

# How Do Mathematics Teachers in Higher Education Look at E-assessment with Multiple-Choice Questions

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**Abstract:** This paper presents a part of a global proposal aimed to create and put forward an e-assessment strategy using tests with multiple-choice questions (MCQ) implemented in *Moodle*. This strategy was planned in order to allow the use of continuous summative assessment in mathematics' courses in a higher education institution, in classes with a large number of students. The main goal of this work was to analyse how this procedure can affect the teaching and learning processes. Changes in educational practices were ascertained using interviews with teachers. It was found an improvement in the way teachers create questions as well as in teamwork promotion. Furthermore, teachers reported that they pay more attention now on how they teach. Thus, the implementation of this e-assessment approach can be considered successful, namely because it allowed an adequate response to the main needs initially identified.

## 1 INTRODUCTION AND BACKGROUND

New challenges have emerged from Information and Communication Technologies (ICT) and, at the same time, the opportunity to create differentiated learning opportunities for students, through multiple tools available to teachers. The use of ICT is recommended by several European organizations such as the European Parliament (Redecker, 2013; Redecker and Johannessen, 2013). In the assessment process, it becomes an useful resource, through electronic format or e-assessment.

The use of ICT in the student assessment process, from where the concept of e-assessment arose, is largely associated with the need to adapt the traditional forms of assessment in e-learning courses. ICT is used throughout the assessment process from the design of the tests to the storage of the results (Stödberg, 2012).

Closed-response questions remain the most commonly used format in e-assessment (Stödberg, 2012). Among those, multiple-choice questions

(MCQ) are of particular relevance and have some specificities. Based on a review of the literature, some advantages and some limitations of MCQ are presented in tables 1 and 2, respectively. In both tables, the ones presented in bold are related to mathematics, and the ones with the grey background concern the point of view of students.

Structurally, MCQ are composed of 3 elements: (1) a stem that presents the problem and which can take the form of an incomplete sentence or a question; (2) the correct option or answer key; and (3) several distractors, which are incorrect alternatives, but equally plausible for students who do not fully master the subjects to be tested (Clegg and Cashin, 1986; Burton et al., 1991; Bush, 2015).

From our point of view, one of the limitations of MCQ in paper format tests, which we have not found explicitly mentioned in the literature, has to do with the possibility of students to cheat more easily than they would do when the questions are open-ended. To obviate this limitation, some teachers construct several versions of the same test, introducing slight changes to it, but trying to maintain the feasibility and the reliability of the assessment. In the case of e-assessment, a database of questions duly conceived

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and implemented represents a fundamental role here, and may even reach the limit of obtaining a different version of the test for each student, generated randomly by the computer system (Azevedo, 2015).

Table 1: Advantages of Multiple Choice Questions.

<ul style="list-style-type: none"> <li>• Saving time (e.g. in obtaining ratings) and resources</li> <li>• Ease of assessment of large numbers of students in large-scale tests</li> <li>• Ease of calculating statistical analyses and test results</li> <li>• Obtaining a greater and faster scope with respect to the contents of the course, which allows to assess a wider range of topics and knowledge</li> <li>• Compatibility between web-based courses</li> <li>• Greater objectivity and reliability in classifications</li> <li>• Existence of question banks for future use</li> <li>• Ease of implementation through computers</li> <li>• Easier to manage</li> <li>• It is a standard method</li> <li>• Great format variety</li> <li>• Existence of balance between validity and reliability with the logistical facility</li> </ul>
<ul style="list-style-type: none"> <li>• <b>It has the potential to measure comprehension, analysis, problem-solving ability and calculus skills</b></li> <li>• <b>It avoids the introduction of symbolic notation by students, in the specific case of mathematics</b></li> </ul>
<ul style="list-style-type: none"> <li>• Greater confidence in getting the correct answer from processes of eliminating the wrong answers</li> <li>• It allows to evaluate the students' knowledge <i>per se</i> and not their writing abilities</li> <li>• Perception that MCQ tests are more objective and reliable</li> <li>• Useful for self-evaluation and revision</li> <li>• Feedback is fast and impersonal (no concept of judgment)</li> <li>• Increased student motivation and engagement</li> </ul>

When it is intended to use e-assessment in general and the MCQ, in particular, it is useful to construct a question bank (Yorke, 2001). Question banks can contribute to ensure the validity and reliability of the assessment process, saving resources, time and money (Bull and Danson, 2001; McAlpine, 2002). An important aspect in the development of MCQ to be included in a question bank is the assurance that the items are of high quality. Several guidelines for the quality of MCQ writing can be found in the literature (Clegg and Cashin, 1986; Burton *et al.*, 1991; Haladyna, Downing and Rodriguez, 2002; Haladyna, 2004; Camilo and Silva, 2008).

