

MULTISENSORY LEARNING FOR STUDENTS WITH DISABILITIES

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Multisensory learning is an educational approach whereby a variety of sensory cues provide learners with alternative experiences of concepts. In exploring New Zealand secondary school mathematics and statistics teachers' use of multisensory learning, the impact of teaching students with a range of disabilities is considered. The use of multisensory elements appears to be dependent on the senses being utilised and the kind of disabilities these students have. A teacher's preference towards multisensory learning is therefore influenced by these factors. When considering the extent of multisensory elements to be included in task design, it is important to consider the intended users and accessibility of these features. Because statistics is a visually-dependant subject, there is a need for more research into how we can expand inclusivity in statistics education.

BACKGROUND

Constructivism will be referenced as the learning paradigm model that represents the perspective on learning processes in this paper. Constructivism will be considered broadly, collating Piaget's cognitive constructivism, Vygotsky's social constructivism, and von Glasersfeld's radical constructivism (McLeod, 2019). Focussing on building knowledge, active learning, and social interactions, constructivism can be seen in classrooms today as a student-centred learning environment (McLeod, 2019). In a statistics classroom specifically, the constructivism model could be implemented in various ways (McLeod, 2019; Miller, 2002):

- simulations,
- student-generated data,
- predictions,
- presentations,
- group discussions,
- using physical materials, and
- multiple representations.

Multisensory learning is one method for creating an active learning environment, specifically relating to the use of physical materials and multiple representations (Neo, 2007; Renelle et al., 2019; Taljaard, 2016). Multisensory learning involves using sensory cues (such as visual, verbal, tactile, kinaesthetic, auditory, and olfactory senses) to provide learners with novel experiences of concepts covered in class (Broadbent et al., 2020). Provided the use of multiple senses is congruent with prior experiences (Mitchel & Weiss, 2011; Shams & Seitz, 2008), multisensory learning is a beneficial teaching method, particularly for students with learning difficulties and disabilities (Cosentino et al., 2020; de Sousa et al., 2019; Ministry of Education, New Zealand, 2021).

In this paper, seven 'senses' will be considered: visual (images, words, calculations), verbal (student discussions, presenting), sound (non-verbal), tactile (students creating/making, hands on), interactive (online tools), olfactory (food and smells), and active (body movements).

Demonstrating the need for multisensory learning for expanding statistical education inclusivity to those students with disabilities, de Sousa et al. (2019) illustrated how statistics could be taught to visually impaired students using braille and tactile tools. Statistics classrooms commonly use visualisations to help teach concepts (Renelle et al., 2020); however, this means visually impaired students, for example, miss out on important learning opportunities if alternative sensory cues are not utilised (de Sousa et al., 2019). Multisensory learning can also help dyslexic students, relating to phonological difficulties, and help to clarify lexically ambiguous concepts, such as "randomness" (Cosentino et al., 2020; Kaplan et al., 2009; Richardson et al., 2008). For an average student, multisensory learning also aids learners' memory (Mitchel & Weiss, 2011; Purinton & Burke, 2019; Shams & Seitz, 2008).

The National Center on Birth Defects and Developmental Disabilities and Centers for Disease Control and Prevention (2020) define a disability as “... any condition of the body or mind (impairment) that makes it more difficult for the person with the condition to do certain activities (activity limitation) and interact with the world around them (participation restrictions)” (*What is disability?* section, para. 1). Activity limitation and participation restrictions mean students with disabilities may need their teachers to utilise different senses in classroom tasks to ensure effective learning can still take place. The teaching adaptations required will depend on students’ needs. As an exploratory study, this paper will refer to disabilities broadly. Participant examples of student disabilities will be presented, but the aim of this paper is to demonstrate the need for more research in education equality, rather than to expressly demonstrate how to support the diverse range of disabilities teachers may attend to.

