UDL: An Alternative to Ability Grouping in Mathematics?

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Despite years of research into the limitations and negative consequences of ability grouping, the practice remains common in primary schools of Aotearoa New Zealand. In this paper we consider a potential alternative to ability grouping following our exploratory study into using Universal Design for Learning (UDL) as an approach for inclusive pedagogy in mathematics. Our case study of a Year 3-4 teacher over the course of one school year illuminated how planning with UDL inspired her to eliminate ability grouping from her mathematics pedagogy (with some relief) and yet still provided access to rich learning opportunities for all the children. However we also noted a tension between the pedagogies of productive struggle/challenge and scaffolding to support anxiety, and we invite discussion on this tension.

Fixed to the whiteboard was the "Maths tumble" and there I was, still in Yellow Two. Yellow was such a stink group to be in—all the smart kids were in Blue, and Green group always got the easy stuff to do. I hated Yellow. And today we were just doing worksheets. Soooo boring! I wanted to do the iPads, or see the teacher, or something from the maths centre, anything but worksheets….

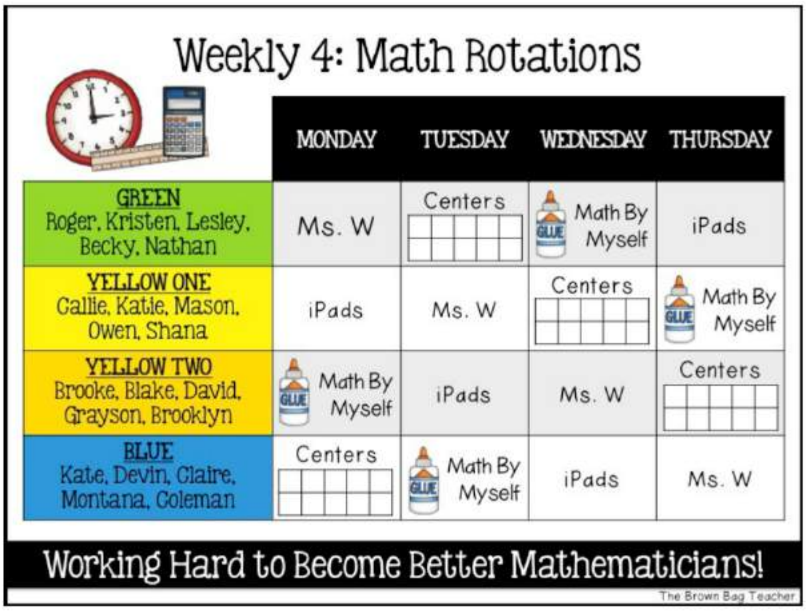

Figure 1. "Maths Tumble" image. Retrieved from https://brownbagteacher.com/reading-and-math-rotation-boards/

The opening vignette is fictional, but it captures the mathematics learning reality for many primary school children in Aotearoa New Zealand, where so-called "ability" grouping (and "maths tumbles" such as depicted in Figure 1) remains a common way to organise learning in mathematics (Anthony & Hunter, 2017; Darragh & Franke, 2021). We contend that the practice of ability grouping forms one of the biggest challenges to inclusive teaching in mathematics. By its design, ability grouping excludes children from mathematics learning opportunities, through limited access to rich content for some groups of learners, and through limited access to the teacher for all groups, who might be with other children 75% of the time.

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Despite decades of research into the negative impact of ability grouping (Wiliam et al., 2004; Zevenbergen, 2005), the practice appears hard to shake. It seems logical to assume that teachers will not break the ability grouping habit unless there is something pedagogically attractive and tangible to replace it. In this paper, we argue that Universal Design for Learning (UDL: Rose et al., 2014) may provide an alternative to ability grouping as it allows a way to plan and teach with everyone in mind, catering to the diversity of learners in our classrooms with the explicit aim of creating access to rich learning for all. In this paper we share the results of a small exploratory study that aimed to understand the challenges of teaching mathematics for inclusion and that trialled UDL as an approach to meet those challenges.

