem.

Lawson (2002) considers the 'indisputable benefits' of quizzes to be: their continuous availability; their ability to give immediate feedback; and that they allow the student repeated practice and anonymity. However, Lawson also reflected on a list of possible problems including: students guessing; whether students should accumulate negative points when they fail a question; quiz conception on a computer may generate extra difficulty; the possibility of not evaluating what is intended; the difficulty to expressing the mathematics; the answers to multiple-choice questions do not give partial credit; and that it may be difficult to assess high level outcomes using quizzes. Lawson also states that if quizzes are only used as a formative assessment, it largely reduces these problems and that 'students derive great benefit from attempting questions and getting immediate feedback'. So quizzes should not be abandoned.

Quizzes are part of several successful approaches with different kinds of students, both in top universities and in other higher education institutions. Examples include: TEAL (Dori & Belcher, 2004) at Massachusetts Institute of Technology (MIT); SCALE-UP (Beichner, Saul, Abbott, Morse, Deardorff, Allain, ... & Risley, 2007) at North Carolina State University; Peer Teaching (Lasry, Mazur, & Watkins, 2008) at Harvard University; and Online Learning Modules (Hill, Sharma, & Johnston, 2015) at the University of Sydney.

Particularly, in the teaching of mathematics in higher education, several approaches have been raised but literature is not yet consensual about the effectiveness of quizzes to enhance learning. Some approaches lead to a higher success rate, others do not. There are many different strategies to apply quizzes: online or in class; mandatory or optional; contributing to final grades or not; weekly or other intervals; generating a slightly different question (new instance) for each student or not; penalty for submitting the answer more than once or not; only multiple-choice questions or more sophisticated ones, etc. Researchers are still looking for the best answers to these issues. The following show some approaches to studying the use of quizzes to teach mathematics in higher education around the world, which demonstrate the diversity of approaches and of results.

Siew (2003) administered six quizzes to 21 students on a Linear Algebra course that contributed 20% to the final grade. The quizzes used Maple in the background, generating questions with different values each time the question is launched. A penalty was assigned when a student resubmitted an answer and the solution was only available after the due date. According to 86% of the students, the quizzes contributed to their understanding of the subject and for 95% of the students, the feedback on the quizzes was useful to their learning. Students' scores on the course were higher in this year than in previous years.

Varsavsky (2004) reports a case where online weekly quizzes were applied to 250 Calculus students. The best eight out of the ten quizzes contributed to 20% of the final grade, if students passed the final exam (due to this restriction, plagiarism was not an issue of concern). During a week, students could answer the quizzes with no time constraints. Introducing the quizzes was considered a positive experience and students performed better in their final examination.

Myers and Myers (2007) assessed a statistics course with around 65 students over two semesters with two different strategies. In the first strategy, the students had two exams during a semester, one at midterm and the other at the end of the semester. In the second strategy, the students had a test every two-weeks. Their results reported that the second strategy produced better results.

Blanco, Estela, Ginovart, and Saà (2009) created a large set of Moodle quizzes for Mathematics 1 and 2 at Catalunya Politècnica Universitat, Spain. The quizzes were used in many different ways. For example, when used in computer lab sessions, students' results were not predictive of students' grades in the course. However, in a questionnaire about the quizzes, more than 80% of students rated quizzes as a positive activity; more than 70% of students stated that the quizzes helped them to understand some topics covered in lectures; and around 45% felt that undertaking quizzes made them more interested in the subject.

Lim, Thiel, and Searles (2012) taught a second-year mathematics course at university about vector analysis, ordinary and partial differential equations and Fourier analysis, with around 120 students. They utilised quizzes contributing 20% to the final grade. Students welcomed the regular quizzes and the pass rate increased relative to previous years.

Broughton, Robinson, and Hernandez-Martinez (2013) used Computer Assisted Assessment at Loughborough University, UK, for more than ten years for Calculus and Linear Algebra. Lecturers found it efficient and timesaving, but had concerns that some students developed tendencies to depend on the feedback to complete assessments and to develop procedural strategies for solving problems.

Shorter and Young (2011) made a comparison of three assessment methods: (1) daily in-class quizzes; (2) online homework; and (3) project-based learning. They found 'daily in-class quizzes' as the best predictors of students' learning (dependent upon post-test grades) for 117 undergraduate students on a Calculus course.