Assessment can profoundly influence the motivation of those who learn, as well as their perspectives on learning. So, the introduction of different assessment systems may have a major impact on the whole educational process (Smith *et al.*,

1996; Wild *et al.*, 1997; Scouller, 1998; Brown, 2001; Bull and Danson, 2001; Jarvis *et al.*, 2003; Jacob *et al.*, 2006; Frankland, 2007; JISC, 2007; Garfield and Ben-Zvi, 2008; Stöðberg, 2012; Redecker, 2013; Holmes, 2015).

Table 2: Limitations of Multiple Choice Questions.

<ul style="list-style-type: none"> <li>• They may not assess the same levels of understanding that are assessed by open-end questions</li> <li>• Possible ambiguity in the questions themselves</li> <li>• Inability to adequately measure certain skills at higher cognitive levels</li> <li>• The development of properly structured questions is quite time consuming and requires a lot of training</li> <li>• They may favour the superficial memorization of concepts</li> <li>• Students may try to hit the answer randomly</li> </ul>
<ul style="list-style-type: none"> <li>• <b>Students can reverse the resolution and one is not evaluating what is supposed to</b></li> <li>• <b>In questions with calculations the student can arrive at a solution that does not exist in the options concluding that his answer is incorrect</b></li> </ul>
<ul style="list-style-type: none"> <li>• It does not allow students to explain their answers, so they are limiting</li> <li>• They may penalize students who do not tend to take risks</li> <li>• Feedback personalization is limited</li> </ul>

This paper presents the last part of a seven years' implementation process of an e-assessment strategy using MCQ, implemented in *Moodle*, which started in fall 2008. This strategy was implemented in order to allow the use of continuous summative assessment in Mathematics Courses in a Higher Education Institution (ISCAP/IPP), in classes with a high number of students. The goal of this work is to reflect on the teachers' practices for the development of MCQ in the area of Mathematics and how e-assessment can influence the teaching-learning process in this institution.

The research method is described in section 2. A discussion and the conclusions are presented, respectively, in sections 3 and 4.

## 2 METHOD

Six mathematics teacher volunteers were interviewed about the e-assessment process with MCQ, since they used this test format for continuous summative assessment. Four of them were female and the average age was 55 years, ranging from 44 to 71 years. The average length of service at ISCAP was 22 years, so the teachers interviewed were quite

experienced. In order to safeguard the participants' anonymity, we identified each of the interviews with "E" followed by a serial number (E1, E2,...).

A semi-structured interview was carried out in order to allow a better organization of the topics to be addressed and, moreover, to enable teachers to freely express their views. The main objective was to analyse and discuss the implementation process of e-assessment, namely possible changes in teaching or learning experiences and resulting advantages and disadvantages for the teacher.

The interview script consisted of descriptive information of the participants (gender, age, disciplinary area and length of service at ISCAP) and seven questions, focused on the following dimensions: i) opinion on the e-assessment procedure implemented; ii) major difficulties found during implementation; iii) changes in teachers' pedagogical practices; iv) advantages of this procedure for the teacher; v) disadvantages of this procedure for the teacher; vi) changes in students' practices in their learning process. Question 7 aimed to assess whether teachers identify any important information beyond those previously considered for the topic being analysed.

The interviews were recorded with the consent of the teachers and later were entirely transcribed. Content analysis techniques were used following two steps: first, a careful reading of all the interviews, in order to capture the general meaning of the speeches and, then, the answers were grouped by each of the defined dimensions already mentioned above.

### 3 RESULTS

We present below the analysis of the content of the interviews regarding each of the defined dimensions. We recall that each question, presented in the interview script, corresponds to a dimension to be studied.