Background: Ability Grouping—A Practice of Exclusion

Research into ability grouping, including streaming, setting, and within-class grouping by so-called 'ability', has a long history globally in mathematics education. Findings are generally consistent that the negatives outweigh any benefits—and for students placed in the lower groups the practice is even more detrimental as it tends to lower their achievement (Wiliam et al., 2004), widens the gap between students variously (and contestably) described as 'high and low achieving' (Hornby & Witte, 2014), narrows teaching (Barclay, 2021; Gervasoni et al., 2021; Wiliam et al., 2004), and promotes negative learner identities (Barclay, 2021; Gervasoni et al., 2021; Marks, 2014; Solomon, 2007; Zevenbergen, 2005).

In Aotearoa New Zealand primary schools, ability grouping is common-place (Darragh & Franke, 2021), particularly since the introduction of the Numeracy Development Project (Anthony & Hunter, 2017; Fitzgerald et al., 2021). In the secondary school context ability grouping practices include setting, streaming, and banding (Hornby & Witte, 2014). Research in Aotearoa New Zealand describes ability grouping as generating equity concerns, with Māori and Pacific students disproportionately placed in lower groups (Anthony & Hunter, 2017; Fitzgerald et al., 2021; Turner et al., 2015) as grouping by so-called ability is subject to teacher bias and low expectations for some students.

Given these negative aspects of ability grouping, why might the practice persist? Possibly it is due to a desire to cater for diverse learning needs, and an assumption on the part of teachers that ability grouping is the way to achieve this differentiation (Barclay, 2021; Fitzgerald et al., 2021). Anthony et al.'s (2019) position paper discusses the "slippery" notion of differentiation arguing that it might either be in the interests of marginalised children, or it might end up reinforcing that marginalisation (see also Webel et al., 2021). A recent special issue of *Mathematics Teacher Education and Development* has explored the topic of differentiation in mathematics (Russo et al., 2021), providing a collection of articles that trouble ability grouping and provide alternatives to this practice. Many of these suggest the use of open tasks with low floor and high ceiling and that promote productive struggle (Barclay, 2021; Ingram et al., 2020; Mellroth et al., 2021; Russo et al., 2021). Other practices include number talks and conversations about strategies (Webel et al., 2021), inquiry communities in heterogenous groups (Fitzgerald et al., 2021) and multi-level approaches involving both changing whole-class instruction and withdrawal interventions (Gervasoni et al., 2021).

Despite the body of research, it remains challenging for teachers to make these kinds of instructional changes (Fitzgerald et al., 2021; Mellroth et al., 2021). Webel et al., (2021) call for more primary school level research into "inclusively responsive instruction … where all students can be supported without grouping by ability" (p. 114). With this in mind, the research question we pose for this paper is:

- How might UDL provide an alternative to ability grouping in mathematics?

Conceptual Frame: Inclusive Pedagogy and Universal Design for Learning

We draw from the concept of 'inclusive pedagogy', which refers to both a *discourse* as well as the *act of teaching* and entails a move away from "deterministic beliefs associated with bell-curve beliefs about ability" (Florian & Black-Hawkins, 2011, p.813). It involves a shift in thinking from an approach to teaching and learning that works for *most students* with additions for *some,* to planning for *all* from the outset (Florian & Black-Hawkins, 2011). It encourages teachers to critically reflect on their teaching decisions to consider whether they might create barriers to participation, or, on the other hand, generate a sense of belonging for all children and celebrate their diversity (MacArthur & Rutherford, 2016). Inclusive pedagogy means that teachers aim to support every child's relationships with others, sense of belonging, and positive identities as a learner (Florian & Black-Hawkins, 2011; MacArthur & Rutherford, 2016).

UDL (Rose, et al., 2014) provides a planning approach for teachers that is consistent with the idea of inclusive pedagogy and it is an approach endorsed in Aotearoa New Zealand (see for example *Te Kete Ipurangi*: Ministry of Education, n.d.). The UDL model sits within the broader field of inclusive education and includes three principles: multiple means of engagement, multiple means of representation, and multiple means of action and expression (Rose et al., 2014). However, research into UDL in mathematics education is still limited. Rachel Lambert has developed "UDL Math" and engaged in various studies to explore the approach (Lambert, 2020; Lambert et al., 2021). For example, during a summer course for mathematics educators the researchers promoted the use of "empathy interviews" together with UDL in order to understand the potential barriers and required supports for learning (Lambert et al., 2021). Paulo Tan (2017) has also promoted UDL as a planning framework in mathematics to ensure that the mathematics is both "for all" and "of all". One final example is Stephan and Dieker's (2022) inquiry into the use of UDL in co-teaching between the mathematics and special education teachers. Such studies highlight the potential for UDL in the context of mathematics.

