Supporting Successful Statistics Learning for Neurodiverse Students

By Michelle Bower & Ibrahim Dahlstrom-Hakki

According to the National Center for Learning Disabilities 2017 report, 1 in 5 children experience significant issues with learning due to underlying cognitive differences (Horowitz, Rawe, & Whittaker, 2017). The National Center for Education Statistics reports that 13% of all students in school have an Individualized Education Plan (IEP) meaning that the base curriculum must be significantly modified to meet their needs. Furthermore, many of the challenges commonly faced by neurodiverse learners are not unlike those faced by other populations of students that typically struggle in the classroom. For example, both students with dyslexia and English Language Learners (ELLs) struggle with word problems in math, and while the underlying reasons for the struggle may differ, many of the same approaches can be beneficial to both populations. In this article, we will provide some suggestions to help teachers make their classrooms more inclusive of a neurodiverse population, as well as suggestions to empower neurodiverse students to take a proactive role in improving their access to content.

What is neurodiversity?

Neurodiversity is a term that has been increasingly used to define a broad range of individuals whose brain neurology significantly differs from the norm. Originally coming out of the autism community, it is increasingly being used to describe other populations of students with disabilities including those with learning disabilities and ADHD. The term aligns with a reconceptualization of these disabilities as representing normal variability in human cognition rather than disorders of the brain. The disabilities experienced by neurodiverse learners in education are increasingly seen as shortcomings of a rigid system rather than failings of the individuals themselves.

What are strengths associated with the neurodiverse population?

Despite having learning challenges, there is some evidence that neurodiverse individuals tend to have specific areas of strength. Whether it is due to their cognitive differences or their need to develop skills to overcome their challenges, individuals with dyslexia, ADHD, and autism often excel in certain domains. For example, a higher than expected percentage of successful entrepreneurs have a diagnosis of dyslexia (Logan, 2009). There is also some evidence that individuals with ADHD may be more creative (White & Shah, 2011), and that some autistics have superior attention to detail and analytic skills (Samson, Mottron, Soulières, & Zeffiro, 2012; Soulières et al., 2009). While each individual's strengths and challenges are unique to them and one cannot overgeneralize based on a diagnosis, it is important for students and educators to consider how strengths can be leveraged and weaknesses minimized in learning contexts.

What Can Instructors Do?

Students bring a wide variety of educational and world experiences to our classrooms. To capitalize on these varied experiences, skills, and needs, we offer a few tips and strategies on working with neurodiverse learners. In our work, we have identified several aspects of neurodiversity-friendly teaching tips and more specific tips related to the teaching of statistics.

General Tips and Strategies

There is little doubt that many students from non-STEM majors are likely to face feelings of low confidence when they first take statistics. The following tips and strategies are adapted from resources that are primarily focused on the needs of Autistic students (Gobbo, Shmulsky, & Bower, 2018; Gobbo & Shmulsky, 2013). However, we have found that developing a Universally Designed Classroom is helpful to all students.

General Instruction

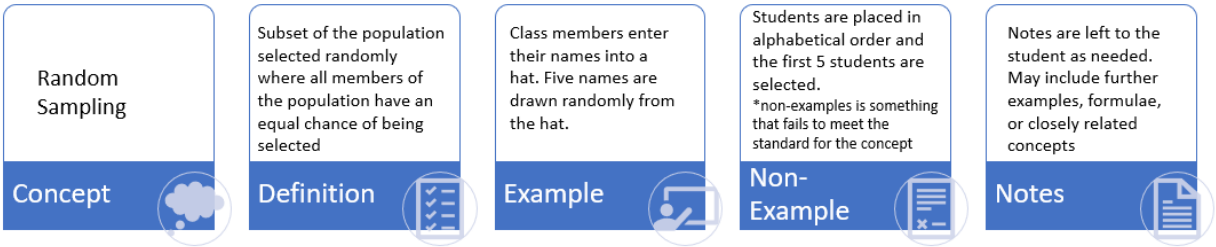
Students across learning profiles benefit from several pedagogical features around instruction (Gobbo, Shmulsky, & Bower, 2018; Gobbo & Shmulsky, 2013). Additional statistics-specific curricular guidelines are presented in the next section.

- **Be Explicit**—Provide direct and explicit explanations for assignments and tasks. Make sure that instructions are free of sarcasm and clearly explain any social nuances. The applied nature of statistics can often be confusing to students. Clearly explain the situation from which the data are drawn. Statistics can contain many new and unusual symbols, so be explicit about writing these on the board and saying their name and correct pronunciation. Students need exposure to these new concepts and combining written and verbal instruction together is effective.

  Pedagogically, applied statistics invites students to investigate data and draw conclusions. This may be a departure from prior mathematics courses. If an assignment is meant to be somewhat ambiguous or open-ended, be upfront about the ambiguity and goal of the assignment. In other words, be explicit about what the student needs to figure out.

