

Teaching introductory statistics to blind students

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Abstract The challenges of learning statistics, particularly distributions and their characteristics, can be potentially monumental for vision impaired and blind students. The authors provide some practical advice for teaching these students.

Keywords: Teaching; Nemeth Code; Kinesthetic explanations; Test autopsy.

Introduction

The introductory statistics course is perhaps the single most dreaded part of the curriculum for many academic majors who have *no* visual impairment. Much of the content in the introductory course is visual in nature, including measures of central tendency and dispersion, distributions, correlation, and simple linear regression. Gibson and Darron (1999) stress that to successfully understand basic statistical concepts students need “visual and spatial skills.” Many faculty rely on visually-based materials in their pedagogical approaches of these topics. Research supports this observation (Marson 2007; Wilson and Rosenthal 1992). Teaching statistics to students with vision impairment or total blindness is, of course, much more challenging than teaching statistics to sighted students (Kapperman and Sticken 2003; Spindler 2006).

One fundamental concept that should be understood by everyone teaching statistics to blind students is that the foundation for understanding statistical concepts is visual (Quek and McNeill 2006; Sahin and Yorek 2009; McCallister and Kennedy 2001). Evidence suggests that fostering mathematical competencies in children is a visual or concrete exercise (Liedtke 1998). Even after comprehending basic arithmetic concepts, advanced learning in mathematics and statistics remains a visual enterprise. In addressing advanced learning, Penrose (1989, p. 424) writes, “almost all my mathematical thinking is done visually.” Gestures, the use of graphs, and other visual illustrations utilized by

instructors while teaching advanced concepts can make the significant difference between understanding an abstraction or complete failure to comprehend the concept. Without the aid of visual pedagogical devices, visually impaired students have a severe disadvantage in mastering statistical concepts.

There are two main categories of visual impairment: low vision and blind. Low vision students usually are print users, but may require special equipment and materials. The definition of legal blindness covers a broad spectrum of visual impairments. The extent of visual disability depends upon the physical sensory impairment of the student’s eyes, the age of the student at the onset of vision impairment, and the way in which that impairment occurred. Vision also may fluctuate or may be influenced by factors such as inappropriate lighting, light glare, or fatigue. Hence, there is no “typical” vision impaired student. The major challenge facing visually impaired students in the educational environment is the overwhelming mass of visual material to which they are continually exposed in textbooks, class outlines, class schedules, chalkboards, etc. In addition, increased use of Web-based course management systems, digital video, Internet hosted media and electronic social networking sites adds to the volume of visual material to which they have only limited access. Overcoming the visual limitations of students requires unique and individual strategies based upon the students’ particular impairments and their skill at communicating their understanding.

Instructors encountering visually impaired students for the first time may wish to examine the articles by Andreou and Kotsis (2005), Cahill and Linehan (1996), McCallister and Kennedy (2001), Meehan, Hoffert and Hoffert (1993) on assisting such students.

Classroom aids

It is rare to find a blind student who is not familiar with Nemeth Code. Nemeth Code, simply stated, is Braille for mathematics (Kaplan and Sticken 2003; Rosenblum and Amato 2004). Over the past 15 years, efforts have been made (Karshmer, Gupta, Geiger and Weaver 1999) to develop software that can translate Nemeth Code (e.g. a blind student's homework) into Latex Code, allowing the sighted teacher to read such. More recently, it became possible for a teacher, using Latex Code, to translate a homework assignment into Nemeth Code (Osterhaus, Weaver, Amerson and Siller 2001). Other recommendations include using textbooks on audio cassette, study guides on audio cassette, and "talking" calculators.

To help visually impaired students "hand see" the normal curve, instructors could construct a 3-dimensional normal distribution. On a piece of wood, one could use a router and produce an indentation of a normal distribution. Indentations could also be routed to mark integer multiples of standard deviations from the mean. Or, one could use clay and form a normal distribution on a wooden or other solid platform. This would give the student an opportunity to feel the concavity of the distribution and note the change of the slope as one moves away from the mean in either direction.