#### Opinion on the e-assessment procedure used

All teachers reported a very positive opinion about the type of assessment implemented and unanimously agreed that this was a good assessment system:

*"It was very appealing to the students and I think it increased their interest and it had good results." (E3)*

*"I think it's an assessment that was worth developing. I like the assessment. I think it's a very good assessment when you want to do several tests during the semester to the students and the number of students is quite high." (E6)*

In any case, two teachers said they were reluctant at the beginning of the process:

*"At first I was very sceptical when we started using this system, especially with regard to multiple choice." (E1)*

*"At first I was not very receptive because I thought it was not as functional as it actually was." (E2)*

Two of the teachers pointed out that there was a positive evolution over time, which resulted from a learning process. The statement of one of them well summarizes this opinion:

*"Over the years, I think we have been refining, learning to build multiple choice questions and I think it has improved a lot." (E1)*

*It was also mentioned by two teachers that there was a need for greater learning regarding how questions should be developed and that this learning was done:*

*"We read and reflect and we studied a little bit about how to improve the formulation, especially the multiple choice where we really could get better results." (E1)*

#### Major difficulties found during implementation

The initial lack of knowledge about how to prepare good questions was pointed out by three teachers as one of the difficulties encountered in the implementation of this e-assessment process:

*"We had to study the best way to ask the questions because the way we work is different from a traditional test. And at the outset there was a difficulty in formulating the questions so that they would be objective and would not evaluate more than one objective in each question." (E5)*

Also pointed out by three teachers as a great difficulty were the problems related to technology, namely with Moodle functionality, the computers for the students to carry out the tests or with the servers contained the Moodle:

*"First, the use of laptops. At the beginning some didn't have. Then I think it turned better. Also at the beginning, sometimes the system crashed and blocked a lot. Sometimes also the adaptation of teachers to electronic/ computer methods." (E3)*

Two teachers referred the introduction of complex mathematical formulas in Moodle tests as a restraint. Although it is a difficulty related to Moodle usage, it is important to mention it, since it is directly related to mathematics. One teacher said:

*"When we had not yet mastered TeX, and then it was all filled with question marks and just with an extra space a point appeared... Correcting an error was complicated and time-consuming." (E1)*

Two interviewees pointed out how difficult it was

to put a team in action due to the initial resistance of some teachers:

*"At first there was some resistance because it was a new method." (E3)*

Finally, it was pointed out by one teacher that initially there was a lack of support from the school management bodies:

*"This was the great difficulty that put or could have unable the start of this assessment. They did not want, the Management, at the time, in 2006, that the assessment proceeded." (E6)*

### **Changes in teachers' pedagogical practices**

Two teachers reported that there were no changes in their pedagogical practices with e-assessment. One of them reported that there had to be a greater process of students' adaptation. These teachers stated the following:

*"Basically no. I mean, the classes continued to be given in the same ..." (E3)*

*"There had to be more adaptation on the part of the students than ours." (E4)*

However, three teachers acknowledged that there were changes, but that they were not a consequence of the type of assessment. One of them even affirmed that the change in the assessment procedure was itself a result of the global change process that was implemented in the course:

*"I do not think my practices have changed due to the choice of this method of assessment. We are changing according to other things: the level of knowledge that students bring." (E1)*

*"Little has changed. It was not because of the assessment system that there were changes." (E5)*

*"The type of assessment was more a consequence of all the changes that were made than the other way around." (E6)*

Only one teacher recognized some changes, but said that it only changed the way he approached the resolution of the exercises in the practical classes:

*"I think it's different from saying 'solve this exercise' and that's it ... because they have to know how to analyse the answers. Therefore, I think practices are guided in another way. But in theoretical terms I think nothing has changed ..." (E2)*

### **Advantages for the teacher**

The main advantage for the teachers that was pointed out by all the interviewees has to do with the automatic process of obtaining the student grades, which represents a great saving of time:

*"The advantage in correction is evident, it is a gain of many hours." (E4)*

Two teachers considered this type of assessment

more objective:

*"Much more objective assessment and much easier correction." (E3)*

*"The criteria are very objective and therefore there is no disparity of correction even elaborating detailed grids of correction in the normal tests that has now gone... There is always disparity of correction between teachers. Here, therefore, the questions are objective, either right or wrong." (E5)*

Another of the advantages, pointed out by three teachers, was that the question bank allowed the creation of more practical and faster tests, for example for the special examinations, which can be requested by some of the students during the semester:

