

Teaching Statistics to Culturally and Linguistically Diverse Students

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Abstract

Resources, strategies, and lessons learned are shared based on the authors' research and experience in teaching statistics (especially introductory statistics) to diverse student populations in varied settings.

Key Words: statistics education; diverse student populations; English Language Learners; online learning

1. Importance of Diversity

Students taking introductory statistics courses are a vibrant and increasingly diverse group. Accessibility to college education is allowing more students with non-traditional backgrounds to enroll in university coursework. The impact of this growing cultural and linguistic diversity necessitates pedagogical changes in order to ensure highly-effective university-level instruction to all student populations.

1.1 Types of Diversity

Student populations can be diverse with respect to many characteristics. From a review of the literature and an invited workshop at a national conference, Lesser (in a paper under review) offers a list of two dozen types of diversity in Table 1 below. As many items as are in this list (almost surely more than what is nontrivially acknowledged by any one book or teacher), we do not claim this list is complete, but simply a good starting point for getting a sense of the many ways in which student populations can be diverse.

Table 1: Types of Student Diversity

<i>Ethnicity</i>	<i>Gender</i>	<i>Sexual Orientation</i>	<i>Age</i>	<i>Digital Native/ Digital Immigrant</i>	<i>Disability</i>
<i>Cross-cultural Status</i>	<i>International</i>	<i>Socioeconomic status</i>	<i>Language</i>	<i>Educational level</i>	<i>Religion</i>
<i>Marital status</i>	<i>Social class/caste</i>	<i>Physical appearance</i>	<i>Learning styles</i>	<i>Behaviors /attitudes /expectations of students</i>	<i>Visual, auditory, motor, or cognitive impairments</i>
<i>Veterans status</i>	<i>Parental status</i>	<i>Political affiliation</i>	<i>Field/major</i>	<i>First-generation status</i>	<i>Anxiety level</i>

Students from diverse cultural or language backgrounds may not always respond in the same way to traditional statistics classroom instruction. We will share ideas about how to communicate statistical concepts in a manner more appropriate for students of diverse perspectives. A strength of these strategies is that they are valuable not only to distinct student populations but also assist the general population as well, thus providing more equal access to statistical ideas and knowledge for all students. For example, strategies that help English language learners usually help all students because Lesser and Winsor (2009) discuss research that indicates that students of all levels of English proficiency struggle with academic language used in statistics courses.

Lesser (2010) reviewed many ways in which diversity concepts are already embedded or potentially embedded in statistics concepts – both in the teaching of statistics as well as in the practice of statistics. Given the undeniable increasing diversity of the student populations college instructors face, we argue that diversity can and should be embraced for its opportunities and resources rather than resisted and reduced to a set of obstacles and challenges.

1.2 Examples Specific to Our Course

Our introductory statistics course uses a statistics literacy approach, usually including at least chapters 1-11 and 16 of Utts (2005). The course is taken mainly by pre-service elementary or middle school teachers, with 10-15% of enrollees consisting of students from other majors satisfying a common core requirement.

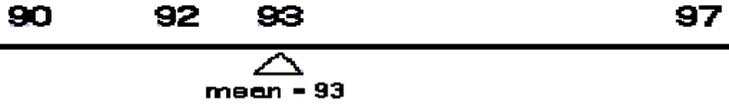
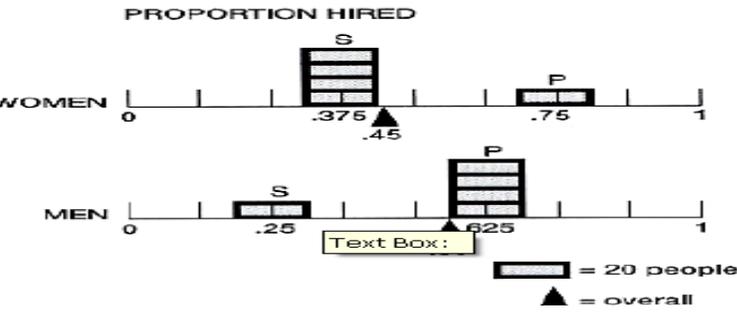
It may be natural for instructors thinking about diversity to focus most of their initial attention on the most common aspects of diversity in their particular student population. For example, a large majority of the students in our introductory statistics class (Stat 1380) are women, which is one reason Lesser (2009) incorporated a gender equity component to the course to illustrate some statistical ideas using examples with a gender equity context, and also raise awareness about opportunities for women in such STEM fields as statistics. Because a large majority of the students are pre-service teachers, Lesser modeled progressive pedagogy and raised awareness of curriculum standards (e.g., the Pre-K-12 GAISE Guidelines, the NCTM Standards, the Texas Essential Knowledge and Skills, English Language Proficiency Standards, etc.) and resources (online collections of datasets, applets, manipulatives, and webinars; teacher-friendly publications such as *Statistics Teacher Network*, *Teaching Statistics*, etc.).

