Universal Design for Assessment in mathematics

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Universal Design for Learning (UDL) is a commonly used framework for designing accessible learning environments. While UDL has been reportedly applied to testing situations, much less is known about how classroom assessment (e.g., formative assessment) could be designed accessible to support the learning of all students. In this conceptual study, the previously introduced idea of Universal Design for Assessment (UDA) is reformulated in the context of mathematics. It is argued that in the test-driven assessment culture of mathematics, UDA holds specific promise; recent studies have noted that mathematics assessment does not enable students with disabilities to participate fully due to inaccessible practices. The proposed framework discussed how UDA could promote the following guidelines in mathematics assessment: i) partnership, ii) diversity, and iii) dialogue.

Keywords: Mathematics assessment, Universal Design, accessibility, diversity, ableism.

Introduction

It is a publicly known secret that classroom assessment has been unable to meet the needs of students with disabilities. In assessment, disabilities are not seen as something to be celebrated but as something to be overcome. Assessment with both its summative and formative purposes largely draws on individualised assessment accommodations rather than on inclusive practices; students with disabilities are seen as the problem to be fixed, not assessment itself (Nieminen, 2021).

While recent contributions have critically examined how mathematics education constructs disabilities through inaccessible teaching practices (e.g., Lambert, 2015; Nardi et al., 2016; Tan et al., 2019), much less attention has been given to assessment. This is surprising given how test-driven the assessment culture of mathematics is. As shown by Nieminen (2020), mathematics assessment plays a crucial role in *disabling* students. The test-driven culture of mathematics does not only create barriers for learning but for inclusion and participation by excluding students with disabilities from other mathematics learners both physically and socially (Bagger, 2022).

In this conceptual study, the commonly used framework of Universal Design for Learning is used to rethink mathematics assessment as an inclusive endeavour. This study draws on earlier critical work to understand ableism in mathematics education (Padilla & Tan, 2019): how assessment produces an ideal of certain normality and then excludes students who do not fit this ideal of a *normal, able* student (Nieminen, 2022). Rather than focusing on the pitfalls of current assessment practices, this study reaches further by formulating a framework for Universal Design for Assessment to guide future research and practice in mathematics education. First, Universal Design is introduced.

Universal Design for Learning

Overall, Universal Design refers to accessible design for everyone, originating from the field of architecture. In education, Universal Design has been largely promoted through the pedagogical framework of Universal Design for Learning (UDL). UDL refers to accessible pedagogical design

that "proactively builds in features to accommodate the range of human diversity" (McGuire et al., 2006, p. 173). Due to such underpinnings, UDL is often connected with the social model of disability that does not understand disabilities as a deficit to be cured but instead sheds light on educational practice that actively *disable* students. While UDL has been most commonly used to design accessible practices with disabilities in mind, recent contributions have expanded the notion to address, for example, racism (Waitoller & Thorius, 2016). The UDL model encompasses three main principles, as formulated by CAST (2011):

- **Engagement** (the 'why' of learning): Multiple ways for stimulating interest.
- **Representation** (the 'what' of learning): Multiple ways for representing knowledge.
- **Action & Expression** (the 'how' of learning): Multiple ways to express knowledge.

UDL builds specifically on the very idea of design: rather than drawing on retrospective, individual adjustments it instead shifts our gaze to careful design of learning before the learning process itself. While UDL has been largely promoted in educational policies and practices, thus far such designs have been rarely reported in mathematics education.

Universal Design for Assessment

While UDL has been widely promoted in education, its implementation in assessment has received less attention. Accessible design in *test item design* has been noted, and indeed Universal Design for Assessment (UDA) has so far focused on how to design accessible large-scale exams (see Ketterlin-Geller et al., 2015). It is fitting that the seminal study by McGuire and colleagues (2006) only referred to UDL in assessment in terms of large-scale national testing.

Some more holistic conceptualizations have been offered. Ketterlin-Geller (2005) defined UDA as "an integrated system with a broad spectrum of possible supports so as to provide the best environment in which to capture student knowledge and skills" (p. 5). Ketterlin-Geller and colleagues (2015) discussed UDA in terms of target and access skills in assessment. According to the authors, assessment is intended to 'measure' certain skills and abilities (*target skills*), while other skills might also influence students' performance while demonstrating their mastery (*access skills*). Through careful pedagogical design, the interference of access skills can be minimized (e.g., a large font size ensures accessibility in a test so that the test item measures the intended mathematical skill).

