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Supporting quality of learning by letting students give their own grades – An innovative self-assessment model in university mathematics

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Abstract

We describe a digital self-assessment model (DISA) designed to offer a meaningful alternative to the traditional end exam in university mathematics courses. Students assess their own competencies throughout the course with the help of a detailed rubric, and at the end of the course, they give themselves their own final grades. Feedback for self-assessments is offered by an automatic digital system. DISA brings self-assessment skills to the forefront as a learning goal. In line with the definition of Assessment as Learning, the assessment method generates learning opportunities through students' engagement in seeking evidence for their self-assessment. We present the DISA model in the context of the Finnish educational system, in which teachers have a lot of autonomy and most assessment is not high-stakes. We describe its implementation and report on research findings published in

earlier studies. Based on these results, it can be said that the model has a positive effect on students' approaches to learning, their perceptions of their own capabilities, and the way they view learning and assessment.

Introduction

In this chapter, we report on an innovative self-assessment model, called DISA (Digital Self-Assessment), developed in the context of Finnish university mathematics education. In the DISA model, students assess their own competencies throughout the course with the help of a detailed rubric, and at the end of the course, they give themselves their own final grades. Feedback for self-assessments is offered by an automatic digital system. We describe the implementation of the model and report on results we have obtained on it in several studies. Our purpose is to inspire both practitioners and researchers by offering enough detail on the self-assessment method and its context, as well as by bringing forth potentially new viewpoints to the research community on self-assessment to draw upon.

In everyday language, self-assessment is a process that occurs when someone is reflecting on and evaluating their own achievements, progress or capabilities. This process occurs probably in every learning situation, at least informally. However, when discussing self-assessment as a formal assessment practice, it is important to consider the nuances between different self-assessment models and their implementations in order to understand how and why the models may produce different outcomes (noted e.g. by Andrade, 2019; Panadero, Brown, & Strijbos, 2016). Therefore, in this text we put emphasis in describing the context in which the DISA model arose, as well as how it is situated among different self-assessment methods.

Situating the DISA model within assessment literature

The frame of Assessment as Learning (AaL) highlights the dual role of assessment tasks as learning opportunities as well as instances of evaluation. It emphasises long-term, sustainable learning gains that stem from students' active and reflective role required by the assessment task (Yan & Boud, Chapter 2). Research at various levels of education has shown that self-assessment, combined with active feedback practices, promotes not only acquisition of content but also other important outcomes such as self-regulation skills and self-efficacy (e.g. Andrade & Cizek, 2010; Panadero, Jonsson, & Botella, 2017; Panadero et al., 2016).

However, calling any instance of self-assessment "Assessment as Learning" would not be reasonable, if students are not required to actively seek and interpret evidence for their assessment. Yan and Boud (Chapter 2) mention an example where students are asked to give a grade for themselves at the end of a learning unit, and propose that this should not be called AaL if students do not adhere to any set criteria for the grading. Now, although self-assessment in the DISA model does include an element of self-grading, this does not exclude it from AaL, as we will explain throughout this chapter.

The DISA model has two main characteristics that serve to identify it among self-assessment models. Firstly, the students *give their own grades* at the end of a study module, so the model comprises a strong summative component. This also means that some actual power over the grading is relinquished to the student. However, the model also serves a formative purpose: self-assessment is taught with repeated exercises throughout the course, and students receive feedback on their self-assessments. Secondly, the students are asked to *assess their own competencies*, as opposed to, for example, grading course products or learning processes.

Assessment is often characterised as being summative or formative. Formative use of self-assessment refers to offering formal self-assessment tasks during a student's learning process,

whereas summative self-assessment has been connected with self-grading that involves students taking part in the grading processes and making summative comments about their work (Andrade, 2019). Many assessment methods carry features of both (cf. Taras, 2005; Lau, 2016). Also the DISA model operates in the intersection of summative and formative self-assessment, employing the summative element to highlight the importance of self-assessment to students. Researchers have stated quite clearly that self-grading practices should not be used in education (e.g. Andrade & Cizek, 2010). However, it has also been reported that formative self- and peer assessment practices might lead to inadequate studying methods, such as rote learning and memorising the content, if, for example, the added workload of these formative practices is perceived too high (Baeten, Dochy, & Struyven, 2008; Gijbels & Dochy, 2006).