Also, a large fraction of the students in our introductory statistics course either are/were English language learners themselves and/or are future teachers who will likely soon teach in El Paso classrooms that include English language learners. Therefore, our diversity focus has a large component on English language learners, informed by the case study research of Lesser and Winsor (2009), which has a teacher-friendly summary of implications in Lesser (2011). Based on the aforementioned papers (which can be consulted to unpack these strategies further), Lesser compiled in Table 2 below a handout listing strategies for statistics classrooms with English language learners.

Another type of diversity in statistics education is in the learning environment itself. Section 2 of this paper deals with Wagler's innovation in launching the first online section of our course and the first-person pronouns in that section refer to her.

Table 2: Strategies for English Language Learners

Strategy	Specific examples (in statistics)																
1. Identify important words that are highly similar in sound and/or appearance, so that these can be explicitly distinguished, especially if they are typically encountered in close proximity	from Lesser & Winsor (2009, p. 12): <table border="1" data-bbox="592 296 1133 583"> <tbody> <tr> <td>mode</td> <td>moda</td> </tr> <tr> <td>median</td> <td>mediana</td> </tr> <tr> <td>mean</td> <td>promedio</td> </tr> <tr> <td>average</td> <td>media</td> </tr> <tr> <td>on average</td> <td>por término medio</td> </tr> <tr> <td>average (ordinary)</td> <td>mediano</td> </tr> <tr> <td>medium (i.e., size)</td> <td>medio</td> </tr> <tr> <td>the middle one</td> <td>el de en medio</td> </tr> </tbody> </table> also: causal/casual; discrete/discreet; compliment/complement	mode	moda	median	mediana	mean	promedio	average	media	on average	por término medio	average (ordinary)	mediano	medium (i.e., size)	medio	the middle one	el de en medio
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2. Identify words with a (possibly different) “everyday meaning”, so they can be explicitly distinguished	random; confidence; population; bias; independent; normal; significant																
3. Phrases > knowing each word	“at least six”; “in the long run”; “expected value”																
4. Identify important words that have a different meaning in another academic register	Statistics vs. math usage: mode (TI graphing calculator), range, mean, variation, estimate (verb), normal, skew																
5. Identify words or symbols that can have more than one meaning even within your field	bias; N ; p ; α																
6. Be explicit about when you assess recognition of multiple terminology for same concept	Median, second quartile, 50 th percentile; Line of fit, least squares line, regression line; z-score, standard(ized) score; scatterplot, scatter graph, scatter diagram, X-Y plot; boxplot, box-and-whisker plot; stemplot, stem-and-leaf plot																
7. Identify content-related resources that may help students in their first language	from Lesser & Winsor (2009, pp. 25-26): Spanish counterparts of collections of applets (http://nlvm.usu.edu/es/nav/ and www.eduteka.org/MI/master/interactivate/) ; bilingual math glossaries or terms handbooks (e.g., COMAP); multilingual handbook of terms at http://isi.cbs.nl/glossary/																
8. Use streamlined language	“Arrange the observations in increasing order and locate the median M in the ordered list of observations. The first quartile is the median of the observations whose position in the ordered list is to the left of the location of the overall median” in a textbook was changed to “Use the median to split the data set into two halves – an upper half and a lower half. The first quartile is the median of the lower half.”																
9. Offer (everyday) context as a conceptual resource	Collection of analogies (e.g., Martin, 2003); use of “median” in <i>FAPP</i> 8e textbook: “just as a median divides a road into two halves (with opposite directions of travel), a median divides a dataset into two halves!”																

