The affective impact of inclusive secondary mathematics for learners with Down syndrome: "I just love it!"

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Curriculum decisions about what mathematics should be taught to students with Down syndrome in secondary school are often based on utilitarian goals and assessments of current attainment. We report in this paper on the effect of an alternative approach - adjusting the standard mathematics curriculum for the year level - on students' affective responses. Using three vignettes and the Educational Quality of Life framework we draw out implications for curriculum design for learners with Down syndrome, and more broadly, those with intellectual disability. We conclude by arguing for factoring in the impact on the affective domain of teaching the year-level mathematics curriculum, adjusted as required.

Curriculum decisions about what mathematics should be taught to students with Down syndrome, and intellectual disability more broadly, are often based on two considerations. The first is a utilitarian perspective concerning what students are likely to need in adult life (Faragher, 2019) leading to a restricted mathematics content focus on calculation and measurement. The second is based on a view of mathematics as a hierarchical discipline requiring attainment of perceived foundational concepts before attainment is possible of what are considered 'higher' concepts. From this perspective, it is viewed as essential that assessment of the current attainment of the learner is undertaken in order to determine what to teach next. Both these perspectives, utilitarian goals and assessment of current attainment, are likely to lead to a diminished secondary mathematics curriculum for students with intellectual disability.

In this paper, we present initial findings from a research project that is exploring possibilities of an alternative approach. We are working with experienced secondary mathematics teachers who have a student with Down syndrome in their regular classroom with a view to supporting them to make the year-level curriculum available to all students, with appropriate adjustments.

Affect and mathematics learning

In an initial conversation about the project, a teacher asked whether we anticipated students in the study would experience distress due to having to do year-level mathematics. This teacher was reflecting a widespread negative affective response to mathematics (Buckley & Reid, 2013). In contrast to this reflection, some students with Down syndrome had very different responses, indeed, the few we knew who were taught mathematics beyond arithmetic seemed to enjoy it very much. In this paper, we explore the idea that students who are not high attainers in mathematics might nevertheless experience positive emotions in their mathematics lessons. High achievers are unlikely to be alone in enjoying a challenge, working on problems, being with their friends, and successfully completing exercises.

It is well-established that negative affect has detrimental effects including a negative association with mathematics achievement (Thomson, de Bortoli, & Buckley, 2013). There

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is also evidence of the converse relationship; that is, an association between mathematics attainment and positive emotions (Villavicencio & Bernardo, 2016) and attitudes (Thomson, Wernert, O'Grady, & Rodrigues, 2017). In their review of the literature, Villavicencio and Bernardo identified the outcomes of emotions on learning that have been summarised in Table 1. These results of positive emotions (e.g., self-efficacy, interest, engagement) are associated with enhanced mathematics achievement (Thomson et al., 2013) since they lead to a tendency to choose more difficult tasks, expend greater effort, and persist for longer (Villavicencio & Bernardo, 2016). Student engagement in school is also related to the intrinsic motivation that comes from school success (Larson & Rusk, 2011, cited in Chase, Hilliard, Geldhof, Warren, & Lerner, 2014) which is a likely reason for which teachers may be hesitant to offer students with intellectual disabilities challenging mathematics.

Table 1
Outcomes of emotions on learning as identified by Villavicencio and Bernardo (2016)

Positive emotions lead to improved:	Negative emotions adversely affect:
Goal setting	Motivation
Self-efficacy	Cognitive strategies
Intrinsic task interest	Perceived control
Cognitive processing and actions	Self-efficacy
Confidence	Achievement
Hope and optimism	Problem-solving
Engagement in learning tasks	Learning goals
Specifically related to mathematics:	
Confidence	
Effort in learning	
Achievement	
Self-regulation	

In addition to the impacts identified in Table 1, enjoyment – or its obverse – influences continued engagement in a task. A moderate level of challenge (i.e. a task that is not too easy nor too hard) is the level of challenge that is associated with most enjoyment (Csikszentmihalyi, 1990). Optimum challenge is also associated with persistence (Gilmore & Cuskelly, 2009), a necessary element of successful learning. In the following section, we turn to the field of disability studies to understand the impact of learning challenging mathematics from another theoretical perspective, that is, through the lens of educational quality of life.