Methods

Context and Participants

We employed case study methodology (Merriam, 2002) to look closely at one classroom teachers' practice. The teacher, who we name Anna Sunshine, had more than 20 years of teaching experience and had done postgraduate study in 'special' education. The school was situated in a mid-socioeconomic area of Auckland and had a reputation for being inclusive; the principal had completed a postgraduate diploma in specialist teaching with a complex educational needs endorsement. Anna's class in 2022 had 24 Year 3-4 children (aged 7-8 years) and was very diverse; there were 12 different ethnicities represented, 10 children were funded for ESOL support, and 16 children had learning or behaviour support needs identified. Further, the class had been considerably impacted by COVID-19, having only begun schooling shortly before the first in a long series of lockdowns and enforced distance learning. Whilst the class was typically diverse for the context of Auckland, the number of children receiving learning support were greater than usual due to the teachers' experience and expertise.

Our research team included academics from mathematics education, Lisa and Fiona, as well as academics from the field of disability studies and inclusion, Jude and Missy. Together with the school participants, we formed a triangle of expertise with particular areas of knowledge being mathematics, inclusion, and the students in the class.

Data Collection and Analysis

Data collected included interviews, audio-recorded planning meetings, video-recorded lesson observations and reflections. Interviews were held at the start and end of the project, which ran over the full school year. We interviewed: Anna, her colleague and planning partner, the school principal, and the teacher aide who worked in Anna's classroom. Interviews were audio-recorded and ranged from 35 to 70 minutes.

The planning meetings followed a lesson study approach in that we identified a goal, planned the lesson, observed the lesson, and reflected on the goal (Murata, 2011). However, in contrast to typical lesson study, the goal for each lesson was always *inclusion* (defined by presence, participation, achievement, and belonging) for all students, rather than being a goal related to a particular mathematics learning outcome. The lessons were planned with alignment to UDL, that is, we identified possible barriers to participation and achievement and made sure that we planned adaptations to dismantle those barriers. These adaptations were made available to *all* the children in the class during the lesson. Following each lesson we held a reflection meeting (which was typically immediately prior to the subsequent iteration's planning meeting). Planning and reflection meetings ranged from 40 minutes to 1.5 hours and were always attended by Anna and two members of the research team, and variously attended by her colleague/planning partner, the teacher aide, the principal, the other members of the research team depending on their availability. We held four iterations of this cycle altogether.

The lesson observations were made via IRIS Connect technology. IRIS Connect is a platform that enables synchronised video-recording using two I-Pads and an audio device. The synchronised recordings may be shared to a group of users who are then able to make comments that are connected to a time-stamp in the recording. In this way, Anna had autonomy over which lessons to share with the research team, and the entire team were able to view her videos together with her comments in-time, and make their own comments in response. We recorded a total of 333 minutes of mathematics lessons over the course of the year which included seven lessons derived from the four lesson study plans.

Our data analysis was an iterative process. From the initial interviews we engaged in inductive coding to uncover challenges to inclusion, and we used the lesson observations to elaborate these. Prior to the study, Anna's approach to catering for the diversity in her class was to group by ability and use a 'maths rotation' similar to Figure 1, although her groups tended to be somewhat flexible with membership changing regularly. Anna's view that this kind of grouping generated a challenge for inclusive teaching emerged in our initial interviews and thus she was happy to use different strategies for the lesson study iterations. For the purpose of this paper we examine just one of the lesson study iterations and illustrate with some interview data. We share the final iteration of the project: a series of lessons on the topic of *finding fractions of a set*, held on the 17, 18, and 19 October. The lesson was inspired by the problem "Andy's Marbles" from https://nrich.maths.org/2421. In the findings section we briefly describe the lesson and discuss how UDL enabled a differentiated learning experience for the children in the class that was inclusive due to not using ability grouping.

