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Supporting learning in large classes: online formative assessment and automated feedback

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Abstract—The provision of formative assessment and formative feedback is challenging for an educator working with large cohorts of students. To avoid being overwhelmed with the volume of work, appropriate technologies need to be selected to support learners and scale the module assessment and delivery to accommodate the size of the class. This paper presents the results of implemented online formative assessment delivery for a large postgraduate cohort of both full- and part-time students. We experimented with early and frequent student access to online formative assessment followed by immediate automated feedback. We review the impact of this assessment regime on student experience and achievement of learning outcomes. End-of-term student feedback indicates that frequent online quizzes, formative feedback and repetitive practicing were very well received by the students. We observe sustained levels of student engagement through data collected during student interaction with online module content and assessment. Analysis of the data has determined that the quizzes which had the highest number of attempts showed strong correlation with the highest student scores at the end-of-term exam. Such an experiment reflects how students learn via online content delivery and make use of available learning technologies for self-directing and practicing in computing subject. Frequent access to online formative assessment tool followed by immediate automated feedback helps to create effective learning environment and accommodate learners in large full-time and part-time classes.

Keywords—*technologies in education, e-learning, online formative assessment, automated feedback, large cohorts teaching*

I. INTRODUCTION

Automated assessment tools aid both staff and students, especially in large classes, ensuring individual feedback to learners in combination with reduced workload on educators. An early and frequent student access to online formative assessment tool is generally perceived to be the best assessment option [1], given that formative assessment and clear feedback need to be provided in a timely and appropriate manner to every single individual [2]. An effective online formative assessment tool has to be deployed that conforms to the basic principles of formative assessment:

- delivery of high-quality information to students about their learning,
- encouragement of positive motivational beliefs and self-esteem and
- making sure that assessment is an aid to support student learning in order for them to continually improve [3].

Therefore, our online assessment tool has to

- facilitate the development of reflection and self-assessment in learning through automated feedback,
- provide opportunities to close the gap between the current and desired performance through informing about correct/ incorrect answers and
- provide information to teachers through formative assessment statistics that can be used to help shape the learning and teaching strategy.

This paper presents the development of such formative assessments in a format of online quizzes as a part of virtual learning environment. Online formative quizzes were developed for postgraduate taught students studying a software engineering course. Both full-time and part-time large cohorts of 100+ students were taught concurrently during one semester. During the development stage, it was ensured that assessment pieces were transparent and measurable and aligned with the stated learning outcomes and the teaching methodology [4].

II. ONLINE ASSESSMENT DESIGN AND IMPLEMENTATION

Various techniques have been reported in literature for formative assessment by the individual, peers and the teacher [5]. Many of these techniques rely on online tools such as self-test quiz tools, discussion forums and e-portfolios [1]. Research have shown that online environments can enhance opportunities for immediate and ongoing formative feedback. Online formative feedback supports students to identify their strengths and weaknesses, revise their work, and continuously refine their understanding by reviewing feedback, which supports them towards engaged and self-regulated learning. It is evident that formative online feedback can foster student engagement, improved achievement and enhance motivation to learn [1]. Formative assessments were designed in the format of online self-test quizzes in the Canvas virtual learning environment (VLE) that hosts the delivery of teaching and learning activities. Online quizzes, covering topics on a weekly basis and containing questions of different types, were not limited with the number of attempts and were used by students for self-directed learning purposes and to provide immediate automated feedback on student knowledge and skills.

Given the 100+ class size in both PG cohorts and considering automated feedback as the main form of the formative feedback, the questions were designed in several formats, to develop student reflection and self-assessment and

encouraging active participation with theory before they answer the question.

Each quiz covers a weekly structured topic and contains up to 20 questions of the following types:

- Multiple-choice questions with single-right answer and multiple-correct option answer to evaluate broad understanding of the subject.
- Match questions in which the students are asked to match phrases and terms to evaluate their knowledge of terms and definitions.
- Fill in the blank questions to evaluate students' computing skills and challenge their critical thinking.
- Open-response (scenario) questions to evaluate their problem-solving skills.

