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TYSTYSGRIF UWCHRADDEDIG ADDYSGU MEWN ADDYSG UWCH

POSTGRADUATE CERTIFICATE IN TEACHING IN HIGHER EDUCATION

Cylch Dysgu 2 | Teaching Cycle 2

Teaching Threshold Concepts with Cookies

Mae’r Cylch Dysgu hwn o’r portffolio TUAAU wedi’i gyflwyno i CADAIR gyda chaniatâd yr awdur uchod. Adnodd i’w ddefnyddio gan ymgeiswyr y TUAAU yn y dyfodol a staff eraill ydyw, fel rhan o’u datblygu proffesiynol ym Mhrifysgol Aberystwyth. Erys yn eiddo i’r awdur a Phrifysgol Aberystwyth. Os hoffech dyfynnu’r gwaith hwn neu gyfeirio ato, cysylltwch â’r awdur. Cei'r y manylion cyswllt yn http://www.aber.ac.uk/cy/directory/

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1. Introduction

1.1. Overview of the Module

Statistical analysis is a key component of psychological training. In order to conduct experiments and use research methods effectively, a psychologist must understand the basics of statistics. The Psychology Department therefore requires that all first-year Psychology students receive rigorous statistical training in a module entitled ‘Introduction to Psychology: Investigation and Communication’. This long thin module is a foundation course in which students learn to calculate a variety of statistical tests by hand. The module convenes once a week, alternating weekly between one-hour lectures and two-hour practicals. Forty-four students are enrolled in the module although not all students attend lectures regularly. One of the fundamental principles in quantitative statistical analyses is variance. This threshold concept is vital to understanding complex tests that students will learn in their 1\textsuperscript{st} and 2\textsuperscript{nd} years in a Psychology Honours degree.

1.2. Rationale for Change

The main idea of variance is that it is a measure of the difference between a set of scores and the mean of the scores (Field, 2009). Students are taught early in the module of how to calculate variance but often see it as an isolated function, disconnected from other concepts. However, understanding what variance is, how it is modulated, and how to control it is essential to understanding statistical tests. This threshold concept (Meyer & Land, 2003) helps students to realise that most quantitative statistical tests are essentially the same with small adjustments for certain circumstances. A big barrier to learning this important concept and statistics in general is that students greatly dislike statistics. Students who are not confident in their mathematical abilities especially dread this module. Because learning variance and statistics is critical to their success as psychology students, lecturers are always seeking out ways to engage them in innovative ways. This teaching cycle was designed with this aim in mind. The intended outcomes for this teaching cycle were:

- To engage students with a memorable illustration of variance
- To increase student understanding of variance for their next report

The first lecture of the second semester was chosen for this teaching cycle as it would serve as both a refresher of the first semester for students as well as transition into newer, more difficult material. Their next piece of coursework assessed the material learned in this lecture.
1.3. Brief Review of the Literature

Statistics is a challenging field in which to engage students. As vital as it is to psychology, many students resist learning due to their fears about maths and the perception that statistics is extremely dull. As statisticians tackle this challenge, they have come up with a variety of techniques to combat student disinterest.

Research in the education of statistics has shown that active learning promotes better retention of concepts (Garfield & Ahlgren, 1988). Tutors are encouraged to “introduce topics through activities and simulations, not abstractions; try to arouse in students the feeling that mathematics relates usefully to reality” (p. 48). However, students are so diverse that finding activities and real-life examples which appeal to everyone in the class is quite difficult. Sports and current affairs are often used as examples but may not be of interest to everyone in the class and may even introduce gender biases into the class. Lee (2007) proposed an area which he found had universal appeal: chocolate chip cookies.

Statistical educators have found success in using snacks as part of students’ active learning (Dyck & Gee, 1998; Richardson, Rogness, & Gajewski, 2005). Using M&Ms, Dyck and Gee illustrated the concept of sampling distributions (1998). Richardson et al. found chewing gum a helpful way to teach students about independent versus paired sampling (2005). Lee used chocolate chip cookies to show students that uniformity in mass produced products, such as cookies, is not always achieved (2007). Lee’s students counted the chocolate chips in the cookies to illustrate principles of variability, inter-rater agreement, sampling distribution, and measurement error. His students found the use of chocolate chip cookies very helpful in learning the concepts as well as an enjoyable part of the class. Almost all students are interested in snacks, and by using a familiar and relevant example, Lee was able to increase student understanding and enjoyment.

2. Teaching Cycle

2.1. Planning, Structuring, and Implementing

Using a similar paradigm described by Lee (2007), I planned my lecture around the chocolate chip cookies example. I purchased three brands of cookies from a local grocery store, enough for each student (23 students attended lecture on that day) to have one cookie of each brand. The first brand was distributed to students, and they were instructed to count the number of chocolate chips in their cookies. After the students counted and recorded the number of chips, we discussed the variables in this deceptively simple task. Students raised methodological issues such as whether to count chips visible on one side of the cookie or both sides, whether to break up the cookie to count
chips not visible from the outside, how to count cookies that were broken, whether chips of any size were counted or only whole chips, and how to distinguish between chips and aberrations in the cookie. These challenges were framed in the context of challenges in research methods that psychologists face in each experiment. This discussion was directly relevant to their next assignment where they would be pooling their data with other students and would need a standardised methodology to reduce error in the measurements. After this discussion, a second brand of cookies was introduced with the same instructions. To remind students about t-test analyses, we discuss comparing the two brands of cookies to decide which brand produces cookies with more chips. After this discussion, the third brand of cookies was introduced along with ANOVA (ANalysis Of VAriance), a more complex statistical test. Introducing the two in parallel built upon the previous discussion of two brands of cookies and t-tests. Students then orally reported their chip counts to me which I recorded on a spreadsheet. Hearing the diverse range of answers surprised the students. Chip count ranged from 8 to 35, which gave us an opportunity to discuss outliers. At the end of the lecture, a minute-paper questionnaire (Angelo & Cross, 1993; Wilson, 1986) modified to be similar to Lee’s evaluation (2007) was distributed to gauge student understanding (Appendix J). Four weeks later, students submitted a report which required the use of ANOVA.