Another important way of understanding different models of assessment is to consider *what* is assessed. While earlier research has primarily addressed self-assessment of tasks and products (cf. Tai, Ajjawi, Boud, Dawson, & Panadero, 2018) and processes (cf. Panadero, Jonsson, & Botella, 2017), in this text we consider students' assessment of their competencies. These competencies can be content-specific, such as being able to apply the Gauss–Jordan algorithm, or more generic, such as being able to consider another person's viewpoint in conversation around a mathematical topic. As Andrade (2019) notes, self-assessment of competencies is tricky since there is a risk for “global assessment of one's overall ability, self-esteem, and self-concept” (p. 3). In the DISA model, the risk is reduced by guiding the students away from such statements as “I am bad at mathematics” with the help of assessment rubrics, instructions and feedback on the self-assessments.

Cultural and educational context

Before presenting the implementation details of the DISA model, we describe the educational context in which the model was conceived. The surrounding assessment culture not only controls the spectrum of assessment methods at hand, but also affects the learning gains that assessment methods can contribute. For example, in a grade-oriented and competitive environment, summative self-assessment might lead to superficial learning and even cheating, whereas in another context it may promote deep approach to learning and student agency.

Assessment in Finnish universities is, by and large, not high-stakes. Students can usually retake their exams multiple times during the semester, and grades do not play a key role in determining what jobs students can pursue after their graduation. This takes away pressure from students to cheat in assessment. Teachers in Finnish universities, on the other hand, have high autonomy (Nokkala & Bladh, 2014). There are no regulations that would require them to use certain assessment methods, but in practice, most teachers will discuss with their colleagues in case they want to try out assessment methods that are new in their department. It is notable that because almost all Bachelor's programmes are taught in Finnish, most students are of Finnish background. This makes the student population rather homogeneous, and students share common values.

In university mathematics, exam is the most typical assessment method (e.g. Iannone & Simpson, 2011). As students come to university with the experience they have gained from school, also the assessment culture in schools is relevant when considering universities. In Finland, the most common assessment method in school mathematics is individual exam (Atjonen et al. 2019). Alternative assessment methods such as self-assessment, peer assessment, peer feedback, group feedback or assessment discussions are used more rarely in

mathematics than in other subjects. This means that Finnish students are very likely not used to non-traditional assessment in mathematics when arriving to university.

Implementation of the DISA model

The DISA model was born from the need of certain teachers of university mathematics to find a meaningful and less harmful alternative for the traditional end exam. Although the exam had been an efficient way to administer the final grade on a study module and could be accompanied with class activities to earn extra points, it had several drawbacks. It drove students towards superficial learning and memorising content just before exam. It was also unsuitable for assessing many generic skills, such as group work and oral mathematical communication. Furthermore, the teachers felt that the exam painted an unintended picture of learning at university as a matter of achieving grades and satisfying teachers' expectations.

Development of the DISA model began in 2016 in a small Master's level course in mathematics with approximately 20 students. The traditional final exam was replaced by students deciding their own grades at the end of the course, based on a rubric. Students practised self-assessment during the course, and the teacher supported them and gave feedback on their self-assessments in one-on-one discussions. In 2017, this self-assessment model was introduced to a first year mathematics course with approximately 400 students. This course had been designed around a student-centred teaching method, called Extreme Apprenticeship (Rämö, Reinholz, Häsä, & Lahdenperä, 2019). The main idea of the Extreme Apprenticeship method is that students take part in activities that resemble those of experts, and there are tutors who support them in this endeavor. The students work in a collaborative working space, and peer tutors assist them. A crucial role in the teaching is played by weekly tasks that support students' learning. Every week, students receive feedback in various forms on the tasks they have completed: there are computer-assisted tasks that provide automatic

feedback, pen-and-paper tasks for which teachers provide feedback, and for some tasks, the students give and receive peer feedback.

The learning objectives of the course are described in a matrix that contains both mathematical skills and generic skills such as reading, writing and collaboration (see Table 1). Self-assessment is tied to this matrix: the students are asked to give themselves a grade in every topic (row) mentioned in the matrix, and justify the grade in writing. In addition, students are instructed to elicit evidence for the selected grades. For example, the evidence might involve feedback from tutors, coursework marks, discussions with classmates, or internal feelings. The justification is not evaluated; it is merely supposed to help the students to form as accurate self-assessments as possible.

Topic	Skills corresponding to grades 1–2	Skills corresponding to grades 3–4	Skills corresponding to grade 5
Matrices	I can perform basic matrix operations and know what zero and identity matrices are	I can check, using the definition of an inverse, whether two given matrices are each other's inverses	I can apply matrix multiplication and properties of matrices in modelling practical problems
Reading and writing	I use course's notation in my answers	I write complete, intelligible sentences that are readable to others	I write solutions that contain only the essential and use mathematical symbols only when needed

Table 1: Part of the learning objectives matrix of the course. In total, there were 10 topics and 10–15 learning objectives in each topic. In the Finnish higher education system, grades range from 0 to 5, where 0 is fail and 5 is the best grade.