Some senses lend themselves to statistics education more than other senses. For example, in a statistics classroom, as well as using graphs and diagrams (visual), teachers could include physical simulations (active), random devices (tactile—coins, etc.), drag-and-drop online tools (interactive), and carry out in-class experiments (active). Students with dyslexia and/or dyscalculia, Attention Deficit (Hyperactivity) Disorder (AD(H)D), and/or Oppositional Defiance Disorder (ODD), as well as students with auditory impairments all tend to prefer hands on learning that helps make concepts more concrete (Ministry of Education, New Zealand, 2021). This suggests utilising visual, tactile, interactive, and active elements would be beneficial in creating a supportive learning environment for these students. The use of these senses naturally fit to statistical concepts and are often promoted by statistics education literature.

Presentations and discussions (verbal) would also be easily introduced in statistics classrooms but students with auditory impairments, autism spectrum disorder (ASD), Muscular Dystrophy, Down Syndrome, Dyspraxia, and/or Dysphasia may find this challenging to engage in (Ministry of Education, New Zealand, 2021). An alternative may be interactive, online activities that have appropriate accessibility settings. However, computer screens are not always an easy solution and can make learning difficult for students with Irlen Syndrome, for example.

Because statistics often relies on visualisations, students with visual impairments can have a particularly difficult time learning statistics. Students with visual impairments may prefer auditory (verbal and sound) and tactile mediums (Ministry of Education, New Zealand, 2021). Although tactile tasks, such as using random devices, may be easily adopted in a classroom, the use of sounds is novel (Renelle et al., 2020).

Although the use of multisensory learning is consistent with current learning paradigms implemented in classrooms and can benefit students’ learning, particularly students with disabilities, a search of the literature failed to uncover research that explored teachers’ beliefs about using multisensory learning in their classrooms. Specifically, the following research explores the question of whether teachers who needed to adapt their teaching to facilitate students with disabilities (such as the scenario described by de Sousa, 2019) are more accepting of multisensory learning than those teachers who have not needed to adapt to this.

METHOD

Appendix A presents four questions from the Multisensory Learning Questionnaire, which was implemented in December 2020. The questionnaire was created in Qualtrics (<https://www.qualtrics.com>) and aimed to investigate the potential benefits and challenges with using multisensory learning in classrooms. This was an online, anonymous questionnaire distributed to New Zealand secondary school mathematics and statistics teachers ($n = 20$) via an email mailing list, compiled from recruitment through several New Zealand mathematics and statistics associations. Because there is limited previous research investigating teachers’ perceptions of utilising multisensory learning, the questions asked were developed for this research. In terms of validity, the categorisation of listed disabilities was confirmed by the researchers, independently, but the questions regarding frequency of use and barriers to use were only asked in one way, so conclusions cannot be cross validated.

In Q6.2 of the Multisensory Learning Questionnaire (Appendix A), participants were asked to list all disabilities they encountered in their classroom (meaning participants could list more than one). To be able to better compare participants’ acceptance of different types of multisensory learning and the needs to which they adapt their teaching, the list of disabilities was categorised into one of six groups. Disabilities are not defined by one characteristic and often present on a scale, however. This means the

grouping suggested in Table 1 only attempts to classify the disabilities so that they could be more easily discussed in terms of multisensory learning.

Table 1. Categorisation of disabilities encountered by participants

<i>Category</i>	<i>Example</i>
Learning Disabilities	For example, dyslexia and dyscalculia ($n = 6$)
Behavioural Disabilities	For example, ADD and ADHD ($n = 8$), and ODD ($n = 1$)
Auditory Disabilities	Partial or complete deafness ($n = 5$)
Visual Disabilities	Visual impairment ($n = 5$)
Neurological Processing Disabilities	Irlen Syndrome ($n = 2$), dyspraxia ($n = 1$), and dysphasia ($n = 1$)
Developmental Disabilities	ASD ($n = 4$), Muscular Dystrophy ($n = 1$), Down Syndrome ($n = 1$)
None	No disabilities listed ($n = 6$, including 1 participant who indicated they do teach students with disabilities at least once per week)