2.2. Gathering Evidence

Both qualitative and quantitative evidence was gathered to evaluate whether the intended outcomes were achieved. The questionnaire distributed at the end of the lecture (Appendix K) consisted of five open-ended questions which were analysed for their mention of the cookie example. Because only 23 students attended the lecture, the marks that they received on their reports can be compared to the marks of the students who did not attend. Although motivational levels may attenuate both attendance and marks, comparing the marks of these two groups of students may yield interesting findings.

3. Interpretation and Analysis of Evaluations

3.1. Quantitative Evaluations

The marks of the 23 students who attended the lecture (Attending Group) were compared with the 12 students who did not attend the lecture (Non-Attending Group). The Attending Group had a higher mark (M = 58.96, SE = 2.72) for their report than the Non-Attending Group (M = 45.50, SE = 3.81). This difference was significant $t(33) = 2.89, p = .007$ (Figure 6). This difference supports what my outcome that students would understand the threshold concept of variance better. However, two mediating factors may be contributing toward this difference. First, the report assessed more
than only what was presented in the lecture and better understanding of variance using the cookie example may only have marginal impact on the marks. Second, the students who choose not to attend lecture may very well be the same students who struggle with the module and would have received lower marks regardless of the lecture. These caveats need to be accounted for when evaluating this exercise.

Figure 6. Report Marks of Attending Group and Non-Attending Group.

3.2. Qualitative Evidence

To determine whether students were engaged in the lecture and found the cookie example memorable, I analysed the minute papers which asked general questions about student understanding (Appendix K). Although 43% of students (n=23) still had an unanswered question at the end of lecture, the majority of the questions related to the steps of calculating the statistics; this was purposefully not covered in detail in the lecture as the following week’s practical would address the topic. Therefore the majority of the students felt they understood the topic well and did not have questions pertaining to the lecture. 30% of students spontaneously mentioned the cookie
example when asked how the tutor's teaching helped student learning. Examples of these comments are:

- Using the cookies was a great idea.
- Love the cookies!
- Tutor showed some aspects in practical way (counting chips in cookies)
- Kept it fun and easier to understand with the cookies example!
- The practical side of the lecture, counting chips in cookies, kept me engaged and focused.

There were no negative comments made about the cookies, and all comments about the cookies were positive. Although most students mentioned the ANOVA test as the most important thing learned in lecture, a few students mentioned the importance of variance and how this test was related to the previously learned t-test, which were more nuanced learning outcomes of the lecture. Similarly, another outcome of the lecture was the conscientious standardisation of methods in their report. The discussion of how each student approached counting the chocolate chips differently was echoed in the reports. Most students either went to great lengths to ensure that their methods across experimenters were uniform or included it in their conclusion as a possible flaw in their methodology. Having experienced the variance in chip-counting method, students seemed much more aware of variance in psychological experiments.

4. Conclusions and Reflection

The quantitative and qualitative evidence lead me to believe that my intended outcomes for this teaching cycle were somewhat successful. During the lecture, students did appear more engaged and active. The discussions were very lively and helped them make connections between the cookies and psychology experiments. It is difficult to determine whether this one example had a larger effect (i.e., on their marks) on student learning, but the students who were exposed to the cookie example in lecture did better overall on the report than the students who were not exposed to the cookie example. The qualitative evaluation revealed that students felt that they understood the topic and enjoyed the cookie example very much. Perhaps other methods of evaluation can be used in the future to ascertain the exact effect of this exercise, but I am not sure it is absolutely necessary as long as the general outcome is encouraging.

I believe the overall outcome of this teaching cycle was positive. I felt I was able to introduce statistics to students in an interesting and relevant way which they will remember in the future. Students do not expect to have an opinion in a field like statistics where the formulae are rigid and the rules seldom violated. Being able to see an example of how opinions in counting method can
drastically vary the outcome of a test made an impression on students. I also felt this exercise was a good way for students and tutors to interact on a different level. They appreciated that I used a creative example to help them learn, and students promised to clean up after themselves so that we did not create problems for the porters. Having a jolt of sugar during lecture (which starts at 12pm when stomachs are generally growling) also keeps students awake for the lesson.

5. Recommendations for Future Practice

I certainly recommend that this cookie example be implemented again in the future. It can work with groups of any size, and it is a relatively inexpensive teaching aid. The students enjoy the chocolate chip cookies, and it brings interaction to a lecture that is usually teacher-centred. I recommend more interactive examples so that students can become more engaged as they were in this lecture. Other researchers have extolled the virtues of incorporating snacks into statistical lectures and found them to have universal appeal to students (for a summary see Lee, 2007), which I would like to incorporate into future statistics modules. Larger class sizes should have marginal impact on the execution of this exercise. One possibility would be to introduce this exercise earlier in the module. As variance is a threshold concept, the sooner students grasp it, the quicker they will progress through the module. Although this exercised worked very well as a refresher and transition for students, it may also work well as the first introduction to variance.