Examples of multiple-choice, open-response and match questions with automated feedback are presented on Fig. 1. Such a mix of questions, challenging different aspects of knowledge and skills, allows students to become more aware of their strengths and areas for development within the subject and updates them on their progress.

The automated "correct/incorrect answer" feedback has been complemented by the instructor's personalised comments provided individually for students in VLE Canvas. The most common type of errors in computing domain, such as incorrect formatting, wrong simple calculations or typos were identified by the system. Every submission and individual feedback with wrong and correct answers was visible to a single student in Canvas so they could use it to review answers at any time, show them at a support session or just email through to the lecturer to ask for an extended manual feedback. Such a combination of formal automated feedback provided by the system and personalised feedback provided by the lecturer was appreciated by students as they acknowledged a positive impact on enhancing the student experience and giving essential understanding about their progress.

Online graded quizzes with unlimited number of attempts have become an integral part of weekly formative assessment.

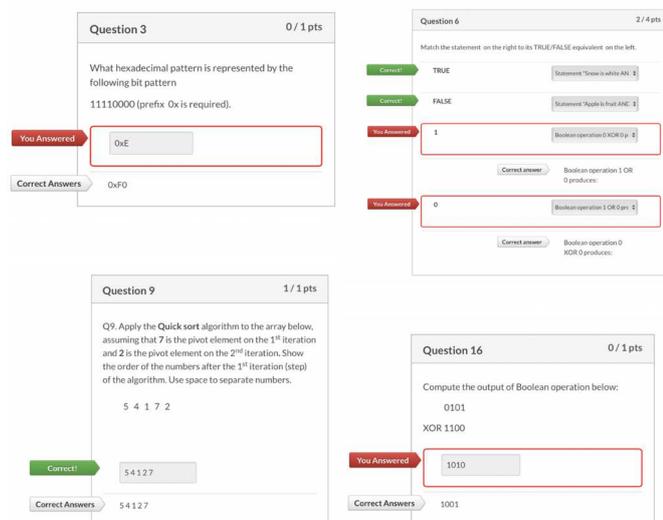


Fig. 1. Formative quiz design and automated feedback format: multiple-choice, open-response and match questions.

Such a formative assessment helps students to get immediate online feedback by seeing their responses, correct answer and instructor's comments after quiz submission. Correct answers were disclosed immediately to memorize them. The designed online quizzes with unlimited number of attempts provided an opportunity for repetitive practice in solving problems in computing, e.g. "find a way to sort this list faster than a bubble-sort does". This mode of assessment allows an individual learner to follow trial and error as a way of building their computing experience and facing common errors as computing subject is extremely practical domain requiring explicit examples and access to practical challenges.

All formative quizzes were designed using the summative assessment criteria, i.e. formative automated feedback was invaluable to students in terms of preparations to the final exam. Summative assessment – a class test - was also designed using multiple-choice and more challenging open-response (calculation/ scenario type) questions weighting 70% and 30% respectively.

Multiple-choice questions required general knowledge of the subject concepts and critical thinking, whereas open-response questions required algorithm development and problem-solving skills. Using online formative quizzes followed by personalised feedback and focusing on repetitive practicing in problem solving have helped students to apply their knowledge in practical aspects of fundamental computing theory on such topics as binary calculation, Boolean operators, data storage, sorting and searching algorithms. After online quizzes implementation, it was also noticed that the volume of general queries from students was much reduced from 35-50 support queries per week to 5-10 individual requests, especially the very large number of queries with regards to low-level easily made errors, such as calculation or logic errors.

Practicing with quizzes was reflected in student exam results. Exam marks statistics taken from VLE Canvas shows an association between the formative quizzes with the highest number of attempts/scores and the highest scores on the exam, and vice versa. Fig. 2 represents the part-time PG class results of taking the formative quizzes. In the summary graph, skewed left, the x-axis indicates the quiz scored percentages, and the y-axis indicates the number of students who received each percentage. It corresponds to the class exam grades, also skewed left, represented on Fig. 3, where X-axis represents student performance, Y-axis represents number of students taken the online assessment.