This paper presents a strategy of applying online quizzes and assessing their interest, relevance, fairness and impact on students' learning. The strategy was to apply quizzes every week, on a fixed day, available for some days, but not mandatory, equal to every student (not a random instance of a question), students could resubmit without penalty and it contributed to 10% of the grade, but only if the student got more than 45% in regular assessments. To study this, quizzes were applied an online anonymous survey for all students; was studied data from students' attempts to quizzes in Moodle and students' regular grades for five years. Two courses were studied in this research. However, this study is a natural continuation of the study, Martins (2016), involving one course in.

## Research design

The central research question of this study was are the quizzes (applied with the particular strategy) a fair and effective tool to increase students' learning? The strategy for the application of the quizzes was that they were weekly, online, non-mandatory, counted towards grades if students achieved a certain level on traditional assessment, were not randomly generated and students could resubmit without penalty.

This central research question was split into five subparts:

- RQ1: Did the students adhere to the quizzes?
- RQ2: What were students' perceptions of the quizzes?
- RQ3: Did the quizzes generate unfairness?
- RQ4: Did the quizzes improve students' grades?

To answer those questions, a quasi-experience research design was utilised, using as instruments, a focus group with some students to prepare the survey; a students' survey about the quizzes; data from

the answers to the quizzes; and course grades over several semesters. The quizzes were applied to two mathematics courses: AM2 with 104 subscribed students and MAE with 108 as outlined below.

## Method

This research took place in two mathematics' courses at the Instituto Superior de Engenharia de Lisboa, Portugal, each during a semester. In those semesters, weekly online quizzes on Moodle (the learning management system of the institute) were made available.

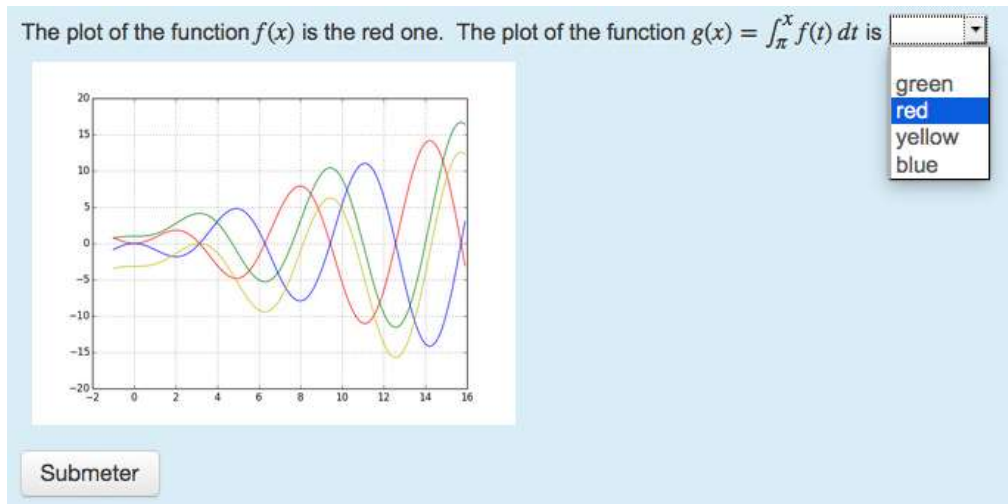
The first course was Análise Matemática 2 (AM2) from the Electrotechnical, Telecommunications and Computers Engineering Graduation with the syllabus of Differential and Integral Calculus in  $\mathbb{R}^n$ . It took place in the second semester of 2013/2014 with 104 students. Three professors taught three classes, two during the day and one during the night, of six hours a week. The second course was Matemática Aplicada à Engenharia (MAE) from the Informatics and Multimedia Engineering Graduation with the syllabus of Derivatives; Integrals: Simple, Indefinite and Improper; and Parameterisation of lines and surfaces. It took place in the first semester of 2015/2016 with 108 students. Two professors taught three classes, two during the day and one during the night, of four hours and half per week. The researcher was the responsible teacher and taught one daily class each semester.

We adopt the name 'Mini-tests' instead of 'Quizzes' to reinforce their relevance. The 'regular' assessment involved two face-to-face tests or the First Exam and the Second Exam. For AM2, the quizzes scored up to two values proportional to the best 12 (out of 14) grades in the quizzes and it was added if the student scored more than 9.0 values (out of 20) in 'regular' assessment. For MAE, it was slightly different: the quizzes valued 10% of the grade if the student scored more than 9.0 values (out of 20) in the 'regular' assessment and if this grade was better than the 'regular' grade. In both cases the quizzes were optional.