However, to date, earlier studies have not built a critical framework to guide the design of classroom assessment in all its diversity beyond test design (e.g., self- and peer assessment) (Nieminen, 2022). Moreover, there is a need for a mathematics-specific UDA framework to address the ableism and inequity related specifically to mathematics assessment.

A socio-political, mathematics-specific framework for UDA

In this conceptual study, UDA is reformulated in the context of mathematics education. Recently, there has been a call for critical approaches to challenge ableism in mathematics education regarding students with disabilities (Tan et al., 2019). This is exactly the approach taken in this study. In fact, the UDL framework has been criticised for its focus on pedagogical design over challenging ableism and injustice, trading disability activism into an 'activation of neural networks'

(Nieminen & Pesonen, 2020). In the words of Hamraie (2016), UDL has become "emblematic of a depoliticized orientation toward disability" while largely ignoring "systems of oppression such as racism, sexism, or ableism" (p. 302). Following Hamraie, this study uses UDA as an inspiration but ties it with a critical approach. The UDL framework is reformulated as a novel UDA framework for mathematics assessment (Table 1). While introducing the UDA guidelines in the following sections, the main issues in mathematics assessment are introduced from the viewpoint of equity and disability rights. The study mainly focuses on the viewpoint of students with disabilities, but the framework holds promise for intersectional work too (Nieminen, 2022; Waitoller & Thorius, 2016).

Table 1: The reformulated framework for Universal Design for Assessment in mathematics

Original UDL principle	Engagement	Representation	Action & Expression
Revised UDA principle in mathematics	Partnership	Representation & Diversity	Dialogue

UDA principle 1: Partnership

The issue: In test-driven assessment cultures, students are merely the targets of assessment rather than active agents. In other words, students are *objects* in assessment, not *subjects*. Even when ideas such as Assessment for Learning are promoted, the process tends to be dominated by teachers' actions and choices. As students are not enabled opportunities to co-design assessment practices, they might learn to be dependent on teachers' actions rather than to truly 'own their own learning'. The effects of such unilateral idea of assessment might be more prevalent for students with disabilities who have historically been dependent on teachers' actions (Nieminen, 2021) and in mathematics education (Lambert, 2015; Tan et al., 2019). As the medical model of disability dominates in assessment, students are dominantly seen as the objects of support services determined by others.

The first UDA principle draws on the ideal of democratic education that understands learners' rights to take part in actions and decisions that concern themselves. This is achieved through the principle of *partnership* that provides students with opportunities to act as co-designers of educational practices (Cook-Sather et al., 2018). Matthews and colleagued (2021) noted that while co-design practices has been reported widely in educational literature, such approaches have been rare in assessment. This highlights the urgency of the first UDA principle, especially in the test-driven context of mathematics assessment. The first UDA principle taps into the design-based roots of UDL (McGuire et al., 2006). Traditionally, UDL has emphasised that accessible educational design benefits everyone. The design process should hear the voice of the end users: designing *for* students with disabilities is not enough as assessment needs to be designed *with* them. This was noted by Nieminen and Pesonen (2020) who reported a university mathematics course whose design drew on UDA. As the design process only heard students' perspectives after the course design, the process was certainly not inclusive; a worthwhile lesson for both the authors and the readers! Importantly, the first UDA principle emphasises that all students need to be heard in

assessment design processes, but marginalized students in particular to enable accessibility (Cooker-Sather et al., 2018; Matthews et al., 2021).

In practice, the first UDA principle means that students are enabled possibilities to design the mechanisms of assessment. The principle disrupts the individualizing nature of assessment by rendering the mathematics assessment design process as a collaborative, communal project (see Matthews et al., 2021). Traditionally, it is the teacher who determines the learning goals and then designs assessment accordingly. While seeing students as partners, they need to have their voice heard in terms of which assessment practices are used and how. Experiences of co-design might be especially powerful for students with disabilities as this way they could feel sense of agency in how their mathematical skills are assessed: they indeed become subjects in assessment.

Students might co-construct a rubric with the teacher and, in the process, engage in a discussion about the relational standards regarding mathematical skills and knowledge. Students could design novel assessment practices, perhaps drawing on accessible digital technologies. Students with disabilities have been shown not to be able to fully participate in mathematics tests (Bagger, 2022; Nieminen, 2020); students could co-design other, more accessible forms of both summative and formative assessment. Even tests can be communally co-designed as reported by Rapke (2016) in the context of university mathematics. In Rapke's study, students have an opportunity to co-design a mathematics exam, as sitting an exam was required by the regulations of the university. This way this summative practice became a communal process instead of an individualised practice in one given time.

