Winning them over

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Abstract

This paper provides examples of a method to engage and inform a student. The method is based on enabling students to uncover, by themselves, what they did not realise they already knew. The technique involves the students answering a series of questions which ultimately results in the student explaining a concept or method in lieu of simply being told by the lecturer. This helps to lessen the mystery that otherwise acts as a barrier to students’ understanding of, and progression through, the field of Statistics.

Keywords: Improved learning methods, increasing student confidence, pedagogy, teaching introductory statistics

1. Introduction

University students enrolled in Business and related degrees approach mandatory introductory Statistics courses with varying levels of trepidation. Such emotion is based upon their perceptions of the value of Statistics to their area of study, their beliefs that Statistics is ‘mathematical’ and their own mathematical ability. Indeed the majority begin the course under sufferance, with a level of resistance related to their beliefs of the relevance of Statistics. Such students do not aspire to become statisticians; however, they do need to acquire certain statistical skills.

This paper discusses methods for engaging and educating students using an approach which enables students to uncover what they already knew but did not realise. This overcomes a student’s level of resistance and improves their interest. These methods reduce the mystery surrounding statistical concepts and techniques by enabling students to explain or define a concept themselves rather than simply being told the concept.

The technique parallels the educational approaches known as Vygotsky’s ‘zone of proximal development’ and ‘scaffolding’ [1]. Vygotsky’s approach involves assisted discovery which relies on the learner working with the assistance of an educator’s instructions to move to a new level of understanding. Instruction is provided for an activity within the learner’s zone of proximal development, in which the educator reduces the ultimate task into component parts and provides routes to mastery. The educator supports the learner’s efforts and helps the learner evaluate these efforts. Consequently, the learner acquires new knowledge and steps up to a higher level of mental development [1].

The method described in the paper also builds upon the concepts of ‘active learning’ [2] and ‘making it memorable’ and ‘striking demonstrations’ as theorised by Sowey [3, 4]; having both similarities and differences to the latter. Active learning is contrasted to passive learning in which information is presented to students who are expected to absorb it through contemplation and memorization of notes and textbook material. Students can learn actively by working problems for themselves, thinking about concepts to form their own summaries ” [2]. There

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are many existing resources that involve aspects of active learning. A couple of good examples are Deming’s Red Beads Experiment and the Ballistat [5, 6]. These instruments are commonly used with outstanding success to explore statistical concepts with students who are not undertaking mathematics degrees [6]. However, the advantages of the examples described herein are that they do not require the purchase of apparatus and are sufficiently simple and low on time consumption that they may be immediately incorporated in any lecturer’s present lecture format.

2. Enabling students to see what they already know

By providing sequences of semi-directed, or purposeful, questions that students can answer, students can lead themselves to important statistical results, allowing them a sense of achievement. Consequently, a result which may have normally appeared a foreign idea if simply stated as fact is actually a conclusion which they reach. This not only increases students’ interests but also their ability to learn and retain information.

Examples of the teaching technique are provided in Sections 2.1.1 and 2.1.2 respectively based upon:

a. providing diagrams and related questions which students can answer, cogitate upon and ultimately explain a concept or method; and

b. providing purposeful questions which students can answer and will lead them to the correct conclusion or concept by themselves.

2.1.1 The standard deviation – diagrams and questions to empower students

The following is an example of using diagrams and related questions which students can answer that helps them to describe, at least in layman terms, what a standard deviation measures, in lieu of being told.

The class is shown a diagram similar to that in Figure 1 and asked to select which of the two data sets A and B they believe has the smaller standard deviation. It is important to draw students’ attentions to the relative positions of the crosses representing data along the number line, not to focus on their exact values.

In the lecture it is useful to simply label the lowest and highest values along the number line and place the crosses between them to ensure students are not being distracted by numbers. An interactively-drawn sketch in colour pen on an overhead transparency can aid the presentation, reducing the rigidity that may be felt if Figure 1 was typed up and pre-prepared for display.

Figure 1 Abstract illustration 1 to understand what the standard deviation is measuring

| Data Set A | x | x | x |
| Data Set B | x |   | x |
| 2 | 18 |

A show of hands reveals unanimous support for Data set A. A follow-up question asks why Data Set A was selected. If there is not an immediate response then reassuring the class that they have chosen correctly will invariably see a student suggesting that the data are less spread. It is important to use positive reinforcement to that student by informing them that they are correct that the standard deviation is a measure of spread but to then follow this with the question to the whole class of whether they are basing their decision on the range or something else. The class is shown that the range of Data Set A is clearly less than the range of Data Set B and asked whether it was this that lead them to say Data Set A had the smaller standard deviation or some other reasoning. This is left as an open question for students to ponder before quickly presenting them with Figure 2.

Figure 2 Abstract illustration 2 to understand what the standard deviation is measuring

| Data Set C | x | x | x | x |
| Data Set D | x | x | x | x |
| 2 | 18 |

1 It must be mentioned that students are exposing themselves, and leaving themselves vulnerable, if they are expected to hold their hand up in the air in support of an answer. This can reduce a student’s willingness to participate and reduces the lecturer’s chance of assessing understanding. Accordingly, students are asked to place their fist against their chest and raise their fore-finger in support so at least it can be seen by the lecturer if they are firstly thinking and secondly choosing correctly. This reduces students’ concerns of being seen as ignorant by their peers; I’ve successfully used this in lecture theatres holding some 160 students.
After highlighting that the range is the same for both data sets C and D, students are asked to determine which data set has the smaller standard deviation. Unanimously, data set D is chosen. When the students are asked if they can say why they have chosen this data set, someone will comment, often after the class is told that they are correct, with words to the effect that "the data are closer to the centre overall" and "the data are closer to the mean on average" and "the data are less spread away from the centre". Before commenting on these suggestions, the class is asked whether they all chose data set D for this reason. After they agree it is simply a matter of saying, "Brilliant!". The students have identified that a standard deviation is a measure of how far spread the data are away from the mean and that essentially it measures the average distance from the mean.

