ENHANCING STUDENT LEARNING IN MECHANICAL ENGINEERING THERMODYNAMICS WITH A TWO-STAGE TEST

M. Duarte

Instituto Superior de Engenharia do Porto (PORTUGAL)
mic@isep.ipp.pt

Abstract

For years, it has been recognized in the literature, the need to change and improve assessment methods. In spite of that, the purpose of most assessment is still grading students, and not the learning enhancement.

In the early 1970s, researchers found that what influenced students most was not the teaching but the assessment, which lead to the idea of the hidden curriculum. According to students' testimony, what and how much they studied were completely dominated by the way they perceived the demands of the assessment. This effect of assessment in students' learning is what Biggs defined as backwash, which means that students' learn what they think will be assessed. Backwash is almost seen as negative, but studying for the test is only negative if the test doesn't assess what we intend students' to learn.

A two-stage test was used in Thermodynamics (Mechanical Engineering, 2nd year), as a way to improve learning of a particular topic (state properties determination). The stages were a week apart. In the first stage, the students answer 20 questions in 30 minutes. Based on what they thought they missed in the first stage (grades were not published at this time), they could try to improve their performance in the second stage, by studying harder in the week between the two stages. The teacher didn't interfere with this process, encouraging self-assessment and self-regulation, in order to promote the autonomy of the learners. In the second stage, the test only included the questions that each student missed and had the duration of 30 minutes.

Students' evaluation of this task was done through a series of questions, in an anonymous questionnaire. Results (143 valid questionnaires) show that this kind of assessment, that uses a more student-centred approach, as required by the Bologna Process, is seen by the students as a helpful tool to promote study (85,3%) and enhance learning (87,6%). Students express the will to have more two-stage tests (89,1%).

Keywords: Higher education, formative assessment, two-stage tests, test enhanced learning.

1 ASSESSMENT FOR LEARNING IN HIGHER EDUCATION

In the last decades, several studies on assessment and its influence on learning have been developed [1], [2]. So, it has been recognized in the literature, the need to change and improve assessment methods. In spite of that, the purpose of most assessment is still to grade students, and not the learning enhancement [3].

To the *Assessment Reform Group*, assessment is one of the most powerful educational tools in promoting effective learning [4]. However, it must be used properly. There is no evidence that an increase in assessment will improve learning. So, the focus must be in choosing the right kind of assessment.

In higher education, Boud [5], [6] claims that, besides facilitation learning and certifying achievement, associated with formative and summative assessment, respectively, assessment should also prepare students for lifelong learning. This involves preparing them for the tasks of making complex judgements about their own work and that of others and for making decisions in the uncertain and unpredictable circumstances in which they will find themselves in the future. A central feature of this purpose of assessment is that students are constructed as much more active players in the assessment process than is implied by summative or formative assessment [5], [6].

Self-regulation and autonomy for lifelong learning, key aspects to be foster in higher education, are closely connected with feedback. Although increasing its specificity may benefit students' academic

performance, it may undermine learning in the ways it relates to an autonomous and independent learning, in the long term.

Goodman *et al.* [7] shown that, in higher education, the feedback specificity influences the way in which the different aspects of a task are learned. More specific feedback is beneficial for learning how to respond to good performance and detrimental for learning how to respond to poor performance (knowing what to do when things go wrong). So, in higher education, using feedback to improve student's performance may be prejudicial to the way they react to difficulties and problems as active professionals in the real world.

2 TEST-ENHANCED LEARNING

Test-enhanced learning or test effect is the increase in the recalling capability (retrieving the item from memory) as a result of that same retrieving effort as is done during assessment, when compared with additional study instead of assessment. However, if the test trials are so difficult that no items are recalled or if the correct answers to the non-recalled items are not given to the test subject, than minimal or no learning will occur [8].

Karpicke & Roediger [9], [10], [11] showed through a series of studies that repeated studying after learning had no effect on delayed recall, but repeated testing produced a large positive effect.

Roediger *et al.* [8] refers the importance of frequent classroom testing and student self-testing as a way to improve education from kindergarten through university. The fact that this takes away valuable class time that could be used for instruction or discussion isn't important because testing is an aid to learning. Also, using frequent testing in the classroom causes students to study at a more regular pace and also seems to reduce test anxiety.

3 TWO STAGE TEST

A two stage test is a test in which the students have the opportunity to improve between the two stages. In the first stage, students try to respond to as many questions as possible, in the best way they can. In the second stage, they only have to answer questions regarding subjects that they failed in the first stage. Each second stage test is individual and automatically generated. The final grade is the sum of the grades of each stage test.

In both stages, multiple choice questions (MCQ) were used, namely long menu questions (LMQ), because they combine the advantages of traditional MCQ, being easy and quickly to mark, with the possibility of assessing high cognitive level objectives. Rotthoff *et al.* [12] shown that the answers to long menu questions and open ended questions didn't differ significantly, especially when they are short answer questions with unique and clear answers (which was the case).

