

Teaching Statistics to Students from a Non-English Speaking Background

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1. Introduction

Australia is a multicultural society. It has an indigenous aboriginal population and welcomes about 130,000 migrants each year. In addition, 25,000 overseas students come each year to study in Australia. Twenty percent of all school students in New South Wales have a first language that is not English. The range of cultures makes Australia a wonderful place to live but can create difficulties for the Anglo-dominated education system. Students need to function in English if they are to succeed in the education system. Statistics teaching can be adapted and enriched by adopting second language techniques in teaching.

Success in statistics requires high levels of literacy in natural English and mathematical English and an ability to translate between the two. Mathematical English is a register of natural English. It has vocabulary and syntax that are related to natural English but are used in a more precise and stylised manner. Mathematical English is the way we communicate mathematical ideas to other mathematicians and to students (Austin and Howson, 1979). Mathematical English is useful, generally precise, and well-known, but mathematical English needs to be *taught*.

Mathematical English, particularly in typed form, is dense (more meaning per square millimetre) and has little redundancy. The words and symbols are precise. The way the words are used (syntax) is often idiosyncratic and ambiguous to the uninitiated. Mathematical English relies often on clues other than the words and symbols. There are visual clues such as graphs and tables of figures. Think of how you would teach the normal distribution to a blind student and you will realise just how much we rely on visual clues.

Reading skills in mathematics are different to natural English. Eye movements are up and down and side to side, needing to comprehend a block as a whole. Writing skills in mathematics are almost non-existent in senior high school and junior tertiary level.

Many teachers are frustrated by the lack of resources for non-English speaking background (NESB) students and often by the difficulties of communication (Dale and Cuevas, 1987, p.10). However, the resources and techniques are widely available. There is a body of techniques from English as a second language (ESL) teaching that can assist statistics teachers. Adapting textbook materials, being aware of language, working with ESL teachers, will increase statistics and language learning for our students.

This paper suggests ways of teaching and adapting materials to help all students, not only those from a non-English speaking background. These techniques are well-known to teachers of English as a second language but not well-known to statistics teachers. Techniques canvassed in this paper include cloze, matching, composition, sequencing, and cooperative logic. The methods are in line with the trend in mathematics education towards small group activities, problem-solving and open-ended activities. For students studying in a second language, however, group work will need to be structured to encourage verbal interaction.

2. Language acquisition

Non-English speaking background students will learn English, some quicker and some with less effort than others. We, as teachers, can make learning of language easier by presenting our instruction in ways that help that process.

We learn language skills through interaction, through real situations which force us to observe, to take risks, to *use* language. These situations can be simulated in the classroom by using strategies which encourage verbal interaction between students as well as individual reading and listening tasks. Students need to be encouraged to take risks with language, to experiment with pronunciation, to translate statistics written in natural English to mathematics and *vice versa*, to listen to and read mathematics.

Language teachers divide the task of language acquisition into four macroskills. They are *reading*, *writing*, *listening*, and *speaking*. Teaching methods reflect these four skills. Small group activities are structured to facilitate the development of speaking, listening, and reading skills. Group activities using probability experiments become report writing activities. The use of concrete materials, where appropriate, gives a focus for discussion.

The atmosphere of the class is extremely important. Krasten (1984) states that language will be acquired if the student has sufficient comprehensible input and a low affective filter. Students with low anxiety and no mental blocks caused by an environment perceived as threatening will acquire language. So we need two elements in our teaching, comprehensible input and a supportive environment that will encourage students to develop skills in reading, writing, listening, and speaking.

3. Linguistic problems with probability and statistics

In addition to the problems with mathematical English documented in Dale and Cuevas (1987) and Burton (1988), there are problems specific to statistics and probability. These problems exist for native English speakers, but are more extreme for NESB students.

Broadly these can be divided into *vocabulary and syntax, sequencing and logic, and culture and context*. In early statistics courses vocabulary and syntax need emphasis, whilst sequencing and logic are needed later. Culture and context are important throughout, as even the easiest probability work requires a context that may be unfamiliar to students from different cultures.