RESULTS

The use of multisensory elements in classrooms appears to depend on the frequency teachers connect with students who have disabilities. Demonstrating this, as seen in Figure 1, those who never teach students with disabilities indicated they always or mostly use visual mediums but use other senses half the time or less. Teachers who interact with students with disabilities once a month suggested they use visual, verbal, and/or interactive elements most of the time. By comparison, participants who teach students with disabilities once a week always used the visual medium and implemented activities using visual, verbal, interactive, and/or active elements most of the time. Those participants who teach students with disabilities every day indicated they always or mostly use visual and interactive tasks and most of the time use verbal and tactile tasks. Participants who teach students with disabilities tend to have a higher variety of multisensory elements that they try to implement in their classrooms at least some of the time.

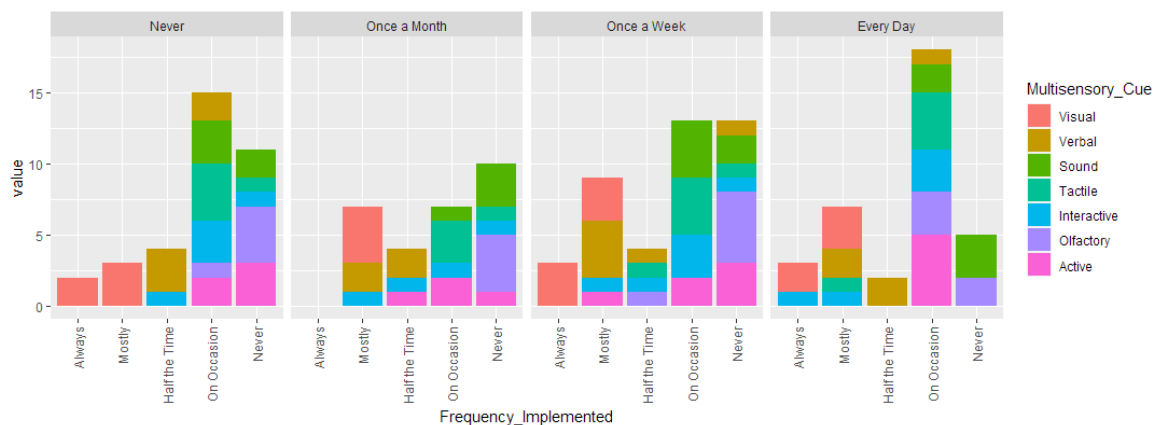


Figure 1. Counts for the frequency in which each multisensory cue is implemented by participants who teach students with disabilities never, once a month, once a week, or every day

As can be seen in Figure 2, visual mediums are used most often by all participants. Understandably, particularly with COVID-19, olfactory senses are used least often by all participants. Those who indicated olfactory elements are sometimes used teach students with auditory, neurological processing, and/or visual disabilities. Regardless of the disabilities students in their classes have, participants rarely use sounds in their classrooms.

Participants with students who have behavioural, developmental, and/or visual disabilities use verbal cues half the time, as shown in Figure 2, whereas teachers with students who have auditory,

neurological processing and/or learning disabilities use verbal activities slightly more often than this. Teachers with students who have auditory disabilities use interactivity more than half the time. Half the time, teachers with students who have visual and/or neurological processing disabilities will use interactive tasks, whereas those who teach students with developmental disabilities rarely use this. Figure 2 also highlights that tactile elements are used by participants who teach students with neurological processing disorders half the time, whereas tactile activities are used occasionally by teachers with students who have auditory, behavioural, learning, and visual disabilities or rarely by teachers with students who have developmental disabilities. Active elements were implemented most commonly by participants who teach students with visual disabilities—up to half the time. Active elements are also occasionally used by teachers with students who have auditory and/or neurological processing disabilities.