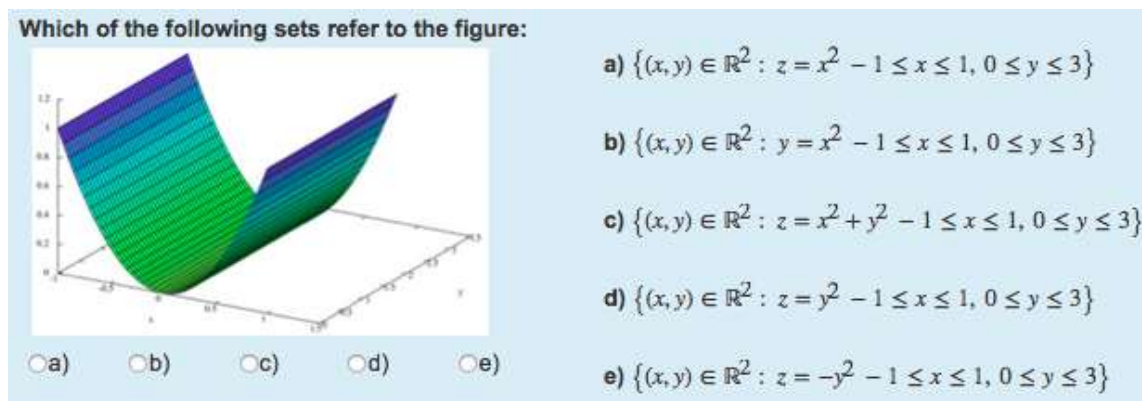
The aim of the quizzes was not to assess students, it was to make them study more, to encourage them not to postpone their study, and to provide more balance in their study program rather than focusing on the other subjects that were naturally more pleasant for them; and to make students more aware of their level of understanding (often students only realise that they cannot solve the exercises when they get the first test, in the middle of the semester). Students are usually optimistic about their capabilities (Wandel et al., 2015). The quizzes were available in Moodle and teachers repeatedly reminded students that the aim of the quizzes was to make students study more and be aware of their level of understanding. Students were also reminded that they could copy all quizzes, but probably would not get the 9.0 values required in 'regular' assessment, making it a futile approach.

## The quizzes

The quizzes were produced through the 'Moodle activity: test'. It allows the introduction of images and mathematical symbols using LaTeX (see Fig. 1 and 2 translated).



**Figure 1. Multiple-choice questions including a figure and mathematical text, MAE example. (Translated)**



**Figure 2. Multiple-choice questions including a figure and mathematical text, AM2 example. (Translated)**

The possibility of creating questions with different instances for each student was considered, but it would take much more time to create questions and students also know how to solve a problem with a constant instead of a number, so it did not seem worthwhile. Whenever it was possible, we used numeric or short answers instead of multiple-choice answers since in multiple-choice answers, with a few tries, students could get the correct answer. The type of questions that we used mostly involved ‘embedded answers’, as this enables a teacher to embed more than one sub-question and those sub-questions may be chosen from all the different question types: numeric, short answers, multiple-choice, true or false, etc. The ‘embedded answer’ question type allows the teacher to evaluate the student through their pathway and not only their final result (see Fig. 3). The feedback only shows if the answer is correct or incorrect, it does not show the correct answer.

Consider the function

$$f(x, y) = \begin{cases} 0 & \text{se } (x, y) = (0, 0) \\ \frac{x^3}{x^2+y^2} & \text{se } (x, y) \neq (0, 0) \end{cases}$$

$\frac{\partial f}{\partial x}(0, 0) = 1$  ✓ (use two decimals in answer)

$\frac{\partial f}{\partial y}(0, 0) = 2$  ✗ (use two decimals in answer)

Then, to study the differentiability of  $f(x, y)$  at  $(0, 0)$ , by the definition, we must study the limit of point **c** ✓

a)  $\lim_{(h,k) \rightarrow (0,0)} \frac{-h^2k}{(h^2+k^2)^2}$

b)  $\lim_{(h,k) \rightarrow (0,0)} \frac{h^2k^2}{(h^2+k^2)^2}$

c)  $\lim_{(h,k) \rightarrow (0,0)} \frac{-hk^2}{(h^2+k^2)^{3/2}}$

d)  $\lim_{(h,k) \rightarrow (0,0)} \frac{-3hk^2}{(h^2+k^2)^3}$

And the value of that limit **do not exist** ✓

And it makes that the function **is not** ✓ differentiable at  $(0, 0)$ .

**Figure 3. A question with multiple embedded questions along the path (including numerical answers), an AM2 example. (Translated)**

The expression

$$\left(\frac{x+3}{2}\right)^2 + (y+1)^2 \geq 4$$

represents **the inner part of a** ✗ **ellipses** ✓ centered in  $(a, b)$  with  $a=3$  ✗,  $b=-1$  ✓, horizontal radii **4** ✓ and vertical radii **2** ✓.