<p>10. Be aware what contexts or analogies commonly used in your field may have cultural pitfalls</p>	<p>Lesser & Winsor (2009, p. 20): courtroom analogy for hypothesis testing typically has the null hypothesis of innocence, but this is not what ELLs from countries with a Napoleonic Code of Law are used to; the currency they grew up with may not have “heads” and “tails”; the Utts (2005) ski resort exercise may not work well in El Paso!</p>								
<p>11. Consider how informal language or a picture may indicate conceptual understanding</p>	<p>Consider this: How might a student convey when the mean can exceed the median, even if she can’t readily generate a phrase like “unimodal, right-skewed distribution”?</p>								
<p>12. Scaffold learning of new vocabulary with “sentence frames”, “word squares”, etc.</p>	<p>“Z is the number of _____ that a value is above the _____” “The <i>p</i>-value obtained was _____, which is [less / greater] than our preset significance level of _____, and therefore we [reject / fail to reject] the null hypothesis that _____.”</p> <table border="1" data-bbox="594 697 1279 1171"> <tr> <td>mean</td> <td>el promedio</td> </tr> <tr> <td>la suma de los valores de los datos dividida por el número de elementos en la suma</td> <td>En el conjunto {1, 2, 3, 4, 20} para encontrar el promedio suma todos los números y divide por 5 porque hay cinco elementos en el conjunto.</td> </tr> <tr> <td>the sum of the values in the dataset divided by the number of elements in the dataset</td> <td>el promedio = (1 + 2 + 3 + 4 + 20) / 5 = 6</td> </tr> <tr> <td></td> <td>the ‘balance point’ or ‘leveling value’ of the data</td> </tr> </table>	mean	el promedio	la suma de los valores de los datos dividida por el número de elementos en la suma	En el conjunto {1, 2, 3, 4, 20} para encontrar el promedio suma todos los números y divide por 5 porque hay cinco elementos en el conjunto.	the sum of the values in the dataset divided by the number of elements in the dataset	el promedio = (1 + 2 + 3 + 4 + 20) / 5 = 6		the ‘balance point’ or ‘leveling value’ of the data
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<p>13. Multiple representations to make learning more visual (& less language-dependent)</p>	<p>here is the ‘balance point’ representation of the mean:</p>  <p>can be extended to explore Simpson’s paradox (Lesser, 2001);</p> 								
<p>Also: Group work; active learning; more wait time; emphasize setups; build on everyday language</p>	<p>Lesser and Winsor (2009)</p>								

2. Teaching Diverse Student Populations in an Online Environment

A definite trend in higher education is the movement of undergraduate courses to the online environment (SCUP, 2007). While many instructors focus on creating online courses that mimic as close as possible the f2f learning environment, it seems preferable to take a step back and consider how the online environment may be a flexible and affirming environment for diverse student populations. In the following sections, an online statistics course is described that was offered to a student population with a high proportion of ELLs, and subsequently, research informed findings are presented about teaching diverse students populations in an online environment.

2.1 Description of Online Statistics Class and Student Population

The online statistics course discussed in this manuscript is a “statistical literacy” course taught at a large urban university in the Southwest with a majority of dominant Spanish-speaking students. The course was designed to align with the GAISE recommendations and particularly focused on developing “statistical literacy” for consumers of statistics rather than producers of statistics. In the pilot semester (spring 2011), there were 60 students enrolled in the course where 3.45% were freshman, 27.59% were sophomores, 31.03% were juniors, 27.59% were seniors and 10.34% were graduate students. Most sections of this course are geared to pre-service teachers, but the online version had a significant proportion that was not pre-service teachers (24.14% elementary school pre-service, 6.90% secondary pre-service, and 68.97% not pre-service teachers). The class was almost equally divided between ELLs and non-ELLs (48.15% had native language of English and 48.15% had native language of Spanish and 3.70% self-identified “Español”, [Spanish], as his/her native language). This cohort provides a reasonable combination of native English and non-native English speakers along with a diverse array of ages and backgrounds.