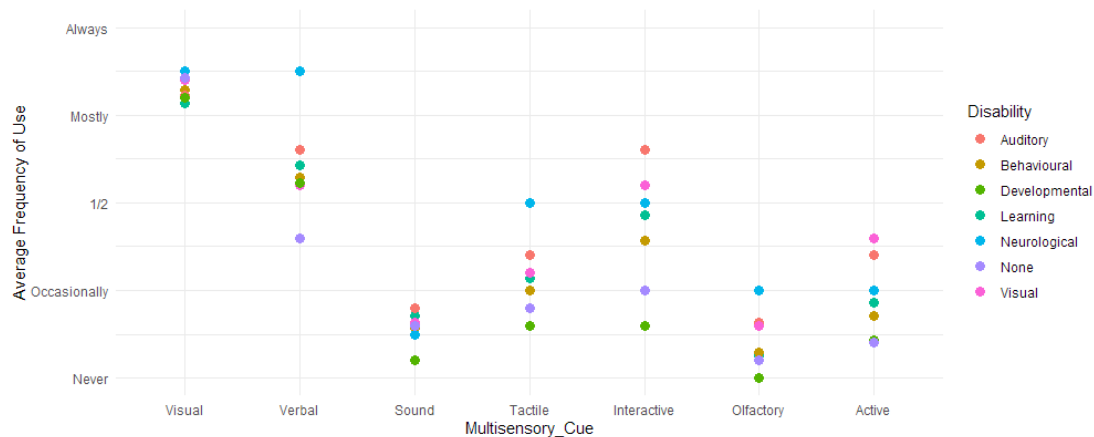


Figure 2. Average use of multisensory cues in participants' classrooms depending on the student disabilities being accommodated

Somewhat surprisingly, as seen in Figure 3, the participants who felt multisensory learning did not help students obtain a deeper level of understanding teach students with disabilities once a week or once a month. The only participants who did not disagree that multisensory learning increases students' motivation were those who teach students with disabilities every day but, by comparison, the only participants who did not disagree that multisensory learning is enjoyable never teach students with disabilities. The participants who agreed that they were expected to use multisensory learning were only those who taught students with disabilities every day. No participant felt that they had access to good professional development (PD) or access to resources that use multisensory learning. Those who somewhat agreed with this teach students with disabilities every day (somewhat good PD) or once a week (somewhat ample resources).

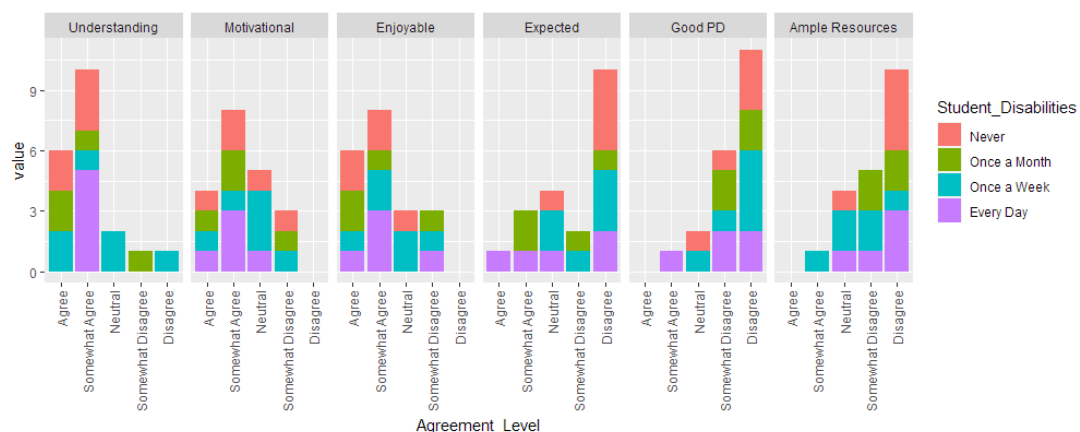


Figure 3. Level of agreement for each part of Q5.3 by frequency of student disabilities