**Figure 4. A question with multiple embedded questions along the path (including numerical answers), an MAE example. (Translated)**

### Data collection, analysis and results

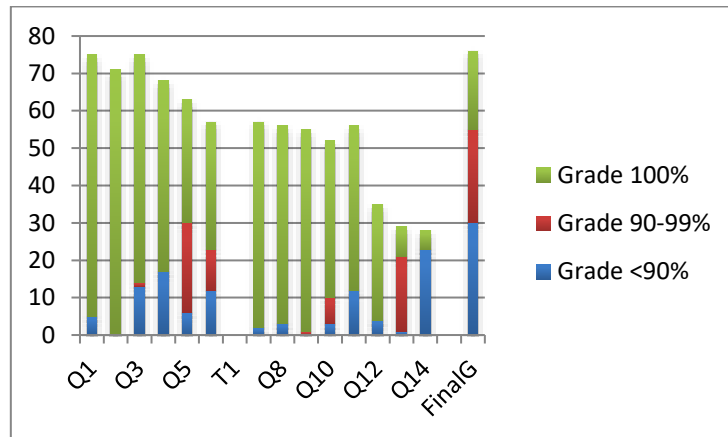
The anonymous survey on Moodle was addressed to all students. The sample of students who answered the survey was considered reasonable. From the 104 students subscribed to AM2, all subscribed to Moodle and 65 answered the survey. From the 108 students subscribed to MAE, 94 in Moodle, 61 answered the survey. Moreover, by splitting the students by their grade at the first test (the survey was applied before the second test), the number of students answering the survey with a given grade reasonably correlates to the number of students in general who achieved that grade. Pearson correlation coefficients are  $r=0.6$  and  $r=0.5$  respectively.

Students of the institute may be subscribed to a large number of courses, so it is usual that students subscribe to some courses where, in fact, they do not attempt to achieve success. For example of the 108 students subscribed to MAE only 94 were subscribed to Moodle, so the 14 remaining students did not access anything from the course: syllabus, slides, quizzes etc. Since there is no simple and

fair way of identifying these students, in this research used the subscribed students to make measures. However, it is relevant to have in mind that it includes those ‘ghost students’.

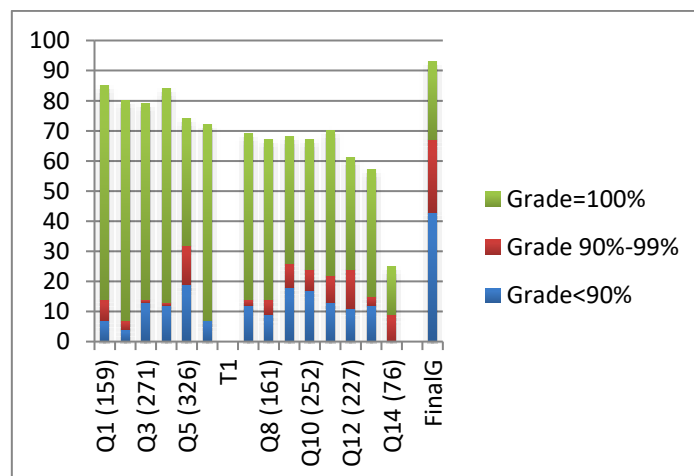
**RQ1: Did the students adhere to the quizzes?**

AM2 had 104 subscribed students, 79 attempted regular assessments and 76 students attempted at least one quiz. All but one of the approved students answered at least one quiz. The final quiz grade was the average of the best 10 out of 14 grades in quizzes, so it was natural that the last four quizzes had lower attendance (and for this reason we modified this rule for MAE, where the best 12 grades were chosen).