*"When we build our tests it also becomes very simple, because we just go to the database and choose this category or that subcategory and therefore quickly build the test. That's why it's all faster. If you were to build a test from scratch now, you had to waste more time." (E1)*

*"At any moment one can resort to a test" (E4)*

*"If there is a need to take a test for the next day or the next hour it is easier to have the question bank." (E5)*

One of the teachers said that this process made it easier to integrate new teachers into the course. This same professor pointed out as a great advantage the fact of being able to carry out a more creative work:

*"In the matter of the time that one has to spend on course is more about creative aspects and less about 'minor' aspects like those of correcting tests." (E6)*

### **Disadvantages for the teacher**

The main disadvantage, which was reported by four teachers, was that it takes a lot of initial effort and a lot of time to develop the question bank, but that had improved over the years. Here are the statements of two teachers, who mirror very well the opinion of all:

*"Put the questions, then the options and create the database itself, divide it into categories and subcategories... All this, we have been building over the years, took a lot of time. There were many hours there." (E1)*

*"Of course they give a lot of work to build the question, it's not it... It's more the work of building the questions. But also with some practice ... initially you invest enough time in this and we write and do not like and then it is not how it should be ... With practice this disadvantage is diluted." (E5)*

Another disadvantage pointed out by two teachers, when comparing the formulation of open-ended and multiple choice questions, was that MCQ were more difficult:

*"If you have to ask an open question it's very fast. And when you are formulating the answers, you must have a lot of attention ... it's a lot more attention ..."* (E2)

*"In the beginning there was a difficulty in elaborating the questions so that they were objective and did not assessment more than one objective in each question."* (E5)

Another disadvantage, in the view of two interviewees, had to do with the impossibility to evaluate students' creativity and reasoning:

*"the tests he did not allow to see the students' reasoning. Therefore, it was enough to have an error in the way and sometimes even could arrive at the right result with wrong reasoning or the other way around."* (E3)

### **Changes in students' practices**

Teachers perceived some changes in students' practices. Most of the teachers (five of them), reported that there was an increase to the classes' attendance. The following statements reflect the opinion of all teachers:

*"What I think in what they have changed is that they were much more 'seduced' by continuous assessment in these terms... it gives me the impression that if it were in a much more open regime, we would have more absences than there were. If we had the traditional continuous assessment they would miss more often."* (E2)

*"I think with our assessment system we got the students attending the classes. And when they come to school more, they end up learning more."* (E6)

Three teachers emphasized that there had been an evolution in the way students behaved in responding to the assessment questions. It was found that initially the students attempted to respond at random and then became aware of the penalties in case of wrong answers, beginning to be more careful about the selection of answers. One teacher said that:

*"It is noted that, for example, they have come accustomed from the secondary to having multiple choice. In the case of mathematics, they have multiple choice in the national exam only that does not discount. And that, I think at the beginning, when the students reach the first year they tried to fill the whole grid not having well the notion, this in the first test, of what it would discount. But then they will learn and select."* (E1)

Another behavioural change identified by three teachers was that students study more regularly:

*"They study more assiduously, I do not say every day because I think they should work even harder, but in the next test they always work harder."* (E5)

*"If there are several moments of assessment, the*

*students will also have to study something else and that is good too."* (E6)

One teacher pointed out as a negative aspect the fact that the students were limited to mechanize the processes without worrying about the reasoning:

*"It mechanized the students more. The students became more mechanical. I noticed a disinterest, one might say, in reasoning. (...) The main goal was to achieve the result."* (E3)

### **Other aspects emphasised during the interviews**

In addition to the aspects related to the dimensions under study, during the interviews there were some aspects mentioned by the teachers that we consider relevant. One aspect pointed out by four teachers was the fact that the high number of students in the classes made it difficult to carry out continuous assessment and that this form of assessment actually made it possible to implement continuous summative assessment. The following statement sums up this aspect:

*"(This type of assessment) was a good choice, given the large number of students we have. As we want to make continuous assessment, the only way to be able to implement the continuous assessment system was to opt for such a system."* (E5)

Three teachers reported that students' grades improved with continuous assessment:

*"I think that, given the results, it has gone better now. From what I can remember from our statistics, the results have been a lot better. Well, we also have the advantage of doing some tests, more than three at least ... three or four... we've had four already. And the distributed subjects may be a little easier."* (E2)

*"The assessment was so much better that the results with continuous assessment in terms of approvals have improved a lot."* (E5)