Findings

> I think also, this sounds crazy, but having permission to drop my ability grouping and to kind of go okay these people agree with me this isn't working I'm chucking it out and gosh they are from the university they must know. [...] I guess because I have got so much evidence now it is working, it makes it feel like okay for me to keep going in this way. (Anna, final interview).

By October, Anna had engaged in three iterations of lesson study cycles and was taking increasing ownership over the UDL planning process. Initially she chose to teach 'safer' lessons in the area of geometry, by this lesson she felt comfortable to tackle a riskier topic of fractions. As can be seen in the quote above, she was already happy to do so without any grouping by ability.

"Andy's Marbles" is a challenging problem for students even up to age 11 and thus posed a considerable challenge for the children in Anna's class. The research team certainly thought it was an ambitious task. Anna developed three lessons to build up students' skills and knowledge so that they would be able to access the problem. The first lesson introduced the children to the equipment of counters and fraction rectangles for solving exercises such as $^1/_5$ of 20, $^1/_3$ of 21 (see Figure 2). Anna explicitly modelled for the children "gathering resources" in which she asked herself which resources might be useful to solve the problem, such as selecting the fraction rectangle cut into fifths and counting out 20 of the counters, in the case of the first example. The children were sent away to work in small groups with the equipment and individual whiteboards to solve each problem, then returned to the mat to discuss their solutions after each. Finally, they created their own questions to solve.

Figure 2. Counters and fraction rectangles to solve questions about fractions of a set.

The second lesson introduced the "maths drain"—a piece of equipment Anna made in order to make the notion of 'drain' more accessible (this was an ice-cream container with drain grills cut into the lid—the lid was removable so children would be able to check the number of marbles that went down it). In this lesson Anna posed questions such as: "I had 30 marbles and $^2/_5$ went down the drain—how many marbles did I lose?" The reverse was also asked (e.g. $^2/_5$ went down the drain and I had 18 left, what did I start with?) The final lesson included multi-step questions similar to the one in "Andy's marbles" yet slightly simplified (e.g. "Pikachu had a bag of marbles. $^1/_5$ of them rolled down the drain. Half of what was left dropped into the mud. Pikachu had only 10 marbles left. How many marbles did he have to begin with?"), and then Anna offered the full "Andy's marbles" problem as a final challenge.

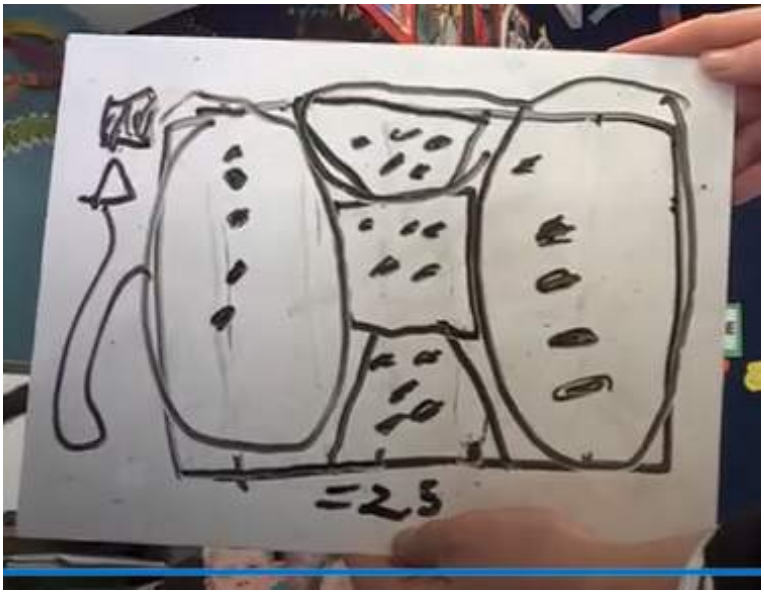

Figure 3. Solution to the Pikachu's marbles question.