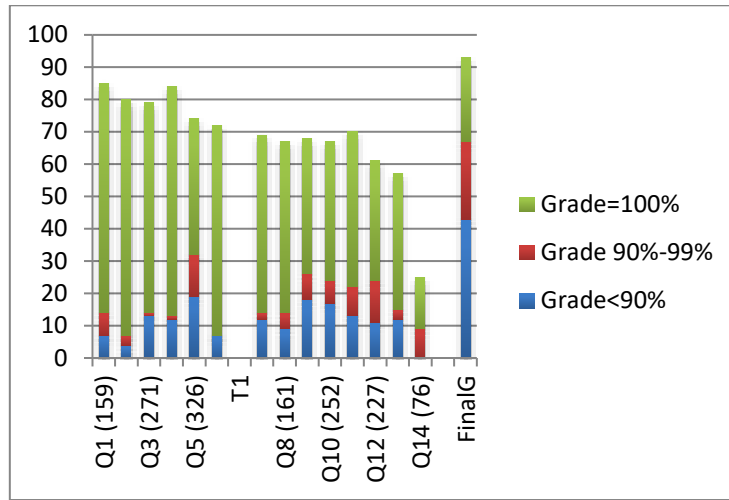


**Figure 5: The number of students who answered AM2 quizzes split by grade**

MAE had 108 subscribed students, 103 completed regular assessment and 93 students attempted at least one quiz. All approved students answered at least one quiz. The final quiz grades were the average of the best 12 out of 14 grades in quizzes, so it is natural that the last two quizzes had a lower attendance (this rule changed from AM2). It is important to note that, for example, in Q5 the number of students with a total grade was lower than in the other quizzes and the number of attempts to solve the quiz was higher than in the others (326). This shows that students were, in fact, trying to reach the correct answers (this test was particularly large and complex).



**Figure 6: The number of students who answered MAE quizzes split by grade. The number of attempts to answer the quiz, registered by Moodle, is in parenthesis.**



**Figure 7: The number of students who answered MAE quizzes split by grade. The number of attempts to answer the quiz, registered by Moodle, is in parenthesis.**

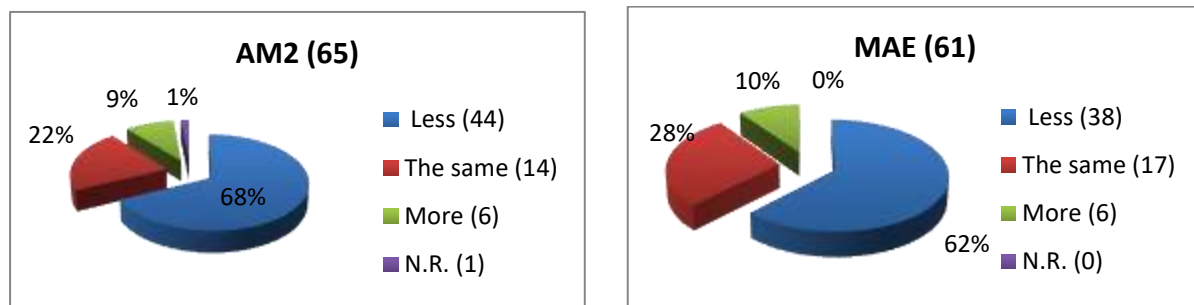
A large portion of students achieved a very high grade, but this was natural since students may retry without penalty and the questions were equal to all students, so it was expected that students talk to each other and reach the correct answer.

The quizzes were not mandatory and improved the grade if the student got more than 9 out of 20 values in regular assessment, so it could be expected that many students decided not to take it. However, on a regular basis, nearly half of the subscribed students answered the quizzes.

Despite the optional policy, the data shows that students adhered strongly to the quizzes. The percentage of subscribed students that answered one quiz was  $93/108=86\%$  and  $76/104=73\%$ . All the quizzes had a high rate of attendance. Among the students that undertook ‘regular’ assessment, almost all took a quiz and a large percentage achieved high average grades on the quizzes.

**RQ2: What were students’ perceptions of the quizzes?**

The answers to the question: ‘Without quizzes, I’ve studied more/the same/less time to AM2/MAE’ showed that more than 60% of students studied more due to the quizzes (see Figure 8). This question was expressed in a negative form and this may have resulted in some biases in the answers. For future use, the questionnaire will be revised.



**Figure 8: Percentage of student responses to ‘Without quizzes, I’ve studied more/the same/less time to AM2/MAE’ in both surveys.**

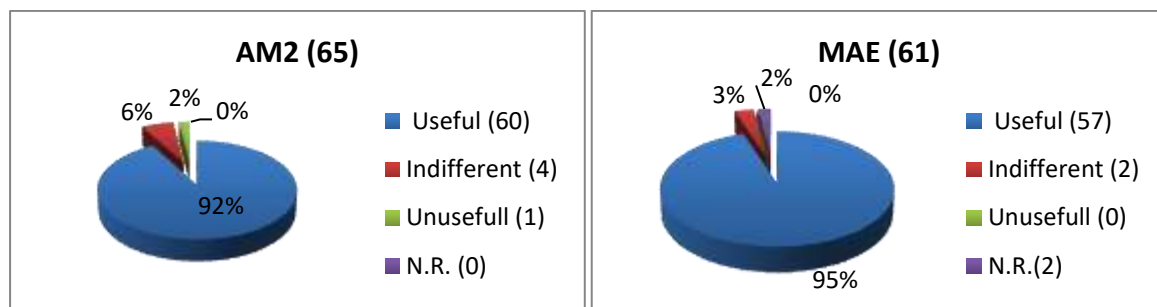


Table 1 shows that, according to the survey, none of the students thought that the quizzes were of no interest and did not care about the quizzes, while a large percentage believed that the quizzes reminded them to study, showed them the level that they were reaching and encouraged them to learn new parts; some of those parts they thought they understood, but in fact did not. The survey had some open questions, but the answers did not add anything new, only reinforced the topics previously addressed.