Two teachers mentioned the advantages of performing the "recovery" test, saying that it is good because it allows students not to give up right after the first test if the grade is low:

*"It was really good because, in fact, when they did the first test and it went bad, they became unmotivated... And now they know that there is a chance of catching the first one or any and it keeps them in class. And I think that's pretty important."* (E2)

*"Another aspect that does not have to do directly with this assessment but the fact that there are 'recovery' tests... I think that was a very important aspect, they give up less in the middle of the semester. And so... because they have yet another chance in case something goes wrong, to recover. And this aspect was fundamental."* (E6)

One teacher mentioned his concern about

students' fraud, having even been confronted with this problem by some students:

*"I think my biggest concerns are in that sense. Do not cheat. And the student do not tell us: 'Ah! I know someone approved that did not know the contents but I knew...'" (E2)*

Another teacher stated that there was a need to make several changes:

*"...The first step was to realize that things were not going well, because there were too many failures, school failures and, taking that into consideration, we tried to diagnose problems (...) without pretending to analyse everything at one time, but because there were some problems that were being worked out over the years, there were things that were clearly necessary to do to make sure that we all follow the syllabus more or less the same way, without limiting the freedom of each one. But there was a well-defined orientation on syllabus and what was important for us to do. And for this we were all involved in some way in the preparation of class notes of the classes. So, in my point of view, when people are involved in this process, then changes occur. And people also had to try to act always by consensus, generate consensus in the team... there was a syllabus that we had to accomplish and from the syllabus we started to create tools and we discussed many times. (...) And more. How the class notes themselves have been worked out. The work was distributed, then passed me to... let's say I was perhaps the person who later gave some unity to things and made some revisions... but all people were involved in the process. And in that way it was possible to make a consensual change of things in which people would join and participate. Then, the assessment system... at the beginning not everyone was in agreement. And it ended up with everyone, I think, adhering to the process and realizing, or at least starting to believe, that that was the way. According to the objectives we had and according to the circumstances it was the best way forward." (E6)*

This professor emphasized the importance of teamwork with motivation:

*"I think it was funny to get a relatively large team working, pulling everyone to the same side and everyone working together. This demonstrates once again that, above all, people are capable of doing things, that there is a minimum of motivation and that they believe in what they are doing." (E6)*

## 4 DISCUSSION

An e-assessment process was developed and

implemented to allow the use of continuous summative assessment in mathematics' courses in a higher education institution, in classes with a large number of students. In this study, we analyse the perceptions of teachers involved in this process concerning its application, the difficulties they found, potential changes in their pedagogical practices, advantages and disadvantages of this procedure for the teacher, and potential changes in students' practices in their learning process.

Although some teachers were sceptical at the beginning of the process, all teachers interviewed in this study reported a very positive opinion about the type of assessment implemented and agreed that it was a good assessment system. Some of them highlighted the progress made over time, namely the need for greater learning on how questions should be formulated and the importance of effective teamwork. In fact, the initial lack of knowledge about how to prepare good questions was pointed out as one of the difficulties encountered in the implementation of e-assessment.

Another difficulty experienced by the teachers during the creation of the question bank was about the use of *TeX* to write the mathematical expressions to put in *Moodle*. For teachers who start writing mathematical characters in e-assessment this is an added problem, since the software used for the construction of the MCQ does not always allow quickly writing (Brito et al., 2009, p. 167). Most of the teachers did not master *TeX* and therefore *TeXaide* software was used to help teachers with more difficulties. Even so, teachers had constraints in writing the mathematical expressions. In recent years the experience of teachers in the use of *TeX* already allows to overcome this problem. Furthermore, the latest versions of *Moodle* also have a good built-in *TeX* editor, which allows to insert mathematical formulas directly into *Moodle* for those who do not master *TeX*. Even with the evolution and improvement in the introduction and interpretation of *TeX* by *Moodle*, some students still mentioned a certain difficulty regarding the reading of some of the formulas, especially when they were very similar. However, in recent years, these problems have specially affected to those using Tablets with small screen. We think that with the implementation of the latest version of *Moodle* this problem should disappear. At the moment, all the teachers are very familiar with its usage, being able to solve the few problems that arise, especially during the tests. In addition, at this time all the teachers can, without any difficulty, introduce the MCQ in *Moodle*.