Between the two stages, no feedback or grades were provided and there are no interactions teacher-students. Based on what they thought they failed, students try to improve their performance, by studying harder. Not only this kind of task promotes autonomous study, but also leads students to improve their auto-assessment skills.

This ability to work in an autonomous way, which is essential to lifelong learning, is in this way promoted because the students are held accountable for their actions, and their success depends on it.

The teacher provides support to the students work, using the first stage as feed forward to the second stage, by publishing all the questions right after the first stage.

Another advantage of this kind of tests, besides the development of self-regulation and autonomy is the possibility to develop learning through test effect, because it allows repetition of the subjects that are being assessed.

After the two stages, grades and feedback are provided. An individual sheet for each student is available online with clues to help correct each wrong question.

Also feed forward is considered, as detailed information is given about the expected learning outcomes of each assessment task, the grading criteria and other helpful information.

Care is taken in adapting the degree of requirement and complexity not only to the content but also to the extent students are expect to have learned in that particular time of the semester.

4 THE CASE STUDIE

Thermodynamics is a second year course in a Mechanical Engineer graduation of Oporto's School of Engineering (ISEP). In 2008/09, 238 students were enrolled; 150 students choose to do the continuous assessment that included: homework assignments; 20 minute quizzes in class and a two-stage test.

The two stage-test was about a subject (determination of state properties of water and gases) that needed to be well understood because it was necessary for the consequent topics (first law of thermodynamics in closed and open systems). Students didn't usually invest enough time and effort in it at the right time, only to realise latter that this subject is crucial.

The stages were a week apart. In the first stage, the students answer 20 long menu questions in 30 minutes. In the second stage, the number of questions varied between 20 and zero. The students had also 30 minutes.

5 RESULTS

Students' evaluation of this task was done through a series of questions, in an anonymous questionnaire (143 valid questionnaires), with a five point Likert scale. The question that had the highest score (89,1%) was "I would you like two have more two-stage tests in this and other courses", followed by "The two stages instead of one made me learn more" (87,6%). These two questions shown that students react enthusiastically to change and innovative assessment, as long as they perceived it as useful.

When asked solely about the satisfaction regarding this task, students scored it at 79,6% (80,8%-it was an interesting task; 78,3%- I liked doing this task).

In the questions regarding feedback, the score were 81,1% (81,3%-the feedback was appropriate; 80,8%-the feedback made me learn more).

Considering that there is no learning without effort and study, and that this ability to develop autonomous work is a fundamental competence, students were asked if this task demanded study. The score was 85,3%.

6 CONCLUSIONS

The overall results show that this kind of assessment, that uses a more student-centred approach, as required by the Bologna Process, is seen by the students as a helpful tool to promote study (85,3%) and enhance learning (87,6%). Students express the will to have more two-stage tests (89,1%).

REFERENCES

[1] Black, P. & Wiliam, D. (1998). Assessment and classroom learning [electronic version]. Assessment in Education: Principles, Policy & Practice, 5(1), 7-74.

[2] Gibbs, G. & Simpson, C. (2004). Conditions under which assessment supports students' learning [electronic version]. *Learning and Teaching in Higher Education*, *1*, 3-31.

[3] Fernandes, D. (2005). Avaliação das aprendizagens: Desafios às teorias, práticas e políticas. Lisboa: Texto Editores.

[4] Assessment Reform Group. (1999). *Assessment for learning- Beyond the black box*. Retrieved in July, 28, 2008 de http://www.assessment-reform-group.org/AssessInsides.pdf

[5] Boud, D. (2004). Assessment and learning: Contradictory or complementary? In P. Knight (Ed.). *Assessment for Learning in Higher Education* (pp.35-48). (2nd ed.). London: Routledge.

[6] Boud, D. & Falchikov, N. (2006). Aligning assessment with long-term learning [electronic version]. *Assessment & Evaluation in Higher Education*, *31*(4), 399-413.

[7] Goodman, J. S. & Wood, R. E. (2004). Feedback specificity, learning opportunities, and learning [electronic version]. Journal of Applied Psychology, 89(5), 809–821.

[8] Roediger, H. L., McDaniel, M. & McDermott, K. (2006). Test Enhanced Learning. Observer, 19(3),

[9] Karpicke, J. D. & Roediger, H. L. (2008). The critical importance of retrieval for learning. Science, 319(5865), 966-968

[10] Karpicke, J. D., Butler, A. C. and Roediger III, H. L. (2009). Metacognitive strategies in student learning: Do students practise retrieval when they study on their own? Memory,17(4),471-479.

[11] Karpicke, J. D. & Blunt, J. R. (2011). Retrieval Practice Produces More Learning than Elaborative Studying with Concept Mapping. Science, 331, 772 (2011)

[12] Rotthoff, T., Baehring, T., Dicken, H. D., Fahron, U., Richter, B., Fischer, M. R., Scherbaum, W. A. (2006). Comparison between Long-Menu and Open-Ended Questions in computerized medical assessments. A randomized controlled trial. BMC Medical Education. 6(50).