**Table 1. Students’ responses to ‘Select ALL the statements that you agree with’ in both surveys.**

	AM2		MAE	
Total	65	100%	61	100%
Quizzes remind me to study the subject every week.	55	85%	50	82%
Quizzes show me there are things I thought I knew but I didn't.	48	74%	53	87%
Quizzes help me to have a better perception of the level I'm reaching.	47	72%	38	62%
I learn new things answering to quizzes.	33	51%	35	57%
Quizzes have no interest.	0	0%	0	0%
I do not care for quizzes, I just copy the results.	0	0%	1	2%
I do not care for quizzes, I not even copy the results.	1	2%	0	0%

Figure 9 below indicates that, in both courses, more than 90% of students responded that quizzes are useful.



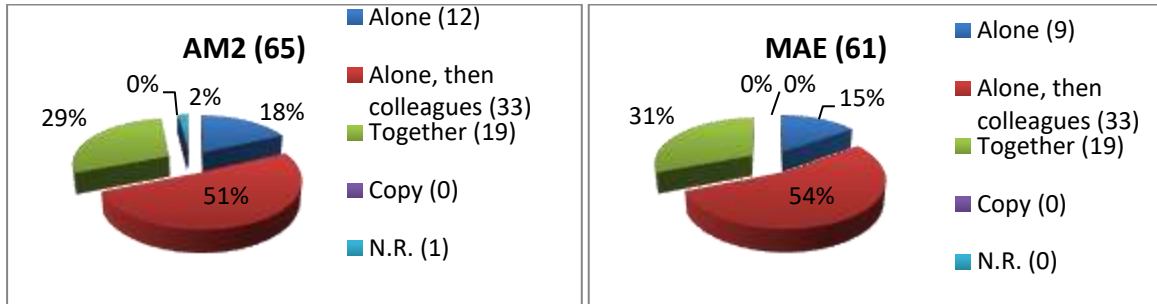
**Figure 9: Percentage of student responses to ‘The quizzes were...’ in both surveys.**

Summarising, more than 90% of students found quizzes useful; more than 60% stated that they study more due to the quizzes. Students agree that quizzes remind them to study, show them that there were parts that they thought that had understood but did not, encouraged them to learn new parts and gave them a better perception of level that they were reaching.

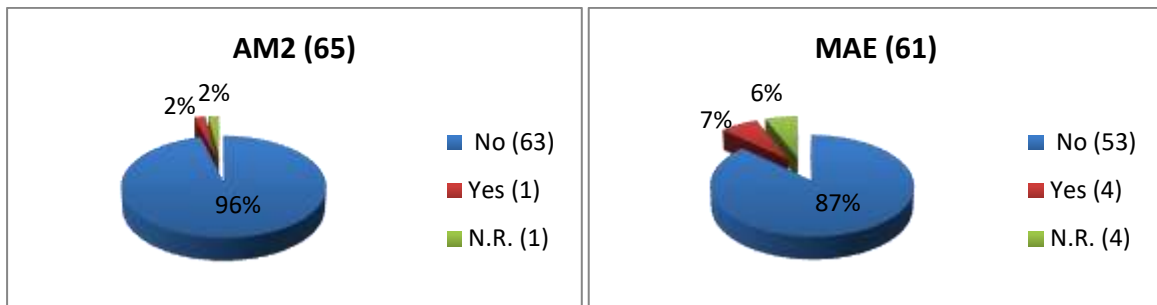
**RQ3: Did the quizzes generate unfairness?**

Teachers routinely comment that the main reason they don't use online quizzes was that students may cheat, thus making the process unfair. To mitigate that problem, it was strongly emphasised to students that quizzes were much more relevant as formative assessments than summative assessments; students could resubmit the quiz without penalty to stimulate them to try to answer by

themselves without fear of being penalised; and a clause was included that the quizzes only count towards grades if students get 9.0 values (out of 20) in regular assessments (Varsavsky, 2004). As a result, the responses in the survey to the question ‘Quizzes generate unfairness?’ show that very few students perceive the quizzes as unfair (see Figure 10).