Most teachers reported that there were no changes

in their pedagogical practices resulting from the e-assessment. In spite of this, teachers recognized that they have improved the preparation of the MCQ and that now they pay more attention to the formulation of the questions and to the way they teach. Another aspect of change has to do with the introduction of ICT in the teaching and learning process, which was incorporated in a natural way after the entire developmental process that took place throughout the implementation of e-assessment.

There were teachers who acknowledged that some changes were not triggered by the implementation of e-assessment. For these teachers, the change in assessment was, rather, the result of an institutional global change. They were referring to the required adaptations to implement the Bologna Process, namely the equipment installed and all the investment made in the assessment process. Contrasting with this view, other colleagues considered that those broader adaptations were only possible due to the use of the MCQ in assessment, which served as a catalyst for a global change in the institution.

A great advantage of this tool for the teachers seems to be the automatic process of obtaining ratings, and then saving a lot of time. This is also one of the main potentialities stated in the literature, as well as the easier assessment of large numbers of students (Clegg and Cashin, 1986; Nicol, 2007; Bible et al., 2008; Camilo and Silva, 2008; Green and Mitchell, 2009; Liu et al., 2011; Douglas et al., 2012; Jordan, 2013; Heron and Lerpiniere, 2013).

Another two benefits pointed out by teachers, and emphasized by many authors, were an increased objectivity in classifications (Burton et al., 1991; Wild et al., 1997; Haladyna, 2004; Bible et al., 2008; Jordan, 2013) and the existence of question banks for future use (Ferrão, 2010; Guo et al., 2014).

On the other side, the amount of the initial effort and time needed to build the question bank seemed to be the major constraint of this tool for the teachers. This was somehow expectable, since the development of properly structured questions is quite time consuming and requires a lot of training (Clegg and Cashin, 1986; Burton et al., 1991; Ferrão, 2010; Liu et al., 2011; Jordan, 2013; Guo et al., 2014). Other issue that deserves attention is teachers' perception of the impossibility to evaluate students' creativity and reasoning through MCQ. In fact, some authors acknowledge for the limitation of this kind of tests or exams in properly measuring certain skills at higher cognitive levels (Nicol, 2007; Bible et al., 2008; Green and Mitchell, 2009; Ferrão, 2010; Rod et al., 2010; Lee et al., 2011). Related to this, some of them note that MCQ may favour the superficial

memorization of concepts (Nicol, 2007; Liu et al., 2011; Heron and Lerpiniere, 2013).

With the implementation of this tool in continuous summative assessment, teachers perceived some changes in students' practices. They point out, for example, the increase to the classes' attendance, greater regularity in academic work and the evolution in the way students behaved in responding to the assessment questions (less randomly). Other authors have found an increased student motivation and involvement (Green and Mitchell, 2009; Jordan, 2013).

We can thus conclude that the change in the type of assessment had impact in both teacher and student practices, as documented in the literature, in which it is stated that the introduction of different assessment systems can have an important impact throughout the educational process (Smith et al., 1996; Scouller, 1998; Bull and Danson, 2001; Jarvis et al., 2003; Jacob, Issac and Sebastian, 2006; Frankland, 2007; JISC, 2007; Boticki and Milasinovic, 2008; Garfield and Ben-Zvi, 2008; Stöberg, 2012; Redecker and Johannessen, 2013; Holmes, 2015).

## 5 CONCLUSIONS

In this study, teachers' perceptions about an e-assessment tool with multiple-choice questions were analysed. This strategy was planned in order to allow the use of continuous summative assessment in mathematics courses in a higher education institution, in classes with a large number of students.

Despite all the initial resistance and difficulties, both in terms of technology proficiency and formulation of the MCQ, it can be concluded that teachers developed a favourable opinion about the accomplished evaluation process. To put forward this strategy, it was fundamental teachers' effort and commitment to adapt an entire process that they were not used to do. We can say that the initial resistance was triggered by a certain "fear" by the unknown. There was a need to rebuild the way they do assessment, and to embrace a new methodology. Once experienced, this tool would become very useful given its objectivity and time savings, due to the immediate test ratings and to a whole process of automations that made certain bureaucratic tasks much easier. However, there are some disadvantages, such as a major initial effort required to construct a database of questions. Teachers also noticed great improvements in students, especially in the way they study and an increase in class attendance.