Educational Quality of Life

Quality of life (QOL) is an established theoretical framework in the field of intellectual and developmental disabilities (Schalock, Keith, Verdugo, & Gomez, 2010). A development of this framework has produced a model of Educational Quality of Life (EQOL). EQOL, from a theoretical perspective, acknowledges links with QOL in general through five foundational *principles*. These principles are indicated in Figure 1. For detail of the development of EQOL, see Faragher and Van Ommen (2017). QOL models include *domains* and *indicators*. Domains represent aspects of the construct and indicators are a guide to how QOL may be measured or assessed in the domains.

Of the five principles, *Student voice is central* has particular relevance to this paper. Student voice is an indicator to consider in the domain of *Learning*, along with *Student well-being* and *Student identity*. EQOL can be improved by responding to students through listening to their voice, enhancing their well-being, and making efforts to support their engagement with mathematics. Combining the EQOL model with the research undertaken on mathematics affect emphasises the value of exploring positive emotions exhibited as a result of learning challenging mathematics.

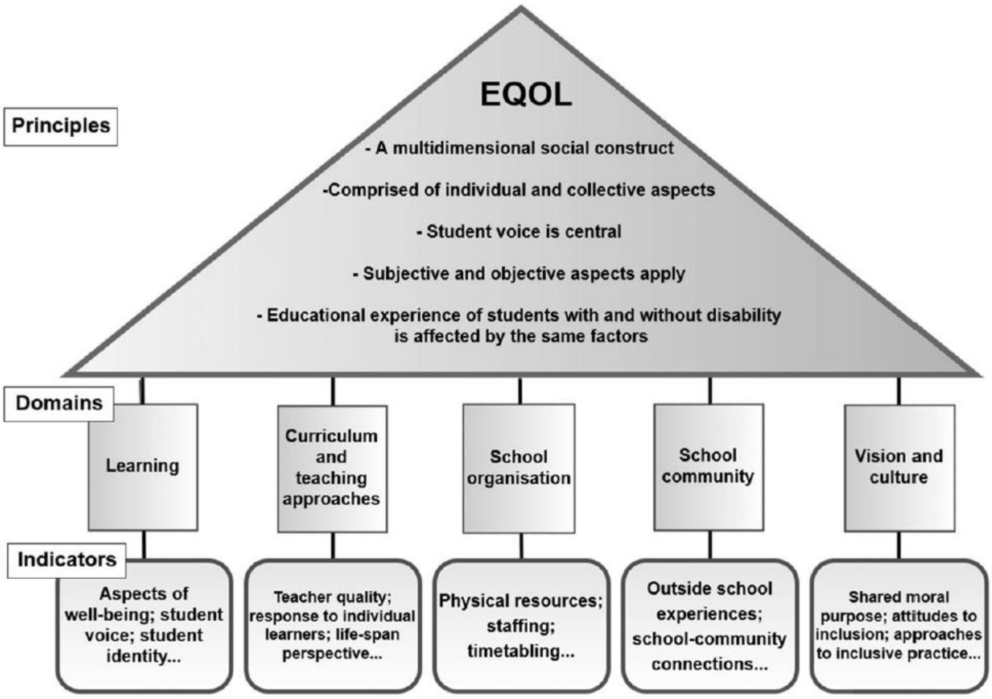

Figure 1. Overview of the model for educational quality of life, from (Faragher & Van Ommen, 2017, p. 44)

Methodology

Our current study is investigating the work of secondary mathematics teachers as they adjust year-level mathematics from the Australian Curriculum for students with Down syndrome in their regular classes. The data reported in this paper comprise a subset from that research. The broader study uses a case study methodology where the teaching team around a student with Down syndrome forms the case. There are five cases – three in Brisbane, one in Sydney and one in Tasmania. Involvement for teachers began with completion of an on-line professional learning module, which was followed by observation rounds, one each term. The study commenced in 2018 and continues in 2019. In some of the cases, the student has stayed with the same teacher into the second year. In one school, one teacher has taken a different class and as a result taught one student participant in 2018 and a different student participant in 2019. Another teacher at the school taught one participant for a term, covering for a teacher on leave, and is now teaching a new student with Down syndrome who has just been enrolled in the school. A third teacher has commenced with the project this year. The online professional learning materials were designed in expectation that teachers would join the project at different times throughout the research cycle.

