Sustainable e-assessment in mathematics instruction

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This study aimed at moving beyond content mastery to help students develop sustainable, transferable skills such as self-regulated learning. Each Student conducted a self-inquiry on a selected topic in mathematics. They also formulated some multiple-choice questions, asked their peers to solve them and engaged in active discussions afterward. Collected data were analyzed in terms of Student-generated Questions' (SGQs) quality by two instructors independently. Findings showed while taking the responsibility of assessment is a promising strategy in developing self-regulated learning, it might not automatically lead to a higher-order learning (i.e., critical thinking). It is suggested that a combination of instructors' feedback and regular use of digital technologies can enhance students' questioning competence.[1]

Introduction

Assessment should meet both the specific goals of a course and equip students with necessary skills to undertake their own assessment activities, i.e., *judging the quality*, in the future professional workplace (Boud, 2000). However, the conventional assessment conducted in higher education mainly aims at measuring mastery of content knowledge at the end of a course (summative assessment) instead of developing sustainable competences in students (integrative or formative assessment). Mathematics is inherently an inquisitive discipline which evolves around questions and problems. In a typical classroom, teachers retain control of asking questions: the questions are initiated by teachers and students take their turn to answer. There are some opportunities when the teacher invites students to ask questions. However, when the teacher is the one who constructs the most interesting questions and problems, students become dependent upon the teacher to catalyze inquiry (Bowker, 2010). To facilitate development of mathematical competence, teachers should create effective learning environments and encourage students to ask relevant and scientifically sound questions (Foster, 2011).

[1] This paper is a short version of Caspari-Sadeghi, Forster-Heinlein, Maegdefrau, & Bachl (2021), where further explanations can be found.

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Objectives of the study

This study aimed at moving beyond content mastery to help students develop the sustainable, transferable skill of self-regulated learning or 'learning to learn' as one of the 'key competences for life-long learning' (European Commission, 2012). Generating well-crafted questions is a creative act, and at the heart of what doing science is all about (Chin and Osborn, 2008). SGQs open a window to the mind of the students: they indicate what counts as significant for the students, what they understood, misunderstood or missed altogether. In this empirical study, we tried to use SGQs as a technique to (a) foster a culture of inquisitiveness in mathematics learners, (b) involve students more critically and meaningfully with the content, and (c) make the students the owners of their own and peer assessment.

Context of the study

As higher education is forced to turn to online teaching and learning during the COVID-19 pandemic, the authors used this short-term crisis to reconceptualize what constitutes Student Learning Outcomes in an online mathematics instruction. This study was conducted in an applied mathematics course during COVID-19 pandemic (March–Sept. 2020). The course was run in online, synchronous mode (via ZOOM) with the further support of Learning Management System. The course was taught jointly by a professor and her teaching assistant who was recently graduated. The participants were Bachelor and Master students with no prior experience in online instruction.

Procedure

The students were required to select a related topic in mathematics, conduct an inquiry on it and present their summary and findings to the class. Self-directed learning was supported by the instructors, by recommending literature, answering questions, etc. The students also formulated some multiple-choice questions, which they asked their peers to solve and engaged in subsequent active discussions.

Results

Students' perception towards the value of the SGQ strategy was assessed through an online questionnaire. Findings revealed students' positive attitude towards the experience, with 88% of the participants reporting that it contributed greatly to their focused attention and engagement with content. The Quality of SGQs were analyzed based on a two-dimensional rubric, (a) the overall quality, i.e., content coverage, relevance/clarity, and plausibility of a question, and (b) cognitive demand involved in a question based on Bloom's Taxonomy (1956). Each dimension has several levels. The majority of questions generated by students (66%) were classified at the lowest category (remembering), 25% at level 2 (understanding), and less than 10% at level 3 (application) of Bloom's taxonomy. None of the SGQs was at the higher-order levels, such as analysis, synthesis, evaluation/creativity. No significant correlation

could be established between SGQ quality and students' academic attainment in the final exam (for full discussion, see Caspari-Sadeghi, et al., 2021).

Although Bloom's taxonomy received some criticisms (Moore, 1989), and there are alternative frameworks, i.e., Anderson & Krathwohl (2001) or Illeris (2002), Bloom's Taxonomy was preferred due to its clear categories as well as its widespread use in education, which facilitated comparing our results with other available studies.

Bottomley and Denny (2011) suggested such results are to be expected, since this was likely the first time these students were asked to write their own questions systematically. The development of appropriately aligned multiple-choice questions is not an easy or trivial task. The instructors decided to use both human support and digital technology solutions, i.e., *PeerWise,* to improve the process in the next course. Authoring questions for self and peer-assessment is an effective strategy to develop self-regulated learning which can facilitate future life-long learning beyond academia.

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Supplement: Sample of SGQs

Wandle die Dezimalzahl 67,25 in das Oktalsystem (b = 8) um. Welche Antwort ist die korrekte Ziffernschreibweise?

- ○ a.34
- ○ 103.2
- ○ 1000011.01
- ○ 1003.1

Was war nicht Teil der Kettenreaktion, die durch den ungeschützten Cast losgetreten wurde?

- ○ Die SRIs schalteten sich nacheinander ab.
- ○ Der OBC interpretierte nichts aussagende Bit-Pattern als korrekte Messdaten.
- ○ Das Haupttriebwerk wurde kurzzeitig abgeschaltet
- ○ Eine Hardwareexception wurde ausgelöst.

In welchem Fall ist das Nash-Gleichgewicht eindeutig bestimmt?

- ○ F ist quasikonvex
- ○ F ist pseudomonoton
- ○ F ist gleichmäßig monoton

Gibt es im Spiel „Schere-Stein-Papier“ ein oder mehrere Nash-Gleichgewichte?

- ○ Ja, in den Punkten {Schere,Schere}, {Stein,Stein}, {Papier,Papier}.
- ○ Nein, es existiert kein Nash-Gleichgewicht.
- ○ Ja, in den Punkten {Schere,Stein}, {Stein,Papier}, {Papier,Schere}.