**Figure 10: Percentage of student response to ‘How do you answer to quizzes?’ in both surveys.**



**Figure 11: Percentage of student responses to ‘Quizzes generate unfairness?’ in both surveys.**

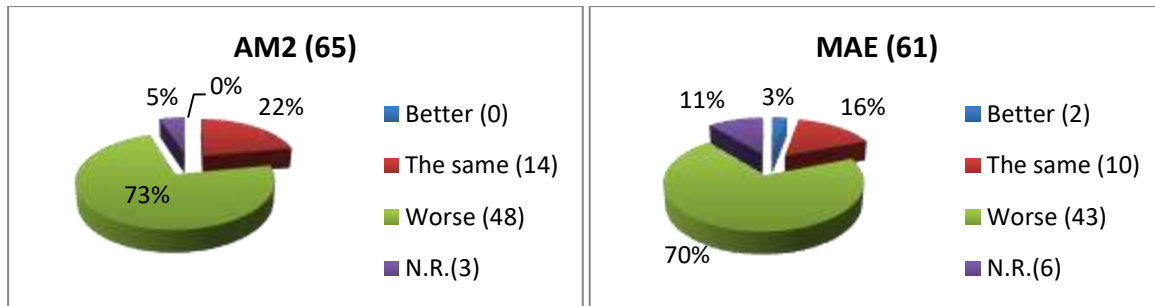
When questioned in the survey, no student stated that they had copied the results (see Figure 10), despite it being reinforced in that question that the survey was automatically anonymous.

From the data it can be concluded that the level of unfairness of quizzes is not considered as relevant.

**RQ4: Did the quizzes increase students’ grades?**

Since the goal was that all students achieve a total score in all quizzes, it was expected that quiz grades would not correlate to final grades. This, in fact, did occur and it was verified using the non-parametric Spearman Rho for AM2 ( $r = 0.34, N = 54, p = 0.01$ ) and for MAE ( $r = 0.28, N = 61, p = 0.03$ ), since data were not normal (Kolmogorov-Smirnov,  $p < 0.01$ ).

According to Figure 12, around 70% of students responded that they believed the quizzes helped them to achieve a higher grade.



**Figure 12: Percentage of students answers to ‘Without quizzes, I’ve scored...’ in both surveys.**

The data, of Tables 2 and 3, relate to five responsible teachers/approaches and thirteen different teachers. The syllabus was essentially the same across the semesters, but changes the responsible teacher and then approaches were naturally different. In the intervention semesters happened the same. Since there is such a different number of responsible teachers and approaches we nearly may state that the quizzes were the only different variable in that semester. But, by deep rigour, we will consider that we cannot attribute grade differences directly to the quizzes.

For AM2, the pass rate nearly doubled in that semester, the average grade also increased significantly.

**Table 2. Grades of AM2 students across ten semesters, the responsible teacher is underlined and the experimental semester is shaded**

AM2	2010/11		2011/12		2012/13		2013/14		2014/15		2015/16	
	S1	S2	S1	S2	S1	S2	S1	S2	S1	S2	S1	S2
Subscribed students	101	200	128	153	90	123	80	<b>104</b>	56	66	56	108
Pass students	27	38	31	41	20	23	12	<b>54</b>	10	19	16	33
Average grade of pass	11.7	11.8	12.3	11.7				<b>13.9</b>	12.4	11.5	11.7	11.5
Pass/Subscribed	27%	19%	24%	27%	22%	19%	15%	<b>52%</b>	18%	29%	29%	31%
Professors	<u>A+</u> ...	<u>A+</u> ...	<u>A+</u> ...	<u>A+</u> ...	<u>A</u> +B	<u>A</u> +C	<u>D</u> +E	<u>F</u> +G+ <b>H</b>	<u>D</u> +F	<u>D</u> +I	<u>J</u> +K+L L	<u>J</u> +K+L

The MAE course had, in some instances, five or six quizzes in class. It is curious to note that in the year that there were no quizzes, the pass rate was much lower. However, it may have been a coincidence and there is insufficient data to draw other conclusions.

The MAE pass grade and the average grade had the highest value in the experimental semester.

**Table 3. Grades of MAE students across five semesters, the responsible teacher is underlined and the experimental semester is shaded**

MAE	2011/12	2012/13	2013/14	2014/15	2015/16
	S1	S1	S1	S1	<b>S1</b>
Subscribed students	73	109	121	125	<b>108</b>
Pass students	17	30	58	56	<b>61</b>
Average grade of pass	12.7	12.2	13.5	12.7	<b>13.5</b>
Pass/Subscribed	23%	28%	48%	45%	<b>56%</b>
Number of quizzes	0	6 in class	5 in class	5 in class	<b>14 online</b>
Professors	<u>A</u>	<u>A</u>	<u>A</u>	<u>A+B</u>	<b><u>B+A</u></b>

Summarising, as expected, quiz grades do not correlate to final grades; around 70% of respondents to the survey stated that as a result of the quizzes they achieved a better grade. The pass rate and the average grade increased significantly in the semesters in which the quizzes were applied, which is a positive indicator, but cannot be directly attributed to quizzes.

