

# CROSSING THE BOUNDARIES OF MATHEMATICS ASSESSMENT THROUGH SUMMATIVE SELF-ASSESSMENT

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*The idea of 'Assessment for Learning' is widely encouraged in education, but mathematics assessment lags behind. In Finland, mathematics is mainly assessed through exams. Implementing alternative assessment practices might cause resistance, from both teachers and students. The present study, conducted in the context of undergraduate mathematics, introduces summative self-assessment that includes the element of self-grading as an assessment model that violates the norms of mathematics assessment. Utilising the discursive framework of boundaries, it was observed whether students were able to cross the boundaries of mathematics assessment.*

## INTRODUCTION

“Cultures of assessment” are often advocated as beneficial for students, but they might actually hinder learning. This might be true in university mathematics, where the assessment culture is heavily based on examinations and students even prefer these traditional ways of assessment (see, e.g., Iannone & Simpson, 2015). The situation does not seem to differ too much at lower levels of education, either. A recent Finnish national report (Atjonen et al., 2019) revealed that mathematics teachers mainly assessed learning through traditional methods such as exams, although this is clearly against the ethos of the National Curriculum that calls for “Assessment *for* Learning”. For example, mathematics scored the lowest of *all* of the school subjects in the use of peer-, self-, and group-assessment. It seems that if assessment is to truly “reflect the mathematics that is important to learn and the mathematics that is valued” (Suurtamm, 2016, p. 5), there would need to be a substantial rethink of the culture of mathematics assessment.

The present study introduces an attempt to challenge the culture of Finnish university mathematics assessment that as such reflects the current international culture of undergraduate mathematics education (Iannone & Simpson, 2015) and the culture of lower levels of Finnish mathematics education (Atjonen et al., 2019). The aim of this study is two-fold: By reporting on an empirical study of an innovative assessment model, the study seeks both to highlight the outlines of the usual norms of mathematical assessment culture and to reimagine them. Following Ben-Yehuda and colleagues I argue that “a norm becomes explicit and most visible when violated” (2015, p. 183). Here, student perceptions of an implementation of a summative self-assessment model are reported (see Nieminen, Asikainen, & Rämö, 2019). In a linear algebra course we asked students to self-grade, therefore challenging the usual norms of summative assessment in mathematics. I call this a “shaking up method”, since rather than simply

interviewing students about the norms of mathematics assessment these norms were shaken up by self-grading to make their outlines more visible.

In the field of higher education, it has been suggested that mathematicians are to be held responsible for their resistance to developing new assessment practices (Burton & Haines, 1997). However, as they have been shown to favour traditional assessment methods in university mathematics (Iannone & Simpson, 2015), the students themselves might also show resistance towards non-traditional assessment practices. Furthermore, implementing alternative assessment methods in mathematics would require students to adapt to these practices by changing their concept of learning (see Martínez-Sierra et al., 2016). However, exactly how this is achieved is rarely covered in the literature. The present study approaches the concept of mathematical assessment culture by utilising the theoretical framework of boundaries, aiming to understand how students both challenge and co-create the cultural norms of assessment.

### **THEORETICAL FRAMEWORK: BOUNDARY CROSSING**

The present study conceptualises the assessment culture of mathematics through the framework of boundaries. The approach draws on discourse analysis by defining cultures of assessment as the outputs of discursive practices. This theoretical lense allowsme to capture the two-fold nature of assessment cultures, both as the overarching artefact of the way assessment is done and simultaneously as a factor influencing the assessment practices and students' perceptions of those (Fuller & Lane, 2017). Connecting the framework of boundaries with that of discursive practices shifts the focus from “what are the boundaries of mathematical assessment culture?” to “how are the boundaries of mathematical assessment culture constructed?”

Boundaries have been defined as ‘socio-cultural differences leading to discontinuity in action or interaction’ (Akkerman & Bakker, 2011, p. 132). Therefore, boundaries are constructed to maintain sameness and continuity through categorisation. These categorical boundaries organise social life and maintain social order (Lamont & Molnár, 2002). A person’s transition between different fields has been characterised as *boundary crossing* (Engeström, Engeström, & Kärkkäinen, 1995). Boundary crossing involves entering a new territory through negotiation of the boundaries themselves – for example, crossing the boundaries of mathematics assessment through self-assessment might leave the students feeling unqualified to assess their own learning if the transition is not truly made. *Boundary objects* (Star, 1989, cited in Akkerman & Bakker, 2011, p. 133) are used to bridge various fields in the process of boundary crossing. Here, these objects refer to concrete actions and artifacts that are conducted to help students cross the boundaries of mathematics assessment. In the present study, personal boundary crossing is defined to have happened when the new norms of mathematical self-assessment are internalised in the discourse of a student.