Assessment co-design processes (e.g., students taking part in constructing digital assessment forms) could promote students' understanding of mathematical knowledge and how this could be validly assessed: this is *assessment literacy* in action. As students learn the 'hidden mechanisms' of mathematics assessment, they also learn to examine their own assessment actions reflexively. For example, Nieminen and Lahdenperä (2021) discussed how mathematics students' preference for traditional assessment practices resulted from an assessment culture that undermines students' assessment literacies. Instead, students could be trained to critically examine how mathematics *is* and *should be* assessed, and what their active role in the process could be. Fostering assessment literacy is especially important for students with disabilities. This way students can learn not to only determine themselves as mathematical learners through the assessment information provided by others.

UDA principle 2: Representation & Diversity

The issue: Mathematical knowledge is most often presented in the form of text. While graphs and graphical illustrations are an important part of presenting mathematical knowledge, in the end, what is considered as the most powerful form of representation is abstract mathematical text and notations. In mathematics assessment, *time* has been another crucial determinator of mathematical knowledge. This is most imminent in controlled testing situations. These very boundaries of text and time are not accessible for all learners (Bagger, 2022; Thomas et al., 2015). While inaccessible representation of knowledge can exclude learners from mathematical communities in overt forms (e.g., by dividing students with hearing and vision impairments to segregated classrooms), covert

forms are also present. For example, students with dyslexia might feel they do not belong in mathematical communities due to the dominance of visual text format (Nieminen, 2020).

Much like the original UDL principle, the second UDA principle promotes the idea that mathematical knowledge can be represented through a variety of ways. This UDA principle promotes multiple forms of media in presenting mathematics. For example, mathematical knowledge could be presented in the forms of images, videos, and embodied ways such as dance, gestures, signs and movements. In assessment situations, and especially in summative assessment tasks, enough time should be provided for students for whom time management itself might be an access skill (see Ketterlin-Geller et al., 2015). Mathematical concepts are often presented in unnecessarily complex ways, especially in high schools and universities. The UDA principle reminds about the ableist underpinnings of abstract mathematical text and the preferred fast pace of mathematical learning and assessment. Sometimes it is simply colors and images that are enough to provide accessibility; even such simple ideas might disrupt the ableist norms of mathematical representation. This UDA principle ensures that the need for individual assessment accommodations is lowered, supporting not only students with disabilities but also, for example, those needing extra support with language (Thomas et al., 2015).

In order to be successful, UDA needs to disrupt the ableist norms of mathematics assessment (cf. Nardi et al., 2016; Padilla & Tan, 2019). Nieminen and Lahdenperä (2021) showed how mathematics assessment sets boundaries for what counts as mathematical knowledge, thus setting epistemic boundaries for who can *know* mathematics and how. Even if teaching practices would promote conceptual understanding of mathematics through multimodal ways, assessment might override such representations by reminding what is truly important: individual performance textual summative assessment. Indeed, students in Nieminen and Lahdenperä's (2021) study expressed that the knowledge produced through self- and peer-assessment is *invalid*. According to the students, such formative assessment practices could be used, but exams show what one's *real* mathematical skills are. Such a hegemonic role of tests is ableist, as students with disabilities are excluded not only socially but epistemically. They are taught to understand themselves as the 'others' who are not able to fully participate in one of the most sacred rituals in mathematics education: the exam.

The second UDA principle holds promise for many marginalised forms of knowledge. Mathematics assessment always privileges certain forms of knowledge over others. What students with disabilities learn in mathematics assessment is that their personal epistemologies – the knowledge about themselves, their very personhood through which they operate as mathematical thinkers and doers – are something to be overcome, not celebrated. This of course aligns with the harmful idea of disabilities as deficits (Lambert, 2015). Thus, this UDA principle calls for assessment practices that allow students to inclusively use their "cultural repertoires, identities and out-of-school activities" in assessment (Waitoller & Thorius, 2016, p. 384). In this way, marginalized forms of knowledge can be valued in assessment by offering students various ways to understand themselves as mathematicians. For example, both formative and summative assessment tasks could draw on the language (in its both verbal and nonverbal forms) and cultural knowledge of students themselves.