UDL requires adaptations to be made to address any barriers to learning and these are then offered to all the students. During the lesson design process we discussed barriers that the children might face. These included the word "fractions" itself—a few of the children had been told by older siblings that 'fractions' was a topic they wouldn't like (Anna had previously solved this issue by teaching the topic of "pieces" instead). We talked about how drawing fractions can be difficult and decided to make some pre-drawn fractions rectangles available for the children to choose from so that they wouldn't have to draw their own. The context itself could have constituted a barrier—the children had difficulty visualising abstract contexts, before even having to pull mathematics from that context (this is the reason Anna built a "maths drain" from an ice-cream container—so that children could see something physical that marbles would drop into). The "maths drain" also enabled students to predict and then check inside as well. Oral language was a potential barrier, partly solved by physical representations of the mathematics and the context. Prior to the mathematics lesson Anna took one child outside to show him a drain and explain the word. Finally, for some of the children anxiety was a barrier that we identified early in the project. Anna knew that all examples would have to begin with easy fractions and small numbers otherwise some children would be "immediately overwhelmed". Yet a high ceiling was built into each lesson, first by allowing students to write their own questions (some wrote ½ of 104 or 1/3 of 99), and then with the increasing complexity of the challenge questions.

Despite the children approaching the series of lessons from very diverse levels of confidence and prior knowledge the lesson activities were successful in several ways. Children were visibly engaged, with high levels of interest and excitement in the tasks each day. Secondly, all children were able to access the problem-solving—we saw full inclusion in that all children were present, participating, achieving, and belonging regardless of their previous level of attainment in mathematics. Perhaps most crucially, by not ability grouping some children had greater access to more sophisticated problems than they might have had if they were taught in an ability group.

> I think I was putting a ceiling on them by ability grouping them because I had predetermined set outcomes for what I wanted in each lesson […] Whereas like yesterday for example looking at [the maths problem] and [one student] completely blew me away […] this sounds awful but yeah, I didn't think he would be capable of that [level], yet he has done it himself. (Anna, final interview)

In short, Anna was convinced that UDL was an alternative to ability grouping. This was further reinforced for her by the high levels of achievement in the end-of-year mathematics testing results Anna reported to us at the final interview.

Discussion and Conclusions

It was clear to the entire research team, as well as the case study participants, that UDL enabled a lesson planning approach that catered to all the children in the class, giving every child access to rich mathematics learning opportunities. Our findings reflect the recent research looking at alternative ways to differentiate; for example the use of a rich task (Ingram et al., 2020; Mellroth et al., 2021; Russo et al., 2021), no ability grouping (Fitzgerald et al., 2021) and plenty of opportunity for discussion (Webel et al., 2021).

However, we have a few caveats. Firstly, UDL requires a teacher with in-depth knowledge of the children in her class. Anna's experience and connection to the learners in her class meant that she could easily anticipate barriers to a high level of specificity. She quickly identified the word "drain" as being likely to cause an interruption to learning—less experienced teachers may not have anticipated this. Using the IRIS technology enabled Anna to get to know the learners even further as it captured their talk when she was away from them. Here is where the anxiety felt by some of the learners emerged. We support Lambert et al.'s (2021) suggestion of using empathy interviews to help teachers get to know the learners in their classes and suggest that more research could explore this important aspect of planning with UDL. Equally, collaboration that supports the sharing of knowledge amongst teachers, children, families, and teacher aides provides further rich information to inform the question of "what works" for each child (Florian, 2017).

Because mathematics anxiety was found to be a key barrier to some children's engagement in the learning, Anna developed her lessons to reduce this anxiety with a carefully scaffolded approach that built up to the challenging task. This raised for us the question of how to balance the notion of struggle (Ingram et al., 2020) with the reality of students suffering anxiety during mathematics lessons. This concern echoes those of the teachers in Mellroth and colleagues (2021) study as they tried to resolve the tension between allowing for struggle without "funnelling" students answers (that is, showing them how to do it). Whilst we observed plenty of struggle in each lesson in the marbles series—every time the children were sent to solve a problem it required them to struggle with the concepts—we also saw funnelling in the very structure of the scaffolded lesson sequence. We suggest there is a tension here and it may well entail a considerable challenge for teachers using UDL to strike the 'right' balance between productive struggle without too much funnelling of the solution approach.

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