If it is a desirable part of the course the formula can then be described using a diagram similar to Figure 3 to show why we cannot simply take the average distance. The important point, however, is that the students somewhat intuitively, or along with some prior knowledge, gave an explanation for what the standard deviation measures without having to be told this working definition.

Figure 3 Illustration of how to calculate the standard deviation of a data set

2.1.2 The sampling distribution - series of questions enabling students to see what they already know

This example provides purposeful questions which students are able to answer and leads them to describe the concept of a sampling distribution in lieu of a lecturer firstly explaining the concept.

The class is informed that their Sony Manager is interested in them undertaking market research in order to estimate the anticipated profit from the sale of a new mature-aged Playstation® game. They are informed that this will involve taking a random sample from the anticipated market of those aged 18 to 35 years, assessing their reactions and feelings towards the game and that, based on the responses, the proportion of people who will purchase the game is estimated. From this the expected sales and profit can be estimated.

An arbitrarily selected person in the class is told that they must fulfill their manager's need and obtain a random sample of 300 people and report back the expected profit using the methods just described. A second person is then identified and told that they too, independently of the first person, are to obtain a randomly selected sample of 300 people and report back with the expected profit. Finally the class is told that each of them is going to independently undertake this research and obtain a random sample in order to estimate the expected sales and profit.

The class is then asked whether or not they believe they would all get exactly the same mean if they each took a randomly selected sample from the population. The response is overwhelmingly "No". The class is asked whether they are saying the sample means would differ or vary. The class all say "Yes", some with a puzzling look of "well of course".

Students are reminded that the lecturer is not saying they are wrong but merely wanting to ensure that the class' perspective is clearly stated, not accidentally misrepresented. It is vitally important that the lecturer slowly restates the class' response and verifies that this is what they have decided before progressing, not something that the lecturer is deciding! Words such as "is that what you are telling me, I don't want to be putting words in your mouths" and "I'm not suggesting you are wrong, I just don't want to be putting words in your mouths" should be used before progressing at each stage.

The class is then asked whether they are saying that the sample mean would vary depending on the sample obtained and hence their variance should be considered. Again, the class overwhelmingly says "Yes", as if it is obvious.

The class is asked whether or not all of the possible samples and hence sample means could be collected and the average of all of their individual values considered. The class is questioned on whether or not it is possible to consider the mean of all the possible means, based on all the possible samples that could be obtained. The class unanimously confirms this is possible.

2 For brevity the interaction with the students on how to undertake such research (including sampling instead of a census) has been excluded, however, this is another valuable part of the scenario as students can participate.
The class is asked if a histogram could be constructed of all of the possible sample means and its shape observed. They all say, "Yes".

The interaction and class responses are then restated to the class in summary form, verifying that the class agrees that they have just indicated that associated with the sample mean we can measure the variance, the mean and the shape. After the class agrees, the class is asked the three things which describe a distribution. They indicate, as taught earlier in the course, shape and measures of centre and spread. They are then told how they have just indicated that we could find the shape (via histogram as stated above), spread (stated above as variance) and centre (stated above as average) of the sample mean. Hence they have just described that the sample mean has a distribution. They are then told that distribution is called the sampling distribution of the mean.

The sampling distribution of any statistic can then be discussed. The significant point, however, is that rather than trying to describe the concept of a sampling distribution, the lecturer has, through a series of questions which students adamantly answer, enabled the students to describe the concept and existence of a sampling distribution to the lecturer!

To aid the presentation, it is advisable to have the follow-up questions and comments (i.e., after the class has provided their view) already written on an overhead projector transparency or Powerpoint display and revealed at each step. For instance, after establishing the scenario show the class the first question on the transparency "if each of you took a randomly selected sample from the population would you all get exactly the same mean?". Following their response (which will be 'No') reveal the next question on the overhead as "So are you telling me that the sample means would differ or vary? Is that what you are saying?". As well as reinforcing the verbal discussion with written commentary, it is somewhat intriguing, if not comforting, to students to see that they are telling you answers which you expected to hear.

3. Discussion

The suggested presentation methods and the examples provided are "sufficiently clear and self-contained to be immediately grasped", "immediately enlightening... (and),... surprising", "provokes reflection" and can be "presented as to enhance the impact of the foregoing three characteristics". Hence they constitute examples of striking demonstrations [4] and "making it memorable" [3, 7]. However, whilst Sowey's striking demonstration is after the "aha!" reaction and "now I see" and "(b)ut that contradicts what I already know" [4], this paper's approach is after the "wow!" reaction of 'gee I didn't realise what I already knew' and hence is a different way of building confidence via a striking demonstration. It is also "memorable" for the students because it is an event which each will reflect upon as they unwittingly describe a new concept in lieu of simply being told the concept.

It is intended that lecturers will reflect upon the approach and add to these examples. Ad-hoc examples based on asking the class what they would like to measure can be beneficial in further engaging the class.

It is advisable to avoid presenting examples that are only interesting or clever to the lecturer. Non-scientifically-minded students often already have the perception that Statistics is tricky and is part of why they fear the course. Lecturers must work to remove the mystery and be encouraging towards students by enabling them to feel that they can learn Statistics; that it is not so different.

References


http://www.amstat.org/publications/jse/v3n2/sowey.html

http://www.amstat.org/publications/jse/v9n1/sowey.html


http://www.amstat.org/publications/jse/v11n2/martin.html

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