3.1 Vocabulary

Problems understanding the words are the most obvious difficulties encountered by students. Pronunciation is also important for NESB students as they may know the term but may not recognise the sound of it or use it themselves. Students need to understand the meanings of technical terms. But first, do they know the meanings in natural English? Read the following passage and think about how the terms are used.

A confidence interval represents a range of reasonable values. If the hypothesised value is *inside* the confidence interval the null hypothesis is *accepted*, and if the hypothesised value is *outside* the confidence interval the null hypothesis is *rejected*. Use a 95% confidence interval for a test with 5% significance, and a 99% confidence interval for a test with 1% significance.

The words *inside, outside, accepted, rejected* have the same meaning as in natural English but words such as *significance* and *confidence* have precise mathematical meanings related to natural English meanings. In this context the word *confidence* alone has little meaning. It is the phrase *confidence interval* that conveys the meaning. It is difficult for a NESB student to see that *reasonable* is not a technical term and *significance* is. Methods of teaching vocabulary will be discussed later.

3.2 Syntax

Syntax is how words are used. It is the formal rules of composition of the language. The two main areas of difficulty in early statistics courses are the use of comparatives and the use of logical connectors. These can be compounded by the fact that many students have a first language that does not contain the same constructions.

Comparatives cause problems for all students. There are so many ways of expressing the same idea, such as *at most* and *not more than*. Students need to be taught the differences and similarities between constructions such as those listed below.

at least	less than	exactly
at most	neither ... nor	none
more than/not more than	either ... or	only

Logical connectors are words used to connect statements frequently giving a causal relationship. They are used often in mathematical English. In proofs and theorems, the connectors *therefore, because, and if and only if* are used. In examination questions other forms are used such as those shown in the list below.

if find
 if calculate
 given that find
 find if
 calculate if
 evaluate when
 evaluate if

evaluate given that
 if how (much/far)
 if what (is/was/would be)
 if make ... the subject
 given make ... the subject
 solve for when
 express when

The following techniques are useful for teaching vocabulary and syntax.

(i) *Statistical dictionary:* As terms are encountered students devise their own dictionary. It is often useful to have an example of use of the word or phrase in natural English as well as the statistical use. If the student is also in an English/ESL class, natural English meanings of statistical terms can be discussed prior to introduction in their statistics class.

(ii) *Cloze passages:* In a cloze passage, words or phrases are deleted and the student fills in the gaps. Students can fill in the gaps in the passage or be given a list of words to choose from. Whilst this can be done individually, it is more effective if students work in pairs, as discussion and reading practice. Cloze passages are particularly useful for summaries. If your teaching objective is to reinforce vocabulary, delete key vocabulary items or if your objective is to teach structure, delete prepositions and linking words as in the example below. This example could also be printed on cards and used to teach sequencing.

$Z = (X - \mu)/\sigma$	change the subject of the formula to X
$\sigma Z = X - \mu$	multiply both sides _____ σ
$\sigma Z + \mu = X$	add μ _____ both sides
$X = \mu + \sigma Z$	rearrange so that the equation reads from left to right

(iii) *Matching meanings:* These include multiple-choice and sorting or matching for equivalent or opposite meaning. This technique is best in pairs or in groups of three. In the example below, the eight responses to the problem are written on separate cards and students are asked to group the cards with the same meaning. The students are then asked to pair the cards with opposite meaning but similar language structure. Always look for opportunities for discussion with NESB students. Ballagh and Moore (1988) have similar work in algebra.

An unbiased die is thrown. What is the probability of throwing:

at most a 4	less than 5	not more than 4	neither a 5 nor a 6
at least a 5	more than 4	not less than 5	either a 5 or a 6

(iv) *Audiocassettes:* Recordings of vocabulary lists with exercises are popular with NESB students. Pronunciation can be practiced in the privacy of their homes and can be repeated many times. Lecturers can make recordings of the relevant vocabulary and lend them to students or place the cassettes in the library.