In the present study, the boundaries of different assessment cultures are not taken as given; rather, they are actively constructed by various actors in the field through *boundary-work* (Lamont & Molnár, 2002). It is notable that boundary-work is not

always purposeful. As Tan (2012) has argued, both teachers and students bring their previously learned assumptions and roles into the assessment process. Since both may have been conditioned to these roles in assessment, boundary-work done by students occurs only within the restricting effects of the assessment culture itself. However, the present study aims to see students not as passive recipients of the assessment culture but as active agents co-constructing the boundaries of assessment cultures through their own boundary-work (see Raaper, 2018). Finally, boundary-work does not always lead to boundary crossing (Akkerman & Bakker, 2011). The present study utilises a ‘micro perspective’ as suggested by Akkerman and Bakker to investigate whether boundaries are crossed in students’ discourses, and how this is conducted.

## **THE OBJECTIVE OF THE STUDY**

The present study uses summative self-assessment as a concrete example of an assessment model that demands that students cross the usual norms and boundaries of mathematics assessment. By observing university students’ discourses, the study aims to understand students as active co-constructors of the assessment culture of mathematics. The research questions were formulated as follows: What kind of boundary-work did the students take part in when they negotiated the boundaries of mathematics assessment after taking part in summative self-assessment? What kinds of boundary objects did they use to cross these boundaries?

## **METHODOLOGY**

### **The course design: Summative self-assessment in action**

This study utilises the concept of summative self-assessment (Nieminen et al., 2019) to refer to a self-assessment model that builds on formative self-assessment but also includes the element of self-grading. Most often higher educational studies recommend using self-assessment as a formative tool for learning that would help students to monitor their own learning (see Brown & Harris, 2013; Panadero et al., 2016). This means that during the learning process, the teacher would provide some kind of self-assessment tasks that would prompt self-reflection on one’s actions, therefore leading to a better quality of learning (Brown & Harris, 2013). However, it has been argued that effective self-assessment models would not just allow students to compare their skills and knowledge with teacher-generated criteria, but would give them power over their own grade. Hence, in the summative model the students can decide their own grade, but only after a longer process of engaging in practicing self-assessment.

The study took place at a large undergraduate mathematics course (313 participants) in a research-oriented university in Finland. The proof-based course addresses linear algebra and matrix computations and is usually one of the first courses students take in their mathematics studies. Assessment in the mathematics department of this university is heavily based on individual exams. On this course, the traditional course exam was replaced with summative self-assessment; the students graded themselves on a scale of 0 (‘fail’) to 5 (‘excellent’). During the course, self-assessment was practised through formative self-assessment. Digital feedback on students’ self-assessments was offered,

and students could reflect in writing how that feedback represented their skills and knowledge. Self-assessment was based on a learning objective matrix (rubric), making the learning objectives transparent. For further details about the course arrangements, see Nieminen et al. (2019).

### **Data collection and analysis**

In total, 26 students were interviewed after the course about their experiences of summative self-assessment. Eight of the participants were majoring in mathematics and the rest studied, for example, computer science and chemistry. None of the participants had any previous experience of self-assessment practices in mathematics.

The analysis draws on discourse analysis. First, the interview data was reduced through thematic analysis, using in vivo coding to capture the words and meanings by the students themselves. After the data had been structured into meta-themes, further discourse analysis followed.

## **FINDINGS**

### **Crossing the boundaries: “Finally studying for myself”**

Many students described how summative self-assessment enabled them to study in a way that was not aimed at succeeding in an exam but rather at gaining personal mathematical knowledge. These accounts were coded to reflect boundary crossing, since the students needed to internalise the new cultural norms of summative self-assessment.

Student: It supported independent studying [studying through summative self-assessment]. Acknowledging that encouraged me to think that there’s some sense in assessing yourself, and that was inspiring.

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Student: I took more responsibility of my learning. Now I didn’t need to stress about any exams, but I could challenge myself with a good feeling.

Quite soon in the analysis it became evident that boundary objects were needed to support students in their boundary-work. As one student put it:

Interviewer: Will you continue assessing your own mathematical skills after this course as well?

Student: I guess I should (laughs). It would be bad to just leave it here. But it’s another thing if you are offered tools for that.

The most frequently described boundary object was the detailed rubric with exemplars. A frequent theme in the data was that students felt that self-assessment was strange and complicated at first, but could be conducted after becoming familiar with the transparent learning objectives of the course. Overall, the formative self-assessment tasks were described as important boundary objects that taught goal-setting and self-reflection skills. In particular, the feedback offered from the digital self-assessment tasks was described as a crucial boundary object.

Student: In the beginning of the course it [self-assessment] felt more like, well let's just write something here according to my feelings. The learning objective matrix included many confusing concepts that you couldn't even define at the time. But during the course you dug deeper to it, you could learn those skills.

*Reflection* (Akkerman & Bakker, 2011) was the discursive practice that was connected with boundary crossing while the students negotiated the boundaries of mathematics assessment. Summative self-assessment forced the students to reflect on why it challenged the usual norms of mathematics assessment. Furthermore, this process enabled them to critically reflect on those usual norms. Thus, summative self-assessment did not just generate simple boundary crossing, but rather encouraged students towards critical boundary-work.

Student: If I'm studying for an exam, I often feel like now I'm studying for that exam. And for the fact that I would get a good grade. Now I felt more like I would have been learning to be able to use these skills in the future.

Student: I feel it was so useful and should be used in studying everywhere. Once in a while you stop and think about what you really know and what you don't know.