2.2 English Language Learners and the Online Classroom

ELLs bring a diverse array of perspectives to either an online or f2f (face-to-face) statistics class. The contribution of ELLs to an introductory statistics classroom, when their viewpoints and strengths are valued, is an asset that should be cultivated and recognized. As with any other student population, ELLs can contribute new perspectives on the content of the class if and when the instructor is prepared to provide a platform from which their voice may be heard. As noted by Lipske (2004, p. 2),

“An in-class section may offer teachers greater pedagogical flexibilities for group tasks, and it may provide more support for most learners to develop their L2 language proficiencies by allowing them to work with sympathetic classmates who are undergoing a similar acculturation process. However, an on-line section may provide teachers greater monitoring abilities during group work, and it may provide a more nurturing environment for the most reticent learners to develop confidence in their L2 abilities. On-line groups, however, face unique challenges because they are reliant on timely member participation in order to complete assignments. Additionally, in-class sections may enhance writing fluency whereas on-line sections may help students to develop more formal academic writing styles.”

This highlights three important advantages of the online environment for ELLs which are discussed in detail below.

2.2.1 Advantages of an online environment for ELLs

First, ELLs are often very reticent to speak up in f2f settings (Ware, 2004). Consistent with the GAISE recommendations (ASA, 2010), many statistics instructors are including time for active learning and discussion groups in class. In a f2f setting, this can be very intimidating for ELLs that do not feel able to express statistical ideas in English extemporaneously. Though there is little formal research validating this reticence on the part of ELLs to make unrehearsed responses in a f2f statistics classroom setting, this behaviour is documented in other disciplines and arguably exists in the statistics classroom as well. The consequence of this restraint is that ELLs may not benefit from active learning in the same manner as native English speakers. However, Ware (2004) documents that the ELLs in an English composition classroom felt more at ease to participate in classroom discussions when in an online environment because of the ability to “rehearse” an answer and consider the phrasing before making their thoughts public. In one student’s description, as described by Ware (2004), a student Emma (a pseudonym) thought that the asynchronous discussion boards of an online class are “similar to writing” and she would regularly “do a rough draft” and then post the response. Though this is still extemporaneous with respect to the content being expressed, the online environment allows students to spend time “composing” a response they feel confident to post.

A second advantage highlighted in the Lipske (2004) quote above is that ELLs in an online section may better develop their formal academic writing abilities than in an f2f setting. In an f2f setting, many statistics instructors incorporate writing exercises in order to promote reflection and other metacognitive skills. Similarly, discussion boards in an online classroom can serve the same purposes. However, if a student lacks the ability to write formal academic English prose, the online environment may be more suitable since the student will be more focused on correctly expressing her ideas in English and less focused on getting the ideas expressed in a short time frame as required in f2f settings.

Lastly, the online environment does provide better monitoring of student group work. This may be helpful for any population of students and does not clearly benefit one student group more than the others. Nonetheless, it is an advantage for ELLs if there is more propensity to veer off-topic or confuse the intent of the project.

There are also some advantages of an online environment that may benefit non-traditional students common in diverse student populations. First, students that have full time jobs or have children can particularly benefit from a class not limited by physical or time boundaries. These same students may also benefit from an online class because of the ability to view or listen to content repeatedly. This was suggested by the research of Mills and Xu (2005-2006). An online class more easily allows the instructor to provide differentiated instruction (Tobin, 2005). This provides another advantage to diverse student populations if and when the instructor provides the multiple learning options an online class allows. Ideally, an online statistics course should offer content in written, audio, video and interactive format. A f2f classroom does not as easily provide the multiple learning options. Having multiple ways of communicating is helpful for all students, and particularly for ELLs, since experiencing the content in many different ways is an effective method of reinforcement.

For example, one new method of instruction incorporated into the online statistics course was an interactive word wall. This online interactive word wall was utilized for communicating important statistical terminology by providing an academic definition of the term in English, a paraphrase of that term in Spanish (a very common

primary language among students at the university) and an example of that term being used. At least one student emailed to say she found this a valuable tool and regularly utilized it. On the same note, students were allowed to create their own “statistical word walls” for one of the two asynchronous discussion board topics. This allowed each student to pick a term that was difficult to understand, provide a textbook definition, a paraphrase in their language of choice and demonstrate their understanding via example or illustration. Surprisingly, this also became a creative outlet for the course. The time and skill some of the students put into these word walls demonstrated that they enjoyed the activity and it provided an alternate outlet for demonstrating understanding. However, even with providing this method of learning statistical terminology some students still had difficulty understanding what sense of a word was relevant. For example, one student provided the Spanish term “sesgado” for translating “skewed”. This term in Spanish does not really reflect the meaning of skewed in statistics, i.e. asymmetry in a probability distribution. Maybe something like “ametría” would have been more conceptually fitting.