In the small course, the teacher had been able to follow all students in class sessions and have one-on-one feedback discussions with them. In the larger course, this task had to be largely automated, which was done as follows. Before the course, the teacher links each learning objective to a set of course tasks related to that objective with numerical weights describing the importance of that task to the objective. For example, an objective might be connected to a Moodle quiz problem from week one with weight 0.2 and to a teacher-assessed written problem from week three with weight 0.8. (In general, problems related to the same objective but situated later in the course carry more weight, to take into account later acquisition of a skill that was not mastered at the first instance.) This linking is then used to automatically infer the student's mastering of that objective from the coursework they have done.

Continuing the example, if the student got full marks for the first week's problem, but only half for the third week's problem, the system would assess that the objective had been completed to 60%. Depending on completion rates of other objectives in the topic, as well as threshold values set by the teacher, the system will suggest a grade. The system then compares this tentative grade to the student's self-assessed grade.

In order to practise self-assessment and the use of the digital system, students complete two or three self-assessment exercises during the course. The system evaluates their self-assessment and gives them feedback. The feedback is verbal rather than numerical, consisting of carefully worded phrases that are automatically inserted based on the numerical data. The wording is chosen so that it would not give the impression that the computer would know the student's skills precisely and even better than themselves. For example, if the system

estimates a student's progress higher than themselves, a feedback sentence could be "Based on the tasks you have completed, you might consider giving yourself a higher grade in this topic." In the opposite case, the sentence might read "The grade you have assessed for yourself is higher than the tasks you have completed would suggest." For most generic skills, the digital system does not give feedback to the students because it does not contain any information on, for example, communication or group work. However, self-assessment of these skills helps students familiarise themselves with the learning objects concerning generic skills and gives them a chance to reflect on their progress.

At the end of the course, students perform a similar self-assessment exercise, but also give themselves a final grade for the course. The digital system evaluates their grades as before. If the amount of mismatch in the evaluations of the student and the digital system is above some threshold value, the system alerts the teacher. The teacher then examines these students' written justifications, and if needed, goes through their solutions to the weekly tasks. Sometimes the teacher finds that the digital system has mistaken, and in these cases, the student's evaluation holds. If it seems that the student has underestimated their skills, the student is given the option to perform another self-assessment. If the teacher finds that the student's self-assessment is much higher in several topics than what the coursework would indicate, the student is asked to do a short online test in which the student can demonstrate skills that might not be indicated by the coursework.

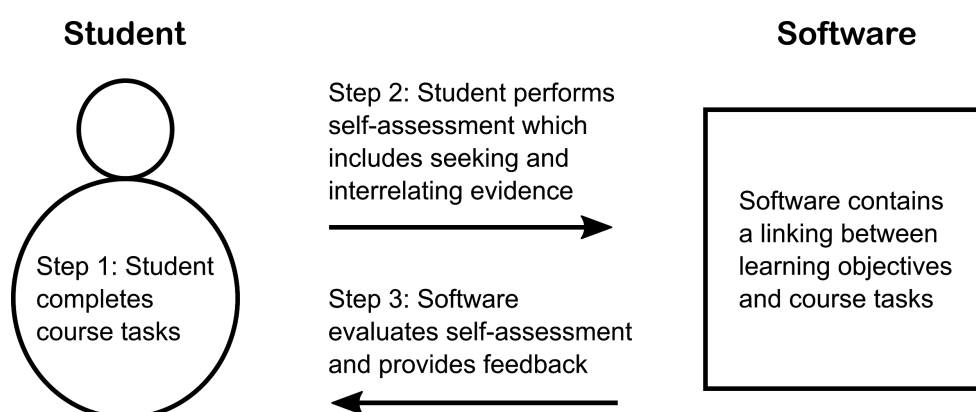


Figure 1: Diagram describing how the software is used to assist student self-assessment. The teacher has prepared the software by linking course tasks to learning objectives. The steps in the cycle are repeated through each self-assessment exercise.