Each observation round involves a planning discussion where the teacher works alongside a member of the research team to plan adjustments to a mathematics lesson that they have already planned for their class. These planning discussions take a variety of forms in response to teachers' requests or needs. In some cases, it is a professional conversation involving sharing of ideas and approaches. In others, the planning discussions can be more directed, in cases where teachers have asked for specific support.

Observing in the classroom context

Following the planning, the lesson in action is observed with a video recording being made focusing on the work of the student with Down syndrome. Depending on decisions made during the planning process, the role of the researcher varied. In some, the researcher was an observer, taking field notes, photographs, and the video recording. In others, she participated in a team-teaching role, and once undertook the teaching. Her role is explained in each vignette.

Capturing the student voice

In the initial design of the research protocol, it was planned to interview the students to capture their views on their learning but this proved not to be a fruitful way of gaining the data we needed. Even in casual settings, such as walking to class or chatting in the library, once direct questions about learning were asked, students who did not know us well became silent. This is consistent with research that has indicated that measurements of the expressive language of children with intellectual disability are reduced when they are tested in unfamiliar contexts (Brown & Semple, 1970) and questions are particularly difficult for learners with Down syndrome (Morgan, Moni, & Jobling, 2009). Instead, therefore, we used less direct techniques. Specifically, we have captured affective responses on video recordings of the students while involved in their mathematics lesson. Other insights emerged from incidents observed during and peripherally to the observed lessons.

Participants

In this paper, we present the analysis of data from three of the study's student participants. Relevant details are given in Table 2. For each participant, two lessons were observed: One in Term 3 and one in Term 4, 2018.

Table 2
Participant details

Pseudonym	Year level	Notes
Brian	11	Studying *Prevocational Mathematics*
Pete	9	Limited verbal communication
Jay	8	Assessed as being at a year 3 level for number work

Results

Vignette 1 – Brian

In Brian's case, the researcher engaged in planning discussions with the teacher, observed and videoed lessons, and followed the lesson with conversations in person, by phone, and with email.

Brian, like most students with Down syndrome, had considerable difficulty with arithmetic. In order to support his study of mathematics, his teachers had encouraged his use of a calculator. In the observed lesson, Brian was calculating the perimeter of a car park which involved adding many different lengths using his calculator. He was working alongside a teacher aide who noticed his result seemed too high. The teacher aide suggested Brian re-enter the numbers. A different, and also incorrect, answer was obtained. His teacher came past, as part of her moving around the different student groups. She brought out her calculator saying they would do it together, and the teacher aide, moved away to help other students. It became clear that the student was sometimes pressing the + key twice. In the discussion following the lesson, the researcher suggested using a calculator that showed the calculation on the display and offered to find a model.

Later that afternoon, the researcher emailed a possible model, but the teacher had already sourced one. She had noticed a student using a graphics calculator and thought that would serve the purpose. Graphics calculators are sophisticated devices that have large displays and features for a range of mathematics including graphing, statistical calculations and displays. The features were particularly relevant for the statistics unit of work to be studied in the following term. Over the holidays, the teacher prepared instruction sheets to guide the student in the steps required to use the graphics calculator. She also undertook task analysis and produced cards with memory joggers for the statistics tasks. She made two copies of each card, one for Brian and one that was left on the front desk as a resource for the other students, who made frequent use of them.

In the second observation lesson, the students were working on an extended problem-solving task for an assessed assignment on statistics. Following a data collection phase, the teacher offered Brian his next task sheet requiring calculations of mean, median and mode. Brian responded with what can only be described as glee. He clapped his hands and grinned broadly, exclaiming, “I just love it!!”. When asked by the researcher what he loved about the task, he replied, “I love using my calculator for mean, mode and median!”.