Future research directions should include a deeper

analysis of the practice changes and a confrontation with the ones pointed out by the teachers in these interviews. It would also be relevant to analyse students' views on the implementation of this approach, as well as on its value, namely the use of MCQ tests and exams in mathematics assessment.

## REFERENCES

- Azevedo, J. (2015) 'e-Assessment in Mathematics Courses with Multiple-choice Questions Tests', in Proceedings of the 7th International Conference on Computer Supported Education (CSEDU 2015). Lisboa, pp. 260–266. doi: 10.5220/0005452702600266.
- Bible, L., Simkin, M. G. and Kuechler, W. L. (2008) 'Using multiple-choice tests to evaluate students' understanding of accounting', *Accounting Education*, 17(sup1), pp. S55–S68. doi: 10.1080/09639280802009249.
- Botički, I. and Milašinović, B. (2008) 'Knowledge assessment at the faculty of electrical engineering and computing', in Proceedings of the International Conference on Information Technology Interfaces, ITI. Cavtat, pp. 111–116. doi: 10.1109/ITI.2008.4588392.
- Brito, I., Figueiredo, J., Flores, M., Jesus, A., Machado, G., Malheiro, T., Pereira, P., Pereira, R. M. S. and Vaz, E. (2009) 'Using e-learning to self regulate the learning process of mathematics for engineering students.', in Bulucea, CA and Mladenov, V and Pop, E and Leba, M and Mastorakis, N. (ed.) *Recent Advances in Applied Mathematics. ATHENS: WORLD SCIENTIFIC AND ENGINEERING ACAD AND SOC (Mathematics and Computers in Science and Engineering)*, pp. 165–169.
- Brown, G. (2001) *Assessment series n.o 3 - assessment: a guide for lectures*. York: Learning and Teaching Support Network (LTNS).
- Bull, J. and Danson, M. (2001) *Assessment series N.o 14 - computer-assisted assessment (CAA)*. York: Learning and Teaching Support Network (LTNS).
- Burton, S., Sudweeks, R., Merrill, P. and Wood, B. (1991) *How to prepare better multiple-choice test items: guidelines for university faculty*, Brigham Young University Testing Services and The Department of Instructional Science. Available at: <http://testing.byu.edu/info/handbooks/betteritems.pdf>.
- Bush, M. (2015) 'Reducing the need for guesswork in multiple-choice tests', *Assessment & Evaluation in Higher Education*, 40(2), pp. 218–231. doi: 10.1080/02602938.2014.902192.
- Camilo, H. and Silva, J. A. P. da (2008) *Os testes de escolha múltipla (TEM), Essências EDUcare*. Departamento de Educação Médica da Faculdade de Medicina - Universidade de Coimbra.
- Clegg, V. L. and Cashin, W. E. (1986) *Improving multiple-choice tests*. Kansas State University: Center for Faculty Evaluation & Development.
- Douglas, M., Wilson, J. and Ennis, S. (2012) 'Multiple-choice question tests: a convenient, flexible and effective learning tool? A case study', *Innovations in Education and Teaching International*, 49(2), pp. 111–121. doi: 10.1080/14703297.2012.677596.
- Ferrão, M. (2010) 'E-assessment within the bologna paradigm: evidence from Portugal', *Assessment & Evaluation in Higher Education*, 35(7), pp. 819–830. doi: 10.1080/02602930903060990.
- Frankland, S. (2007) *Enhancing teaching and learning through assessment*. Dordrecht: Springer.
- Garfield, J. B. and Ben-Zvi, D. (2008) *Developing students' statistical reasoning: connecting research and teaching practice*. Dordrecht: Springer. doi: 10.1007/978-1-4020-8383-9.
- Green, A. and Mitchell, C. (2009) 'E-assessment: opportunities and challenges for the sports marketing and educator', in *Proceedings of the 2nd International Conference of Teaching and Learning (ICTL 2009)*. Kuching, pp. 1–9.
- Guo, R., Palmer-Brown, D., Lee, S. W. and Cai, F. F. (2014) 'Intelligent diagnostic feedback for online multiple-choice questions', *Artificial Intelligence Review*, 42(3), pp. 369–383. doi: 10.1007/s10462-013-9419-6.
- Haladyna, T. M. (2004) *Developing and validating multiple-choice test items - third edition*. 3rd edn. Mahwah, New Jersey: Lawrence Erlbaum Associates. doi: 10.1177/0146621605280143.
- Haladyna, T. M., Downing, S. M. and Rodriguez, M. C. (2002) 'A review of multiple-choice item-writing guidelines for classroom assessment', *Applied Measurement in Education*, 15(3), pp. 309–333. doi: 10.1207/S15324818AME1503\_5.
- Heron, G. and Lerpiniere, J. (2013) 'Re-engineering the multiple choice question exam for social work', *European Journal of Social Work*, 16(4), pp. 521–535. doi: 10.1080/13691457.2012.691873.
- Holmes, N. (2015) 'Student perceptions of their learning engagement in response to the use of a continuous e-assessment in a undergraduate module', *Assessment & Evaluation in Higher Education*, 40(1), pp. 1–14. doi: 10.1080/02602938.2014.881978.
- Jacob, S. M., Issac, B. and Sebastian, Y. (2006) 'Impact on student learning from traditional continuous assessment and an e-assessment proposal', in *Proceedings of the PACIS 2006 - The 10th Pacific Asia Conference on Information Systems*. Kuala Lumpur, pp. 1482–1496.
- Jarvis, P., Holford, J. and Griffin, C. (2003) *Theory & practice of learning - 2nd edition*. 2nd edn. New York: Routledge Falmer.
- JISC (2007) *Effective practice with e-assessment: an overview of technologies, policies and practice in further and higher education*, Joint Information Systems Committee. Available at: <http://www.jisc.ac.uk/media/documents/themes/learning/effpraccassess.pdf> (Accessed: 15 September 2014).
- Jordan, S. (2013) 'E-assessment: past, present and future', *New Directions*, 9(1), pp. 87–106.
- Lee, H.-S., Liu, L. and Linn, M. C. (2011) 'Validating measurement of knowledge integration in science using multiple-choice and explanation items', *Applied*