### **Strengthening the boundaries: “Self-assessment belongs to humanistic disciplines”**

Across the whole dataset, summative self-assessment was largely described as a new, strange, and even radical kind of assessment method. Not all of the students' discourses reflect boundary crossing - many of them were not willing or able to cross the boundaries as the course teacher wanted them to. In these cases, the boundaries of mathematics assessment with their usual norms were strengthened further. Two discursive practices were identified when the students resisted internalising the norms of summative self-assessment: Naturalisation and illegitimation.

*Naturalisation* was identified when the students leaned on simplifications of the assessment culture of mathematics; when socially constructed discourses and practices were taken as natural and even connected to the nature of mathematics itself. For example, the students often naturalised the traditional practices, framing the use of exams as a given. These accounts underlined that mathematics must be assessed with exams. This was seen as the nature of mathematics assessment: Because summative self-assessment does not belong to this nature, it should not be used.

I think self-assessment belongs to humanistic disciplines. Somehow in mathematics I'm used to the fact that knowledge has to be assessed brutally.

The teaching culture of mathematics has never before guided us towards self-assessment, so I can't say it would have felt natural.

*Illegitimizing* the process of summative self-assessment was also a common discourse aiming to frame it as an inadequate assessment model. Many students thought that self-grading is not an adequate way of determining one's grade since it might not reflect one's real skills and knowledge. Often, the legitimacy of summative self-assessment was only doubted in certain contexts or with certain student groups. For example, it

was pondered whether this assessment model was suitable for ‘lazy’, ‘young’ and ‘mathematically weak’ students. Self-assessment was constantly compared to exams, and many students thought that the validity of summative self-assessment could be improved with an external exam.

Maybe this kind of self-assessment would be suited better for advanced mathematics courses later on in the studies. So that in the beginning of your studies you would get a certainty of the level of your knowledge by doing an exam.

I would combine the methods of self-assessment and exams. Just because an exam would really show whether you have really learnt or not.

## DISCUSSION

The present study investigated university students’ discursive boundary-work after taking part in a mathematics course drawing on summative self-assessment. Seeing students as active negotiators of the assessment culture (see Raaper, 2018), this study sought to understand how students either crossed the boundaries of mathematics assessment and adjusted to summative self-assessment or resisted this by further boundary-work that re-established the frontiers already existing.

The results underline the importance of offering adequate boundary objects (e.g. rubrics) to students when asking them to negotiate the boundaries of the culture of mathematics assessment. None of the students had any earlier experience of self-assessment in mathematics, which calls for a careful scaffolding of self-reflection. These findings reflect earlier research on self-assessment in higher education; for example, studies highlighting the importance of practicing self-reflection skills based on transparent learning objectives (Brown & Harris, 2013; Panadero et al., 2016). I argue that these kinds of concrete support systems are especially important in the exam-driven culture of mathematics. Here, the students were not only required to learn new mathematical content but to adjust to new cultural norms as well, each of which is quite demanding in themselves.

Through carefully designed boundary objects some students were able to critically *reflect* (Akkerman & Bakker, 2011) on the boundaries of mathematics assessment. As noted above, a certain structure was needed to support students in this process. However, the results of the present study emphasise the power of offering students alternative experiences of mathematics assessment. I argue that this method of ‘shaking up’ the boundaries of assessment offers a powerful tool not only for practice but for future research as well. The present study showed that summative self-assessment was able to generate reflection; would formative self-assessment, added on top of external summative testing, truly challenge the boundaries the assessment culture of mathematics in the same way?

Not all of the students were able - or willing - to cross the boundaries of mathematics assessment. Two discourses were identified as boundary work: naturalisation of the usual norms of mathematics assessment and illegimitation of summative self-assessment. These findings remind us that students are active co-constructors of

assessment cultures. Their perspective must be considered while re-imagining mathematics assessment, and especially while evaluating whether boundary crossing has actually occurred. It is notable that naturalisation and illegimitation can be made visible to the students themselves through reflection (Akkerman & Bakker, 2011). However, the two-fold nature of assessment cultures (Fuller & Lane, 2017) creates a challenge, as students both co-construct the cultural norms and are restricted by them. We call for future research to tackle this methodological issue by further understanding assessment practices as *discursive* practices; as shown here, the framework of boundary crossing can offer an adequate tool for this.

## CONCLUSIONS

Finally, I argue that mathematics educators have an ethical responsibility to actively try to reconstitute the exam-driven assessment culture of mathematics. Even though the present study examined the viewpoint of the students, the teachers - and researchers! - need to do boundary-work as well. It is argued that the least mathematics educators could do is to avoid strengthening the boundaries of mathematics assessment through offering alternative discourses such as those identified in this study. If new frontiers are not reached in the field of summative mathematics assessment, it might be that external testing and validation will, by default, keep dominating what is seen as 'valued mathematics' (Suurtamm et al., 2016). Finally, there is a need for future research that would boldly initiate innovations in mathematics assessment. A vast amount of literature on sustainable assessment practices already exists - it is time to take that knowledge into mathematical classrooms.

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