- **Multiple entry points**—Allow students to engage with course content through multiple means (e.g., lecture, reading, video, online workshop, office hour conversation). Helping students engage with course concepts via active reading (as noted below) and working directly with concept definitions can be helpful when learning the many closely related concepts involved in statistics.

  For example, we ask students to engage with concepts by defining them, providing examples and non-examples, and making notes about similar concepts or connections, based on the Frayer Model (Allen, 2007). For students with working memory and other recall issues, being able to use these guides on homework and often on exams is critical for success.



Sample Frayer Model from the author's (Bower's) class

Students would be directed to summarize and make edits to their concept sheets as they work through problems and in subsequent classes (see below for more student strategies). Revisiting notes is a key strategy for students that faculty can model and encourage.

Social grouping

We suggest applied statistics courses ask students to experiment with data. This often means having small groups of students work together. Here we recommend a few tips for working with groups (from Gobbo, Shmulsky, & Bower, 2018; Gobbo & Shmulsky, 2013).

- **Intentional Grouping**—Compose work groups intentionally and keep groups together for longer periods of the semester. Provide clear guidance on the roles of each member and assign roles to members. Create guidelines for how students re-negotiate team roles and be prepared to provide alternatives to group work.

- **Role play**—Some students have limited experience with social situations or have trouble understanding some social nuances. Role play can assist students in experiencing a wider variety of perspectives. Do all students know how to collect data? Can all students access the team tools? Provide outlines on how students should share data and other resources.

Environment

Teaching involves more than implementing a well-crafted curriculum. We suggest the following as consideration in the environment of the classroom (for more details see Gobbo, Shmulsky, & Bower, 2018; Gobbo & Shmulsky, 2013).

- **Consistent Classroom Routines**—All students benefit from a clear and consistent adherence to a classroom routine. This includes detailed syllabi, weekly schedules, and well-organized online materials. For example, a large dataset that can provide entry to many concepts throughout the course can provide a necessary consistency for some students. Provide templates for how work is to be organized and adhere to consistent work submission.

- **Sensory environment**—Some aspects of our classrooms can be made more autism-friendly such as installing full-spectrum lighting and carpeting and turning off the LCD projector. We also find that group work can be challenging for some students due to the extra noise in class. Consider ways to limit the impact of these sensory inputs for students.

- **Self-Advocacy**—Invite students to share their classroom needs and work with them to identify accommodations that work for them. For example, some students may benefit from sticking with a software or tool that they already know. Others may need extra time to verbalize their understanding so that they can solidify the concept. Rehearsal can be an excellent strategy for many students to reinforce concepts.

Tips and Strategies for Statistics

Guided by Universal Design principles, Cognitive Load Theory, and the "GAISE Report" on statistics, we suggest the following guidelines (Dahlstrom-Hakki & Bower, under review) for content creation in statistics courses (American Statistical Association, 2005; Guidelines for assessment and instruction in statistics education: College report [GAISE]; Ayres & Paas, 2012; CAST).

- *Students should begin exploring realistic data as soon as possible*
  Neurodiverse students typically need a balance of abstract and concrete. Consider introducing concepts with concrete examples before moving to the abstract. Provide context for the data or situation. Data that seem unrealistic are easily dismissed as not relevant. Students can also get distracted by unrealistic data.

- *Students should explore interesting and/or personally relevant data*
  Students are more invested in data that applies to them. Without the distraction of data that seem irrelevant, students are better able to investigate the concepts.

- *Students should be encouraged to create representations of the data that work best for themselves*
  Be flexible about how students present their findings. Finding ways to make meaning from the data that are most meaningful to the student will have a greater impact on their learning.

- *Students should be encouraged to reach intuitive, informal, conclusions based on their understanding of the data*
  Provide examples of such conclusions and encourage students to grapple with creating their own conclusions based on their explorations.

- *Formal statistical tools and representations should be built on the student's intuitive interpretations of the data*
  Help students make connections to formal statistical tools after building from the conceptual and concrete.

What Can You Encourage Your Students to Do?

Having educators who are able to help students capitalize on their strengths plays a significant role in students' ability to succeed academically. Students must also take an active role in their learning and find ways to engage with the content even when this is challenging for them. Fortunately, there is a wide range of tools and strategies that students can use to reduce barriers and support their learning.

Active Reading

Language processing can be a major barrier for neurodiverse students. Reading textbooks and online materials requires a lot of cognitive effort, as do assessments. In particular, newer assessments of conceptual understanding tend to contain dense word problems which are particularly challenging for this student population (Dahlstrom-Hakki & Alstad, 2018). Students can use easily available text-to-speech software and active reading strategies to reduce the barriers posed by reading. Note however that numbers and symbols are not always read correctly by text-to-speech software and so the student needs to follow along with the text to ensure those components are not missed.