UDA principle 3: Dialogue

The issue: As noted, mathematics assessment is globally built around testing. Even when other forms of assessment are introduced, tests still remain in the very centre of assessment and grading mechanisms of mathematics. Yet it is tests in particular that causes barriers for students with disabilities (Bagger, 2022). To foster inclusivity, mathematics assessment needs to diversify its practices to enable all learners to show their skills and capabilities.

The UDL principle of Action & Expression promotes various actions through which students can demonstrate their skills and knowledge. The second UDA principle is built on this premise: it reminds that all students have the right to be assessed through a diverse menu of practices (e.g., self- and peer-assessment, portfolios, group assessment…). Such practices should also be provided through multiple forms of media (cf. UDA principle 2). UDA principle 2 focused on the presentation of knowledge, but the third principle emphasises that diverse assessment should be used to widen the very idea of what it is to do mathematics. The principle draws on earlier work that has promoted very similar ideas in terms of mathematical tasks (e.g., Nardi et al., 2016).

This UDA principle promotes *dialogue* as the main purpose of assessment. When assessment draws strongly on summative practices, assessment becomes a monologue. The concepts of 'dialogic assessment' and 'dialogic feedback' have been used to emphasise how the learning potential of assessment is best achieved when students have an opportunity to *use* feedback (Steen-Utheim & Wittek, 2017). This means that assessment is not primarily used as the last word but that students could utilise feedback to enhance their mathematical work and understanding further. Importantly, such feedback could be produced in a dialogue not only with the teacher but with other students as well – or even with non-human actors such as computers (e.g., through automatic digital feedback).

The learning benefits of dialogic feedback and assessment are discussed elsewhere (Steen-Utheim & Wittek, 2017), but here the focus is on how such practices promote inclusivity and accessibility. As summative and formative assessment are both understood as forms of dialogue, focus can be shifted from only discussing the 'validity' and 'reliability' of assessment (as is often the case in mathematics assessment). Just as in any dialogue, the importance of content should surely not be neglected: for example, inaccurate feedback does not promote learning nor inclusion. Viewing assessment as a dialogue it becomes possible to notice all aspects of interaction and dialogue, such as expression of mathematical language (Thomas et al., 2015) and bodily expressions such as gestures and signs. In a dialogue, students with disabilities need to have their voice heard: what novel assessment innovations are yet to be discovered (cf. UDA principle 1)? Could mathematical knowledge be demonstrated through a dance? Tests might have their place in mathematics assessment, but only as a part of dialogue. For example, perhaps students might wish to back up their test results with a digital portfolio where they could save evidence of their learning in various forms (video, images, social media posts…).

Dialogue in mathematics classrooms rarely happens only between the teacher and a student. The third UDA principle also includes the idea of communal interaction within the whole learning community in the classroom and beyond, extending to families and school communities. In mathematics assessment, students often produce artefacts only for the purposes of assessment (e.g.,

tests or essays). However, through communal assessment it is possible to challenge the epistemic idea that mathematical abilities are purely *individual* (Nieminen & Lahdenperä, 2021) by producing something concrete and *useful* as a part of the assessment task (Nieminen, 2022). For example, it is possible to conduct assessment in the form of a communal real-life project. Perhaps students might want to demonstrate their statistics skills by conducting a survey about inequities in their school context. In such communal projects, all students can participate through their personal ways of communication and interaction, everyone working inclusively toward a communal goal.

Just as any dialogue could take multiple and sometimes even surprising turns, mathematics assessment now becomes a risky business. As students with disabilities learn to use assessment and feedback for their own purposes (call it 'assessment literacy' or 'critical thinking'), the results might not be what educators wanted it to be in the first place (students might even decide they do *not* want to engage with mathematics at all!). This is the beautiful risk of democratic education. A sustainable dialogue cannot be dominated by any actor, which also holds true for mathematics assessment.

Conclusion

UDA offers a valuable framework for mathematics education to strive for accessible ways to assess students' mathematical skills. While offering practical tools, UDA is, above all, a way to examine mathematics assessment through a critical lens. It offers mathematics educators a way to render assessment – traditionally a major source for inequity (Bagger, 2022; Nieminen, 2020, 2021) – as a tool for inclusion. Thus far disabilities have been understood as deficits in assessment: if we wish to celebrate diversity in mathematics classrooms, assessment simply must be rethought.

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