Vignette 2 – Pete

Pete used little verbal communication and his teacher was unsure how to include him in the regular Year 9 class. In the planning conversation, it was decided that the researcher and the teacher would plan the adjusted lesson. The teacher is supported by a teacher aide; however, teacher aides are rarely involved in planning processes and was not on this occasion. The lesson was on trigonometry and the class was revising concepts for a test. Usually, Pete would work on different material with the teacher aide, often on topics related to money. Through the planning discussion, the researcher and teacher decided to plan a lesson for Pete based on the concepts being revised by the class. Because Pete was a shy student, it was thought unlikely that he would respond to a relative stranger, the researcher, teaching him. Instead, the adjusted lesson was designed to include a peer tutor, Ted, a good friend without disability with whom Pete enjoyed working. The learning goal for Pete was that he would be able to identify right angled triangles from a collection and to mark the right angle with the standard symbol. It was agreed that the teacher would observe as well as teach the rest of the class.

The observed lesson followed the morning tea break but Pete was not among the students as they filed into class. He had decided he did not want to come to mathematics and had taken himself to the office and called his father to collect him. Participants can withdraw from studies at any time and so the researcher was preparing to pack up when Ted announced he was sure he could encourage Pete to come to class. The researcher walked with Ted to the office and observed him chatting with Pete, telling him they would work together and it would be fun.

On returning to class, Pete took his usual place next to his friend, Ted, at desks in the first row of the class. As the teacher started the introduction to the lesson, the teacher aide moved up beside Pete and produced the folder of alternative work. Pete’s face fell and he looked at Ted with dismay: the teacher had forgotten to inform the teacher aide of the change of plan. The researcher quietly explained the lesson approach and the teacher aide moved to the back of the room and supported other students during the lesson. The researcher, Ted and Pete took turns to identify the right angles. The researcher went first, explicitly showing how to line up each angle with the corner of a page until there was a match. The first triangles used were all right angled to ensure success. The standard box symbol was then drawn on the right angle. Gradually, non-right-angled triangles were introduced. Results were recorded on two posters, one marked 'yes' where right angled triangles were glued and one marked 'no' for other triangles. Both the teacher and the researcher observed the student at the end, picking out a triangle that looked right-angled to test it first. It was clear he knew what he was looking for. Pete persisted with the task to the end of the lesson. At no point was he distracted or off-task. At pack-up time, he held his posters and grinned at the camera.

Here we see a student persisting and enjoying his work in the company of his friend. Judicious use of peer-tutors has been shown by previous research to be an effective strategy (McDonnell, Mathot-Buckner, Thorson, & Fister, 2001). Clearly, it should not be the case that peers should be called on to do the teaching to the detriment of their own learning. In this lesson, Ted was already confident with the concepts being revised. Other students could undertake a similar role in other lessons, as could a teacher aide.

Vignette 3 – Jay

Jay was in Year 8 in 2018. Although assessed as being at Year 3 level in number work, he had been successfully working on year level content alongside peers in the bottom stream class. Because of his success, the research role was to observe the lesson in Term 3, following a planning discussion on the morning of the lesson. In Term 4, the class teacher was on leave and the class was taught by a teacher on contract. However, observation of that lesson was undertaken without prior planning discussion.

In the Term 3 lesson, the class were learning about the use of power notation. They were required to expand numbers expressed as powers e.g. 2^4; and to simplify expressions using power notation. Jay was intensely focussed on the task for the full lesson and followed the board work closely. The teacher aide, who sat beside but slightly behind him, assisted by directing him when to stop work on the worksheet and attend to the teacher at the board. He did not need to provide other instructional assistance to Jay, so he assisted other students as required. Jay could be seen counting and checking his work. He completed the worksheet as assigned to the whole class, in the set time and without error.

The Term 4 teacher was happy to have the lesson observed although shared planning discussions had not taken place. The lesson was on writing and interpreting ratios. Again, Jay was seen to be actively attending throughout the lesson. There was a teacher aide assigned to the class but he did not work with Jay. The teacher introduced the task with whole class instruction at the board. The students were then given exercises on a worksheet. Jay was given an easier worksheet straightaway. The researcher approached the teacher and quietly asked if she would consider offering Jay the unadjusted worksheet. Without hesitation, she agreed. She explained later that she assumed he would need a modified task.