Preread

Prereading is best done the day before one intends to read the content itself whenever possible. Prereading provides a sense of what to expect in the text and can help to activate prior knowledge. It helps one anticipate the key themes or structure of the content or problem. Prereading essentially involves skimming through the content to be read, attending to keywords and major headings, and looking at the accompanying images and equations. This will give a basic sense of the text and provide a mental structure to help the reader anticipate the content they will be reading.

Read and Highlight

The next step in the process is to actually read through the content; this can be done either with or without the aid of a screen reader. Most devices now include built-in text-to-speech capabilities with customization options. Students should first read through the content and then go over the content again to highlight strategically and to add questions and comments. Highlighting should be done conservatively and should generally not exceed 20% of the content. The reader should use different colors to identify the main ideas, critical details, and new vocabulary in the text. The reader should also ask questions that they have of the content and see if they are able to answer them as they go through the text the second time.

Paraphrase and Annotate

Readers should then paraphrase the reading using their own words. Paraphrasing creates a quick summary and forces the reader to process the reading deeply which improves retention. Annotations, which are notes or questions added to the text, can be used to distill the core of the problem or content and allow the reader to access the information more easily in the future.

Chunk Related Content

As the reader progresses through the text, their annotations should identify whether a new paragraph builds on the previous paragraph's main idea or introduces a new one. This allows for the identification and labeling of a chunk of related content across multiple paragraphs. This also allows the reader to see if the additional information is providing answers to questions posed in prior sections of the text.

Summarize

Once the reader has completed reading the text, they should produce a summary of the information they've acquired. The summary can be in the form of a written paragraph, a basic outline, a mind map, or a graphical representation. The purpose of the summary is to help the reader restate the content, organize it in a way that makes sense to them, and provide a reference they can revisit in the future for review.

Note-Taking

Effective note-taking strategies are similar to active reading strategies. Their intent is to have the listener actively listen to content that is being presented to them and to engage deeply with that content to aid in their comprehension and retention. Therefore, many of these elements of effective note-taking parallel recommendations from the active reading section. Technologies such as smart pens and note-taking apps can make the process much easier.

Daily note-taking

Students should strive to take a set of complete but concise notes in class or when listening to recorded lectures. The notes should not repeat the lecture verbatim but should instead focus on extracting key ideas and putting them in one's own words. The student should always be asking themselves whether they understand what is being said and by putting the content in their own words, they force themselves to do so. If they cannot paraphrase the content, then this is an indication that they should ask for clarification or additional support.

Daily Note Revisions

Similar to active reading, daily note revisions should involve pulling out the main ideas from the notes, highlighting key points, and identifying new vocabulary. It is also important to look for any gaps in the notes. This is best done by working with a partner or using a smart pen or an app such as noteability that records the lecture and synchronizes it with the notes. The student should also create a list of questions to ask later for clarification.

Weekly Note Revisions

At the end of each week, the student should create a summary of their notes for that week. This will help them to better identify the key ideas and to make connections across class sessions. Visual representations are helpful at this stage because they can translate the data across modalities and encourage revision and deep processing. This summary will serve as a comprehension check and can be used to prepare for assessments.

Manipulatives and Visualization Tools

Active reading and effective note-taking will help students taking statistics courses, but these supports are not specific to math and statistical content. The use of Manipulatives and visualization tools are content specific and can be immensely beneficial to students struggling with traditional representation of statistics. For many students, the use of abstract symbols, new terminology, or opaque equations can significantly impede their ability to understanding underlying statistical concepts. Using Manipulatives and visualization tools can make statistics more concrete and accessible to neurodiverse learners.

Manipulatives

In statistics, a manipulative is a visual and/or tactile object that can be used to represent data or abstract statistical concepts. Physical manipulatives are generally preferred but virtual manipulatives can be helpful as well. The benefit of the manipulative is that it can reduce the language processing or working memory load on a learner struggling with new content. Students with dyscalculia or students struggling with new symbols and terminology will find manipulatives especially helpful. Virtually any statistics example or problem can be represented with manipulatives. This can either be done by an instructor who presents the content using physical representations such as candies or coins, or a student who takes a problem and uses objects to represent it physically.

Visualization Tools

This category encompasses a wide range of tools including graphing software and graphical organizers. Visualization tools are best used in tandem with other representations to give learners a

range of options to understand new concepts. Students can benefit from software such as TinkerPlots or GeoGebra to create custom graphs or explorations of the data (Dahlstrom-Hakki & Bower, under review). Graphic organizers can be useful in presenting complex information simply (as discussed by Maccini & Gagnon, 2005). A single representation can help students see examples and counterexamples of a concept thereby reducing processing load.

Conclusion

Creating successful statistics classrooms for neurodiverse students can be accomplished in ways that help support all students. Core to creating successful statistics classrooms is consistency in classroom practices that provide students with concrete examples, engage and build on students' intuition, and encourage students to access the content in more than one way. It is also critical for students to take agency in their own learning and to make use of strategies and tools that can help them become more effective learners.

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