Although each of these options afford students an opportunity to "feel" a normal distribution, Landau, Russell, Gourgey, Erin, and Cowan (2003) argue that Nemeth Code, most similar to Braille, is best. However, blind students, like their sighted peers, do not always share common learning styles or strategies. For example, a blind student of the authors strongly preferred feeling the indentation of a router over the use of Nemeth Code. However, it may be useful include multiple strategies within one's teaching repertoire.

There are additional approaches to teaching inferential methods to vision impaired students that have proven particularly effective (McCallister and Kennedy 2001). These include the use of kinesthetic explanations, small data sets, and stressing application through a single memo-

orable application exercise. For example, standard deviation can be demonstrated to students by having them stretch their fingers to the width of a standard deviation. Using several different data sets, the varying width of the standard deviation can be demonstrated. This approach can be used to help students equate the "spread" of their fingers to the "spread" of scores.

Logistics

Some issues of test taking for blind students are worth mentioning. Commonly, tests in introductory or survey statistics courses are open book and open note examinations. A number of articles in the literature suggest that open book and/or notes for statistics tests offer great benefits to learning (Brightwell, Daniel and Stewart 2004; Phillips 2006; Williams and Wong 2009). If sighted students are permitted to use notes and books, blind students must be afforded the same opportunity. If visually impaired students are permitted to use audio texts or other accessible materials during the exam, a student proctor can be used to assist them by reading formulas, tables, or other relevant information. Visually impaired students should, then, be permitted to take the exam outside of the normal class meeting period with extended time to work such.

Textbooks represent a serious challenge for visually impaired students in statistics courses – particularly when tests are open book and/or notes. Which kind of text is best: Braille or audio format? At first consideration, Braille seems like the best option. However, Braille books are very expensive and often entirely too large to carry to class. In addition, Wessells, Smith and Rawles (1979) identified a trend in the decline of the use of Braille in the 1970's. Recent evidence suggests that only a small proportion of blind people can read Braille (Boles 2010) and that this trend is international (Papadopoulos and Koutsoklenis 2009).

Questions involving a written narrative response may be problematic for blind students. These have been found to be fatiguing for blind students (McCallister and Kennedy 2001). Multiple choice items may represent a better option for both the teacher and the blind student (Meehan, Hoffert and Hoffert 1993). Multiple choice items in examinations produce less anxiety than other types of questions for students (Sommer and Sommer 2009). Importantly, multiple choice tests are not easier

(Holtzman 2008) nor generate higher grades than those requiring a narrative response (Marson 2007). However, multiple choice exams also pose challenges. These challenges are not specific to visually impaired students. Essay and narrative response questions, based on their length and level of difficulty, can be fatiguing. Exclusive use of multiple choice questions may have a detrimental impact on students, since there is no provision for partial credit and the deflating experience of not “knowing” the majority of answers can cause a student to become frustrated and lead to test fatigue. One suggestion would be to divide the exam into smaller sections that could, if necessary, be administered over multiple classroom meeting periods. Short answer items and computational items are also common parts of any statistics exam and these are more manageable for a blind student.

A useful learning tool, by the way, is the “test autopsy” where students independently, or with assistance from the instructor, review their response to each exam item. For items answered incorrectly, the student reworks the item to ascertain why their initial response or solution was incorrect. Test autopsies have been shown to improve statistical knowledge, provide a deeper understanding of statistical concepts and improve grades (Servetti 2010; Attali and Powers 2010).

Student/faculty interaction

When teaching blind students, faculty must make accommodations in order to provide meaningful learning experiences. This often means additional work in modifying lectures, reworking otherwise visual illustrations, modifying homework assignments, rewriting examinations and assuring that visually impaired students have equal opportunity for learning in the classroom. This is no small or easy task, but is of immense importance.

The attitude of the instructor towards the student plays a significant role in student learning and levels of student satisfaction with the learning experience. An eager and helpful demeanour is of significant benefit to the student, whereas a recalcitrant and difficult attitude does not lead to a good learning experience for the student.

While faculty attitude is paramount there are cautions in this regard, however. The concept of countertransference can assist in understanding the development of teaching strategies for blind students. In psychoanalytic theory, counter-

transference occurs when the therapist begins to project his or her own unresolved conflicts onto the client. While transference of the client’s conflicts onto the therapist is considered a healthy and normal part of psychodynamic therapy, the therapist’s job is to remain neutral. Countertransference includes any type of alternative role activity that person of power accepts which misdirects a relationship from achieving a predetermined goal. At one time, countertransference was widely believed to contaminate the therapeutic relationship.