Initially, Jay seemed concerned that he had two sheets to complete. His Term 3 teacher had explained he gains satisfaction from completing tasks. In the observed lesson, the teacher recognised his concern and emphasised that he did not need to do the first sheet unless he wanted to. As Jay set to the tasks on the unadjusted sheet, he misread the instructions at the top. He thought he had to count all the objects drawn, rather than writing the ratio. The researcher observed his error, and at this point, made the decision to intervene to prevent the student reinforcing an error through many examples. With a restatement of the instructions, Jay went on to complete the worksheet without further error.

There are important points to consider here. Jay enjoyed completing assigned tasks. He was able to work at his year level without adjustment; however, the automatic assumption that a student with Down syndrome will need simplified work could be a risk to his opportunities to do so. A further point concerns the danger of practising an error, if not caught at the time. The role of the researcher here was not that of a detached observer.

Indeed, it could be considered unethical to allow a student to experience negative consequences without intervening. As it happened, the student completed year-level work, though he is considered to be five years behind his peers as assessed by formal measures. We cannot know what would have happened without intervention. We do not know if the teacher (who was busy moving around the class) would have redirected the student. If that had occurred early on, little harm may have been done. If later, the problem of reinforcing errors might be compounded with a possible loss of Jay's confidence in his ability to complete the work. It could be that the teacher was less inclined to interfere in Jay's work when the lesson was being observed. Even though the teacher was encouraged to take the lesson as she normally would, the presence of an outsider with a video camera, notebooks and cameras means the context was necessarily different.

Discussion and Conclusion

In the vignettes presented we see three students studying year level mathematics at various levels of adjustment. Our purpose in this paper is to explore the affective domain to the extent that it can be observed. The three students had their own ways of showing their emotional responses to the lessons. Brian gave overt signs of joy and explained in words that he loved using his graphics calculator. Pete used non-verbal communication through smiles and sustained engagement with the task to indicate his affective response. Jay, too, showed sustained engagement and intense focus on the work at hand. As noted earlier, it is challenging to gain direct evidence of affective responses from individuals with limited verbal communication. Indirect observational techniques are well-established in the intellectual disability field and are particularly useful for studying quality of life of individuals with profound or multiple disabilities (Lyons, 2005). In mathematics education, experienced teachers are similarly familiar with observing subtle communication of affective responses – both verbally and non-verbally. The researchers on this project comprise two experienced mathematics teachers and researchers and two experienced researchers in disability studies. This gives us some confidence in the trustworthiness of our interpretation of the observational data.

From the assumption of the validity of our analysis, we return to the attributes listed in Table 1. We have evidence of intrinsic task interest (Brian, Pete and Jay staying focussed throughout their lessons), self-efficacy (Brian's confidence in the use of the sophisticated calculator), goal setting (Jay wishing to complete the task) and all three students staying engaged in the tasks assigned. Research cited by (Villavicencio & Bernardo, 2016) indicates these are predicted by positive emotions arising from learning. The benefits for future learning of mathematics as indicated in Table 1, are promising for these three students. Continuing to be taught year level mathematics curriculum may be important to that end. Indeed, withholding year-level mathematics curriculum from students based on utilitarian or hierarchical views of mathematics, or indeed, a view that students will not enjoy the experience is not defensible. The beneficial impact on their affective development through learning year-level curriculum can be dramatic and has implications for enjoyment and classroom engagement with subsequent positive impacts on EQOL.

The EQOL model indicates that hearing the student voice, beyond spoken words, can lead to improvements in well-being and other indicators (Figure 1) that have a beneficial impact on learning. The implications for curriculum decisions are clear: low-attaining students can enjoy learning challenging mathematics and important benefits follow from the positive affective experience in allowing them to do so. The affective implications for their teachers remain to be explored, although we have witnessed the emotional boost teachers experience when they see the joy and accomplishment of their students.

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