Figure 1 describes the cycle of self-assessment exercises leading to the final self-grading. Students know that in order to pass the course, their final self-assessment needs to be in line with the coursework. Therefore, they have an incentive to work hard during the course (Step 1 in the figure). When performing self-assessment (Step 2), they need to follow the criteria for distinct grade levels as given in the learning objectives matrix, so they must engage with the learning objective statements to figure out what they are supposed to learn. Also, in order to improve their self-assessment accuracy, they are advised to procure evidence and think critically about their learning. Finally, the system provides feedback for the self-assessment (Step 3), which the students are instructed to compare with their own judgements, in order to further calibrate their next self-assessment. Thus, the DISA model is designed to encourage students' active evidence-seeking and reflection.

Findings from research studies

In this section, we present a snapshot of research findings produced in the DISA research project. The results described here concern quality of student learning, students' experiences with the DISA model, and applicability of the assessment method.

Quality of learning

One characteristic of the DISA model is that students are involved in the summative assessment process. Studies have indicated that this enables moving self-assessment to the focus of students' work during the course (Nieminen & Tuohilampi, 2020; Tuohilampi,

Rämö, Häsä, Pekkarinen, 2017). It has also been reported to foster self-efficacy and deep approach to learning in students (Nieminen, Asikainen, & Rämö, 2019; Nieminen, Häsä, Rämö, & Tuohilampi, 2018). Self-efficacy refers to students' belief in their capability to achieve in the course (cf. Bandura, 1997), and deep approach to learning refers to student's aim to understand ideas for themselves and relate ideas to each other (cf. Marton & Säljö, 1976).

Another analysis considered students' achievement goal orientation profiles, revealing that students using the DISA model for grading were over-represented in the mastery-oriented profile (Häsä, Leppinen, Nuutila, & Rämö, 2020). This profile emphasises motivation towards learning and mastery, as opposed to, e.g. getting good grades or achieving better than classmates (c.f. Niemivirta, Pulkka, Tapola & Tuominen, 2019).

In the DISA model, students assess their own competencies as a whole. Häsä, Rämö and Lahdenperä (in press) found evidence that this type of self-assessment may enhance self-monitoring – in particular contrasted to assessing a piece of one's own work, which in turn may have a stronger impact on learning to recognise quality.

The student perspective

When students' perceptions were investigated in a small Master's level module taught with the DISA model, it was revealed that the students found the assessment method fair, and that their final grades corresponded well to their skills (Tuohilampi et al., 2017). Also, the students did not find it important to have an exam measuring their skills.

The DISA model has also been studied with regard to socio-cultural aspects. A study by Nieminen and Tuohilampi (2020) focused on the notion of student agency, i.e. the capability to act purposefully and autonomically (cf. Biesta & Tedder, 2007). Their study implied that

the DISA model promoted future-oriented agency that did not only focus on the course at hand but on self-assessment skills needed in future life. However, the model was also connected with lack of agency, as some students struggled to make use of the affordances offered for taking responsibility for one's own studying by the assessment practices. This finding indicates that in contexts where students are not familiar with self-assessment, a lot of support systems are needed to promote student agency. Another study by Nieminen (2020) connected these ideas with the notion of power. The findings indicated that the DISA model challenged the prevalent power relations connected with assessment in earlier literature; yet, this required a lot of support and scaffolding.

Applicability

The main purpose of DISA assessment is to enhance student learning. However, it is an assessment method used for grading students, so it is necessary to examine its validity and fairness. Häsä, Rämö and Virtanen (2019) found that self-assessed grades in the DISA model are largely in line with the level of students' coursework, and exceptions are spotted well by the digital system. In another study, Nieminen et al. (2019) reported that there was no difference in student achievement during a course module between students using the DISA method compared to those taking a traditional exam.

Teacher's reflection

In addition to research findings, it is important to hear from the practitioners themselves in order to get a more complete picture of an assessment method. At the early stages of the DISA model, teachers who applied it felt they were doing something risky. This feeling was amplified by some colleagues and students who found the new method too radical and requested going back to exams. Therefore, it was important to have the leader of the department formally support the initiative. Also, research results have been important

incentives for continuing to use the method. Introduction of the DISA model to several generations of students has also started to change student attitudes.

Even with the support of others and one's own conviction, using the DISA method makes the teacher constantly reflect on their motives for assessment. How does one really know what the student's skills are? What is the ultimate goal of assessment in general? This is highlighted in the cases of students whose self-assessment is not in line with teacher's assessment. The teacher should support these students in developing their self-assessment skills, but the teacher's perception of the student's skills might also be biased. Even worse, heavy intervention by the teacher seems to be in contradiction with the idea of self-assessment in the first place! These questions are profound and difficult to answer.