IMPLICATIONS

Because the use of multisensory elements in classrooms appears to potentially depend on the frequency teachers interact with students who have disabilities, it could be important to demonstrate the benefits of multisensory learning to the wider teaching community. Although it seems that teachers who support students' disabilities using multisensory learning already witness advantages to using a variety of senses beyond just visual mediums, better PD and access to resources could encourage the adoption of multisensory learning in more classrooms. For those who teach students with disabilities, the use of some senses more than others depends on the learning preferences of those students, as noted in Background section (i.e., students with Irlen Syndrome tend to dislike computer screens). Careful consideration of the needs of students in the classroom is essential. Multisensory learning does not require engagement with all senses, but the thoughtful selection of alternative senses for certain tasks could offer students a deeper understanding of some concepts and make learning more accessible for students with disabilities. In task creation, accessibility should be considered and incorporating multiple senses could provide students with different avenues for interacting with the task. Not only is multisensory learning beneficial for typical students, it is also an important step towards better inclusivity for our students with disabilities and minimising the gap in education inequality.

Limitations of this research includes the use of subjective measures (whereby participants may interpret the meaning of 'on occasion' differently, for example), voluntary sample (which is unlikely to be representative of all New Zealand secondary school mathematics and statistics teachers), and a lack of internal validity. In particular, the use of subjective measures has limited descriptive validity as the authors cannot be certain of participants' meaning when they say they use a sense 'on occasion' or 'mostly.' The sample is also subject to selection bias and non-response. Also, as a predominately multiple-choice questionnaire, responses are limited compared to the information that might be gathered during focus group sessions, for example. Due to COVID-19 and the stress the teaching community was facing, it was deemed most appropriate to implement questionnaires that were easy to complete and did not take up a large amount of time.

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APPENDIX A: Questions asked to participants in the Multisensory Learning Questionnaire

<p>5.1 Think about the kinds of activities you have done in your class. Please indicate how often each sense is usually engaged across all of these activities.</p> <table border="1"> <thead> <tr> <th></th> <th>Always</th> <th>Most of the time</th> <th>About half the time</th> <th>On occasion</th> <th>Never</th> </tr> </thead> <tbody> <tr> <td>Visual – images, words, calculations</td> <td><input type="radio"/></td> <td><input type="radio"/></td> <td><input type="radio"/></td> <td><input type="radio"/></td> <td><input type="radio"/></td> </tr> <tr> <td>Verbal – student discussions, presenting</td> <td><input type="radio"/></td> <td><input type="radio"/></td> <td><input type="radio"/></td> <td><input type="radio"/></td> <td><input type="radio"/></td> </tr> <tr> <td>Sound – non-verbal sounds (bells, clicks)</td> <td><input type="radio"/></td> <td><input type="radio"/></td> <td><input type="radio"/></td> <td><input type="radio"/></td> <td><input type="radio"/></td> </tr> <tr> <td>Tactile – students creating, making, hands-on</td> <td><input type="radio"/></td> <td><input type="radio"/></td> <td><input type="radio"/></td> <td><input type="radio"/></td> <td><input type="radio"/></td> </tr> <tr> <td>Interactive – online tools, clicks, dragging</td> <td><input type="radio"/></td> <td><input type="radio"/></td> <td><input type="radio"/></td> <td><input type="radio"/></td> <td><input type="radio"/></td> </tr> <tr> <td>Taste and Olfactory – food and smells</td> <td><input type="radio"/></td> <td><input type="radio"/></td> <td><input type="radio"/></td> <td><input type="radio"/></td> <td><input type="radio"/></td> </tr> <tr> <td>Active – body movements. 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<p>6.1 Do you work with student/s who have disabilities?</p> <ul style="list-style-type: none"> • Yes, every day • Yes, at least once a week • Sometimes, at least once a month • No, at most once per year • No, never 	<p>6.2 In the previous question, you indicated you work with student/s who have disabilities at least once per month or more. Without providing identifying details, please describe the kind of disabilities you encounter. For example, one visually impaired student or a group of students with severe disabilities. This will help us understand how your previous responses might differ from those teachers who do not regularly work with students who have disabilities.</p> <hr/>																																																																																																