2.2.2 Pitfalls of an online environment for ELLs

Though the advantages for ELLs in an online environment are important to highlight, the excerpt from Deimann and Bastiaens (2010) also points out some potential pitfalls. One pitfall of the online environment, anecdotally witnessed, is the lack of timely participation. This may be particularly troublesome to non-traditional students and ELLs since these student populations may benefit from added time for completing a project. When forming online groups for projects, the discussion boards utilized were always asynchronous. In order to encourage timely participation, a formal process for online group work fashioned after Meeuwsen (2010) was utilized. This required timely participation, very specific student roles and allowed groups to remove a member for non-participation or other problems (though none of the groups took this step).

Another potential problem is with regard specifically to asynchronous discussion boards. At times, the environment seemed too disjoint for ELLs to follow. Possibly a more structured discussion board structure is necessary if there is a high proportion of ELLs in an online course. On a related note, some students were just unwilling to participate in the discussion boards in a deeper level due to what they perceived as the argumentative nature of the environment. There is a tendency in some cultures to affirm or agree with statements and hence, relevant criticism seems rude and inappropriate. This is very common in cultures where respect is highly valued. In order to address this issue, halfway through the semester all reflections on student posts were required to have a compliment as well as a criticism of every post.

2.2.3 Teaching recommendations for online ELL students

Some of these teaching strategies seem to work equally well with ELL and non-ELL student populations. However, all teaching strategies that were picked out by ELL students as being “helpful” are included in the following.

Group Work: ELLs may benefit from group work even more than traditional non-ELL students. In group settings, students are able to play up their strengths and also learn from the other students. Moreover, in many cultures it is very natural and affirming for the student to work in a group setting since the “group” is more highly valued than the individual. With this in mind, it is important to pair or group ELL and non-ELL students so that a mutually beneficial group is created.

Discussion: The online course utilized frequent student contribution to discussion boards. Overall, the students felt this connected them to the other students (and the instructor). However, as noted previously in Section 2.2, ELLs had the ability to rehearse and prepare for these boards and found this a preferable practice to usual f2f discussion. One comment from a student in the online course was:

“The concepts presented in the online format were understandable and the professor made herself available for questions...By having other students put their perspective on a topic [in discussion boards] made it easier to connect the dots between concept and real life association.”

From this student’s perspective, it was important to have the discussion boards to help with communication among the instructor and students. This need for “connection” was common to all students, but seems particularly important for ELLs. Note her use of the term association and the improper sentence structure. It is likely that she intended application rather than association. However, this is a nice example of how students from other language backgrounds have ideas that, perhaps due to language, do not get expressed correctly.

Inquiry-based learning: For ELLs, reading paragraphs of description is a particularly cumbersome task. Thus, a concerted effort was made the design of the online course to regularly include graphics and/or active learning activities whenever possible. This reduced the reading down to less than or equal to five minutes before another learning activity was required. The types of activities varied from surveying friends about a probability game to “playing” on an interactive applet available online. Thankfully, with the breadth of resources available online, this was not too difficult to include in the course.

Peer Review: The discussion groups were required to review each other’s assignments before turning them in. This created a learning opportunity for ELLs to correct their writing before assessment.

Word Walls: The word walls provided a creative outlet and a chance for students to express statistical content in a comfortable format and/or language. What language was utilized was not dictated for the word walls except for requiring a formal English academic definition. There were word walls for which it was evident that the student understood the content by providing a complete paraphrase of the concept in Spanish, but provided an English definition that did not adequately describe the concept in the context of a statistics course.

Screencasts: There are several free resources for recording screencasts of your desktop. These are useful since the students can “see” your desktop and hear you explain concepts simultaneously. This is a particularly useful tool for students that are not digital natives. These students had frequent technical difficulties. Whenever these issues arose, a screencast showing what to do was posted to the website. These were also useful for ELLs who needed more modes of explanation. Another strength of these screencasts is that they can be made general enough to be reusable each semester. A free program is available for creating screencasts called Jing (TechSmith, 2010). This is very similar to Camtasia and is maintained by the same corporation. It allows screencasts with lengths 5 minutes or less. However, given that the attention span of an average student is

approximately this length, this is not a problem. In the references, a URL is available for a download of the program.

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