Using the DISA model can be very rewarding to the teacher, as replacing the exam with self-assessment shifts students' focus from rote learning and doing well in the exam to learning for oneself and aiming to understand the concepts of the course. However, in some students, the digital DISA software causes undesired behaviour as they try to achieve good feedback from the software and do the course tasks with this goal in mind. The positive effects of the DISA model are particularly palpable to the teacher in small classes in which the teacher has a close contact with the students. Self-assessment, accompanied with other student-centred elements, can create an atmosphere in which students have profound discussions with each other and the teacher, and in many ways work like experts.

Discussion

Assessment as Learning concerns itself with assessment instances that are meaningful also as learning opportunities. According to the theoretical definition by Yan and Boud (Chapter 2), these learning opportunities are generated through students' "active engagement in seeking, interrelating and using evidence". In the DISA model described in this chapter, this

engagement is induced by requiring the students to produce a structured and reasonably accurate self-assessment at the end of a study module to determine the final grade. In order to achieve this requirement, they need to familiarise themselves with the learning objectives of the module, practise self-assessment during the module, and search, engage with and learn from feedback provided for their coursework as well as their self-assessment exercises.

Researchers have warned against using self-assessment for grading as well as using it to evaluate competencies. These warnings are justified, but even so, the DISA model does not seem to suffer from the predicted shortcomings. Students are not driven to surface strategies or cheating, and their justifications for their self-assessments are, in general, analytical and constructive. To us, this suggests that there may be some previously undiscovered opportunities in summative self-assessment methods. It may be that literature on student self-assessment has not fully acknowledged the fuzziness of the dichotomy between summative and formative assessment (see Lau, 2016). Perhaps in the Finnish context where courses can be retaken and the focus is less on grades, even self-grading begins to resemble formative assessment; namely, one can give oneself a sincere evaluation with the intention of taking the course again next term.

The focus of Assessment as Learning is more on developing long-term learning capacities than on short-term benefits (Yan & Boud, Chapter 2). The DISA self-assessment model gives students the opportunity to monitor their gradual acquisition of competencies, as well as to experience summative evaluation of their own skills, which will arguably aid them in future studies and working life. Here, we point out a contrast to those self-assessment methods that aim more towards recognising quality of work, as emphasised by, for example, by Sadler (2010) and Tai et al. (2018). However, we find that all these objectives are valuable for life-

long learning, and therefore students should be exposed to different kinds of self-assessment instances during their studies.

The DISA model cannot be understood without considering its socio-cultural context. With its self-grading component, it might not be possible – or even desirable – to introduce in certain contexts (see Nieminen, 2020). However, in the context it originated in, the model has fared remarkably well. To interpret such results, socio-cultural understanding of the context is needed, for example, what is valued by teachers and students, what is seen as the purpose of learning and assessment, and what kinds of skills are deemed worthy of pursuing.

For someone working in a distinctly different educational environment, it may be most useful to view the DISA model as a source of insight and inspiration to rethink the assessment culture. For example, the principles of the model could be tried out in a course that does not play a significant role in students' degrees. That way, both students and teachers would get a chance to start shifting their views on assessment. Another option might be to vary the DISA model so that it fits the educational culture better. For example, it might be possible to replace the self-grading with discussion or negotiation of the students' grades with the teacher. However, in our view, the following characteristics are integral to the DISA model: students assess their own acquired competencies with the help of clearly stated learning objectives and receive feedback for their self-assessment.

Finally, we encourage both researchers and practitioners to creatively offer new openings in the field of Assessment as Learning. Through our example, we have shown how an innovative assessment design supported learning and brought about new questions for research. Future studies could delve deeper into the differences of various types of assessment models in order to distinguish between the benefits of summative versus purely formative self-assessment, as well as self-assessment of competencies versus products or

processes. Research should also be conducted on the socio-cultural variables that make some Assessment as Learning endeavours successful in their own context. Even further, we encourage assessment researchers to report on their attempts to affect the overall assessment cultures within their contexts.

Conclusion

In this chapter, we have described a self-assessment model, which allows students to determine their final grades in university mathematics courses. Students assess their competencies several times during the course. Self-assessment is guided by a detailed rubric, and a dedicated software is used to evaluate the validity of the self-assessments and generate feedback. When performing self-assessment, students are expected to gather and correlate evidence for their abilities from different sources. The model has enjoyed success in practice, and several research studies performed on the model have given evidence that it has a positive effect on students' perception of their own capabilities, their approaches to learning, and the way they view learning and assessment. We have spent some effort in describing the surrounding cultural and educational context, in order to better understand and evaluate the underlying reasons for the model's success, and to enhance its transferability to other contexts.

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