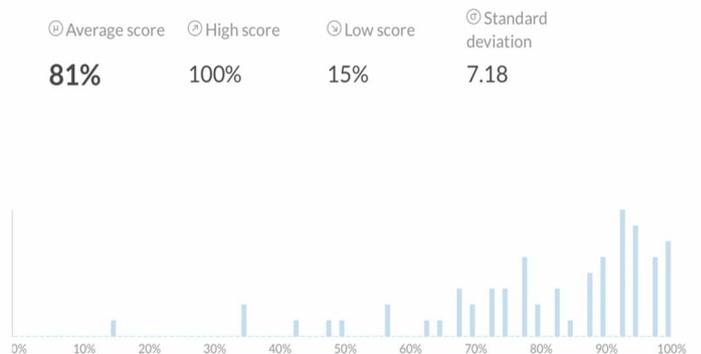


Fig. 2. Online assessment statistics for the part-time cohort.

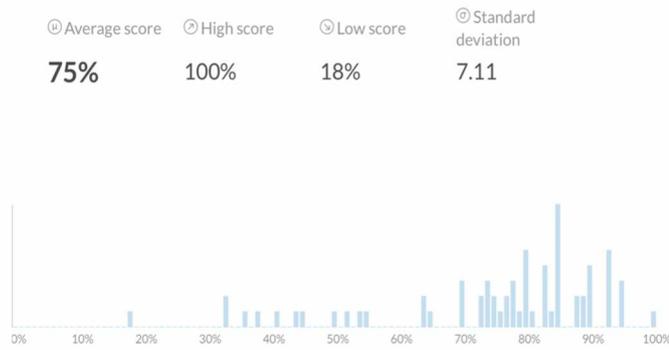


Fig. 3. Exam grade statistics for the part-time cohort.

Two, not equally sized, groups of students have emerged: those who worked frequently on their formative quizzes and those who did not, and consequently passed exam with the lowest grades or did not pass at all. Those data are consistent with the taking of formative assessment quizzes, i.e. the group of students who had ignored formative quizzes got the lowest marks and another group of students who had been diligent in their self-training while formative assessment got highest marks on the exam.

Fig. 4 and Fig. 5 represent data, bell-shaped, for full-time class – formative assessment statistics and exam results respectively – with the exam results appear to be high for students who had got the highest quizzes marks, that shows no statistical difference between part-time and full-time scores distributions.

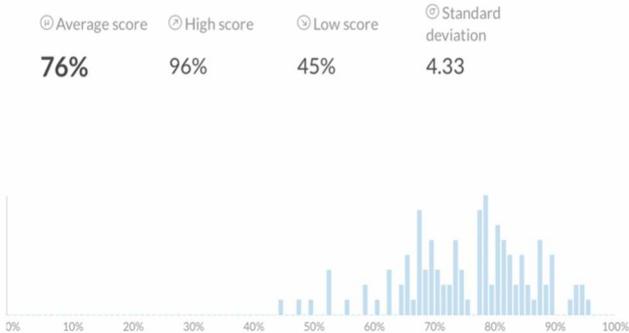


Fig. 4. Online assessment statistics for the full-time cohort.

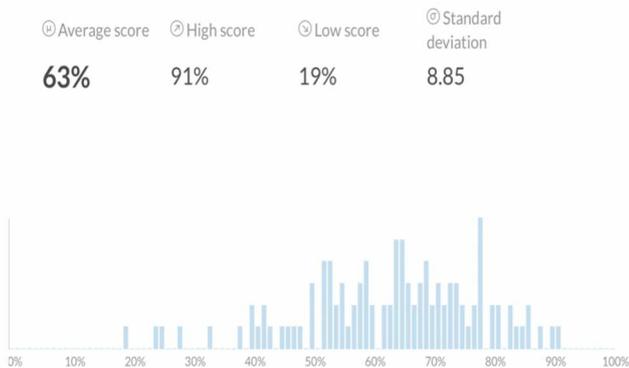


Fig. 5. Exam grade statistics for the full-time cohort.

Unsurprisingly, taking of formative quizzes peaked in the days before the class test and the exam, especially the last day. Online statistics showed that students tended to practice on each formative quiz from 3 to 5 times in average during semester, with the overwhelming number of up to 14 attempts at each quiz before the actual exam.