Countertransference in teaching constitutes a process by which a teacher engages in a role that violates the standard practice of interacting with a student. According to J. Saylor (personal communication, 10 June 2010) countertransference can prove harmful for the instruction of statistics to a blind student, such as exaggerating the blind student’s statistical competence and not knowing when to concede that the student will not be able to comprehend the material within a given time frame.

Feelings of sympathy can guilt teachers into lowering their academic expectations of blind students, which can, in turn, lead to grade inflation. Striking a careful balance between being overly sympathetic versus outright insensitive is vital. Landau, Russell, Gourgey, Erin, and Cowan (2003) note that their focus group research clearly demonstrates that blind students resent faculty who give too much assistance.

The length of the statistics course may need to be extended for blind students. On the other hand, no student (sighted or blind) can be given an infinite amount of time to learn statistical concepts. To this end, a question must be asked for each statistical concept presented: Is this concept relevant to the student’s educational goals? If it is not, including such is counterproductive to the student’s learning experience. If it is, the student’s understanding of such should be assessed and become part their grade.

Visual tools for teaching

The most complex dimension of teaching statistics to a blind student is the reconstruction of visual images that teachers employ for sighted students. Unfortunately, the typical statistics teacher will not have the necessary skills to construct an accurate portrayal of statistical artifacts for the blind students, such as the earlier example of carving a normal distribution of wood with a router.

Three particularly useful resources are available for teachers. First, Inge Formenti from the American Printing House for the Blind offers a collection of helpful resources (see http://www.uncp.edu/soc_cj/blind_statistics/blind.html). Any teacher who is teaching statistics to a blind student should review this list. The resource provides links to instructional resources, including teaching and learning products, and textbook and learning resource publishers who provide materials specifically for vision impaired students.

Second, Pictures In A Flash (PIAF) is a machine that makes raised line drawings on special paper, called capsule or swell paper (many campuses have PIAF within their Disability Services Department). Users can draw, print or photocopy pictures onto the swell paper and pass it through the PIAF. The heat of the PIAF machine causes the lines to swell and then the drawing can be read with the fingers. It is ideal for people who are blind and vision impaired. PIAF is used in a variety of educational, employment and personal settings. This particular technology allows the faculty member and/or the student to create simple linear and non-linear shapes, incorporate handwriting and signatures, develop geographic and conceptual maps, and perhaps most importantly for the teaching and learning of statistics, create charts and other graphical displays.

Third, the authors discovered that art colleagues are an efficient and effective source for the construction of meaningful statistical artifacts. A faculty member specializing in sculpture or ceramics has the potential of assisting in the creation of the necessary pedagogically useful artifacts for teaching blind students. The authors have found that such faculty are quite adept at creating variously shaped distributions using a variety of media that are appealing to the visually impaired student, including but not limited to clay, wood, glass, or plastic. Specifications for constructing such statistical artifacts may be found at: http://www.uncp.edu/soc_cj/blind_statistics/blind.html.

Concluding comments

Comprehension of statistical knowledge is founded on a student's ability to visualize statistical concepts. However, blind students are at a distinct disadvantage in their ability to compete with sighted students in acquiring a statistical education. Teachers have an ethical responsibility to create a level playing field for visually

impaired students. This can be accomplished with the aid of a number of useful resources to assist statistics instructors in providing appropriately mediated instruction to blind and visually impaired students.

The statistics instructor must be sensitive to the learning environment and instructional needs of the student. The literature demonstrates that serious complications emerge in an unbalanced teaching environment in which divergent student learning styles and needs are not recognized and accommodated in pedagogy. Constructing a variety of statistical artifacts to assist in the understanding of visually-based concepts is perhaps the best avenue to help in meeting the learning needs of the visually impaired. No matter which pedagogical approaches are used, it is important to bear in mind that student learning is individualized and will require careful formative assessment to find the most effective combination of teaching techniques and tools.

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Supporting information

Additional supporting information may be found along with the online version of this article:

Appendix S1: Resources for teachers of visually impaired and blind students