- Measurement in Education, 24(2), pp. 115–136. doi: 10.1080/08957347.2011.554604.
- Liu, O. L., Lee, H.-S. and Linn, M. C. (2011) ‘An investigation of explanation multiple-choice items in science assessment’, *Educational Assessment*, 16(3), pp. 164–184. doi: 10.1080/10627197.2011.611702.
- McAlpine, M. (2002) Design requirements of a databank. Leicestershire: The CAA Centre TLTP Project.
- Nicol, D. (2007) ‘E-assessment by design: using multiple-choice tests to good effect’, *Journal of Further and Higher Education*, 31(1), pp. 53–64. doi: 10.1080/03098770601167922.
- Redecker, C. (2013) The use of ICT for the assessment of key competences. Luxembourg: European Union. doi: 10.2791/87007.
- Redecker, C. and Johannessen, Ø. (2013) ‘Changing assessment - towards a new assessment paradigm using ICT’, *European Journal of Education*, 48(1), pp. 79–96. doi: 10.1111/ejed.12018.
- Rod, J. K., Eiksund, S. and Fjaer, O. (2010) ‘Assessment based on exercise work and multiple-choice tests’, *Journal of Geography in Higher Education*, 34(1), pp. 141–153. doi: 10.1080/03098260903062039.
- Scouller, K. (1998) ‘The influence of assessment method on students’ learning approaches: multiple choice question examinations versus assignment essay’, *Higher Education*, 35(4), pp. 453–472. doi: 10.1023/A:1003196224280.
- Smith, G., Wood, L., Coupland, M., Stephenson, B., Crawford, K. and Ball, G. (1996) ‘Constructing mathematical examinations to access a range of knowledge and skills’, *International Journal of Mathematical Education in Science and Technology*, 27(1), pp. 65–77. doi: 10.1080/0020739960270109.
- Stödberg, U. (2012) ‘A research review of e-assessment’, *Assessment & Evaluation in Higher Education*, 37(5), pp. 591–604. doi: 10.1080/02602938.2011.557496.
- Wild, C., Triggs, C. and Pfannkuch, M. (1997) ‘Assessment on a budget: using traditional methods imaginatively’, in Gal, I. and Garfield, J. B. (eds) *The assessment challenge in statistics education*. Amsterdam: IOS Press, pp. 205–220.
- Yorke, M. (2001) *Assessment series n.o 1 - assessment: a guide for senior managers*. York: Learning and Teaching Support Network (LTNS).