(v) *Composition/decomposition:* This technique shows students how to take complex mathematical statements and decompose them into separate sentences.

Composition takes sentences and combines them using logical connectors. As mentioned, logical connectors require students to see a relationship between parts of a question or statement. The relationship can be temporal (when, after, before, etc.) or causal (if, because, therefore, etc.) or logical (or, and, but). Practice interpreting these types of mathematical statements helps students to see the relationship.

Students find it easier if questions are broken into sections. The question below can be separated into three sentences.

The number of breakdowns of a computer printer in a student laboratory has a Poisson distribution with a mean of 3 per week. If it is known that at least one breakdown occurred in a particular week, what is the probability that no other breakdowns occurred that week?

This can be divided into three sections:

Information: The number of breakdowns of a computer printer in a student laboratory has a Poisson distribution with a mean of 3 per week.

(setting the context, supplying data for the question)

Condition: If it is known that at least one breakdown occurred in a particular week, (modifying the data)

Command: what is the probability that no other breakdowns occurred that week? (specifies the calculations needed)

3.3 Sequencing and logic

Logical connectors cover some of the aspects of sequencing and logic, however this section goes further. How do students follow the logic of a proof or derivation in a second language? It is difficult enough in a first language! These skills are related to following a story in English and so teaching techniques can be adapted to teach these skills in statistics. The following techniques can be useful for teaching sequencing and logic.

(i) *Sorting for logical sequence:* A common technique in ESL teaching is to take a paragraph and chop it up sentence by sentence like a jigsaw. The students then put the sentences back in order. This technique can be used with statistics teaching. Take an example, write out the solution, chop it up and ask the students to reconstruct the solution. In some cases there is not a unique solution - this leads to discussion and more practice of speaking and listening skills.

(ii) *Cooperative logic:* Cooperative logic activities have been honed to an art by Erickson et al. (1989) in their book *Get It Together*. Cooperative logic activities use groups of four to eight students. Each student is given a clue which is read, but not shown, to the other members of the group. Each student *owns* a vital piece of information needed to solve the problem. This is an excellent way to practice reading, speaking, and listening skills. The example below is a cooperative logic problem based on the normal distribution.

On the 13th August, a police radar unit monitored 1000 cars as they passed a checkpoint.	The 13th August was a Friday. The mean speed of the cars was 90 km/hr with a standard deviation of 10 km/hr.
65% of the drivers booked were women.	The legal speed limit at the checkpoint is 80 km/hr.
The speeds of the cars followed a normal distribution.	840 cars were travelling above the speed limit.
This stretch of road is long and straight.	How many cars were booked by the radar unit on 13th August?
The police only book cars that are 10 km/hr over the speed limit.	\$66,000 was collected in fines.

(iii) *Experiments*: Experiments using dice, cards, computer simulations, and many others, can be used for formal writing skills. Students learn skills through following written or verbal instructions, working in groups, and writing up results.

3.4 Culture and context

Students from different cultural backgrounds need to be initiated into the context in which they will be expected to operate. Are they familiar with dice, cards, roulette or the English alphabet (many probability questions ask for the probability of choosing a vowel often without specifying which alphabet to use)? There are no specific techniques for teaching this - just be aware of different students and different cultures and teach those areas that your students are unfamiliar with.

Students may have different expectations of you as the teacher and their role as a student. Their previous learning experiences may have been all rote learning of notes or textbook. Be explicit as to your teaching objectives and explain these to students. Again, awareness and goodwill can minimise difficulties.

4. Conclusion

There is a wealth of activities for statistics teachers to use when teaching students of a non-English speaking background. These activities, however, are useful for all students and give teachers a broad range of techniques to teach early statistics courses. Concept development is enhanced by greater use of language.

Affective domain factors are important in language acquisition. A supportive classroom atmosphere where students can take risks with language will enhance

language learning and so assist students with statistics learning.

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