One of the limitations of the study is that the responsible teacher was always the researcher and, although the syllabus remains the same, there are many changes within courses, including the use of quizzes. However, since this study involves so many different responsible teachers, and so many teachers the biases became smaller.

## Conclusions

Two sets of 14 weekly quizzes on Moodle were available to all the engineering students on two mathematics courses: Single and Multivariable Calculus. As recommended by Myers and Myers (2007) a number of quizzes were used. The quizzes were not mandatory, counted to grading if the student got more than 9 out of 20 on traditional assessments, were not randomly generated and students could resubmit without penalty. According to Varsavsky (2004), this reduces unfairness. The research question was ‘Are quizzes (applied with this strategy) a fair and effective tool to increase students’ learning?’

In the answers to the survey, more than 90% of students found quizzes useful; more than 60% stated that they studied more due to the quizzes; students agreed that quizzes reminded them to study; showed them that there were parts that they thought they understood but did not; made them learn new parts and gave them a better perception of the level that they were reaching. Although the quizzes were not mandatory so students could have just ignored them, in fact a large proportion of students attempted the quizzes and kept answering them until the last stages.

Quiz questions were not randomly generated, so all students got the same questions and naturally, students shared the solutions with each other. To avoid unfairness, it was strongly emphasised that quizzes were important to students, to allow them to test themselves and get feedback on their level of understanding. Moreover, quizzes only contributed to grades if the students got more than 9 out of

20 in ‘traditional’ assessments and if a student copied many quiz results they probably would not achieve the minimum grade and it would not be worthwhile. The result was that very few students perceived the quizzes to be unfair.

Over 70% of respondents to the surveys stated that due to the quizzes they achieved a better grade. The pass rate and the average grade increased significantly in the semesters that the quizzes were applied, which is a positive indicator, but it cannot be attributed solely to the quizzes. This research suggests that these quizzes, with this strategy, are a fair and useful tool to increase students’ learning so it is recommended to support teaching. Future research work will test quizzes in other courses, with other teachers and with other responsible teachers to strengthen the validity of this research.

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## Appendix

### AM2 Quizzes

- Q01 – 2D Regions
- Q02 – 3D Regions
- Q03 – Domain, limits and continuity of scalar and vector fields
- Q04 – Derivatives
- Q05 – Differentiability and tangent plan
- Q06 – Composition of functions and optimization
- Q07 – Double Integrals – Cartesian coordinates
- Q08 – Double Integrals – Polar coordinates
- Q09 – Triple Integrals – Cartesian coordinates
- Q10 – Triple Integrals – Cylindrical and spherical Cartesian coordinates
- Q11 – Line Integrals – part 1
- Q12 – Line Integrals – part 2
- Q13 – Surface Integrals – part 1
- Q14 – Surface Integrals – part 2

### MAE Quizzes

- Q01- Functions (Part1 – Inverse function, Prove properties, Applications) (Functions from  $\mathbb{R}$  to  $\mathbb{R}$ )
- Q02- Functions (Part2 – Inverse of trigonometric functions)
- Q03- Functions (Part3 – Trigonometric and exponential: It's Inverse and Applications)
- Q04- Derivatives (Part1 – Derivatives, Derivative of composite functions, Applications)
- Q05- Derivatives (Part2 – Tangent line, Taylor polynomial, Optimization)
- Q06- Antiderivatives (Part1 – Immediate Antiderivatives)
- Q07- Antiderivatives (Part2 – Antiderivatives by parts)
- Q08- Antiderivatives and Integrals (Antiderivatives by substitution, Basic Applications of Integrals)
- Q09- Integrals (Part2 – Numerical Integration, Areas using integrals)
- Q10- Integrals (Part 3 – Applications, Mean value, Changing variables in Integration)
- Q11- Integrals (Part 4 – Fundamental Theorem, Improper integrals, Applications)
- Q12- Parameterizations (Part1 – 2D Regions, Parameterization of 2D and 3D lines)
- Q13- Parameterizations (Part2 – Velocity and acceleration in parameterizations of 2D)
- Q14- Parameterizations (Part3 – 3D Regions and its parameterization)