An added benefit to formative quizzes was the instructor’s ability to see in real time the number of formative quizzes attempted, completed and abandoned in VLE Canvas to get it helped to acquire an overall impression for how the students were progressing towards the exam. Quiz statistics on VLE Canvas alongside with the question breakdown were also used to inform real time adjustments to the teaching and shape the teaching trajectory (Fig.6).

16. In a two’s complement system, what value is represented by the pattern 11111111111111001?

-7	88 respondents	78%	<div style="width: 78%;"></div>	✓	78% answered correctly
Something else	20 respondents	18%	<div style="width: 18%;"></div>		
No answer	5 respondents	4%	<div style="width: 4%;"></div>		

Fig. 6. Question breakdown: attempts and success rate.

Normally, extra time was spent in class to repeat and focus on more heavier computing topics when it had been noticed that quiz scores on these specific topics turned out to be less than expected 75% success rate.

For example, after covering in class sorting and searching algorithms, the lower 48% success rate was observed at quick sort and binary search aspects. Therefore, the instructor’s decision was to take extra time in-class to debrief on the quiz with the suggestion to re-take the sorting and searching quiz afterwards. The latter has resulted into improved success rate of the class up to 82%.

III. STUDENT FEEDBACK

Designed for self-directed learning purposes and to provide immediate feedback on student knowledge and skills, online formative quizzes were very widely used and well received by students. Student module evaluation feedback was positive and suggested that online formative quizzes have become an effective supportive tool for students to enhance their learning experience.

The majority of the class – 86% - expressed their positive and very enthusiastic responses towards online formative quizzes and requested an expansion of the set of practical challenges. Students mentioned, that the quizzes helped them to get familiar with new concepts taught in the module as well as the operation of VLE Canvas. Some individual student responses:

- “I always feel that more quizzes are of great benefit, particularly those that reflect potential exam questions like searching and sorting algorithms”.
- “Like quizzes, they seem very good to me along with the lectures, they give adequate support and self-directing prior to exams”.
- “Weekly quizzes on Canvas were great. Even if I didn’t have time for them that particular week, I

would have liked to have gone back on them prior to the exam”.

- “I liked the variety of quizzes and online interactions. The quizzes questions to work through was really helpful to learn binary and two’s complement“.
- “Happy with computer architecture quiz which gives more training and understanding of basics, thought it would be harder but glad it’s not too difficult”.

There were a few student responses that was used for the instructor’s own reflection, in terms of bug fixes and iterative development of the set of quizzes. Students mentioned non-accessible multiple-choice questions through Canvas mobile app and images not visible to them due to browser settings, so some workarounds were rapidly adopted: some of multiple-choice questions have been substituted by open-response with the problem statement formulated without using of images. In instructor’s opinion, one should be careful about and watch out for inconsistencies in quiz administration settings. Administration set up errors, such as student access error and correct answer setting error might occur and affect student responses.

IV. CONCLUSION

Formative assessment aids learning by generating feedback information that is of benefit to students and to teachers. Using of formative online quizzes and consequently providing automated feedback to students facilitates the development of reflection and self-assessment in learning in large cohorts. Analysis of quizzes success rate could also help teachers to shape teaching trajectory within the module and be proactive with designing and planning appropriate learning activities such as topics to repeat and practice challenges to design.

End-of-term student feedback indicates that frequent online quizzes, formative feedback and repetitive practicing were very well received by our students. We observe sustained levels of student engagement: statistics collected by our systems shows that quizzes were widely used, and that the quizzes with the highest number of attempts strongly correlate with the highest student scores at the end-of-term exam.

The above approach has got its limits, of course. Full automated marking of everything, including essays and reports seems not possible, but this exploratory research though has offered useful insight into providing automated formative feedback and how support tools could effectively be used to pick up common errors and to help students to prepare for the exam session.

Online formative quizzes have become a part of the learning environment within the two PG computing modules and provided valued online support to adult learners. The above approach is flexible in meeting new learning patterns, i.e. the pattern of online and blended learning, and uses innovative VLE Canvas technologies for the module and assessment delivery, so that students have the ability to use technologies effectively for learning and their success.

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