The hidden curriculum in laboratory data analysis: development of a diagnostic test and initial results

S.P. Bates, R.K. Galloway, H.E. Maynard-Casely, H. Singer, K.A. Slaughter

Overview

During the course of a Physics degree, our students spend a long time in the laboratory. As well as learning how to 'do' practical physics, we also expect them to pick up skills in processing, analysing and interpreting data. These skills frequently fall into the hidden curriculum: they may not be explicitly taught and are often not specifically assessed. So do our students really attain a solid grasp of them? We have developed and validated a diagnostic test of data handling skills in the physical sciences, incorporating a variety of data analysis concepts. The test instrument has been evaluated using a trial cohort of over 1200 students and has been found to perform satisfactorily on widely-used measures of reliability. Our initial findings show that overall student attainment in these areas is surprisingly consistent across all institutions, disciplines and educational levels. In particular, there seems to be no clear development of student ability after the initial year of instruction, with widespread stagnation of student skill levels in the later years of the degree.

Motivation

The ability to manipulate and interpret quantitative data is one of the most important characteristics of physics graduates, and is highly valued both within academia and by employers [1].

However, these skills are often assumed (particularly in the later years of a degree) to be 'absorbed' as a side-effect of advanced lab work, and may not be specifically taught. Furthermore, assessment of these skills via the customary lab report can be difficult since they are frequently convolved with other factors such as practical ability and clarity of expression.

Consequently, we have developed a diagnostic test specifically to evaluate our students' understanding of these concepts.

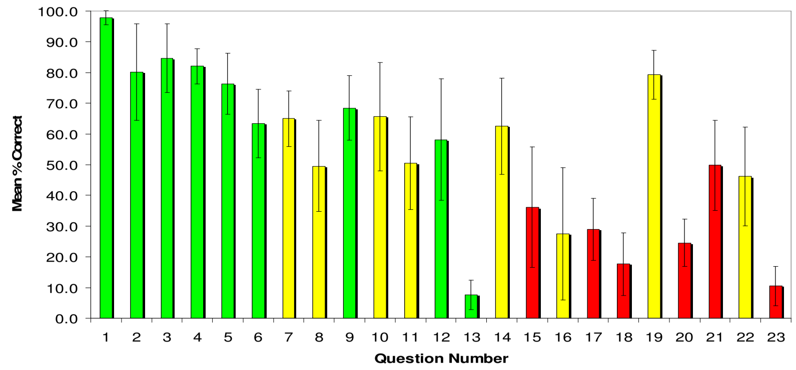

Figure 1: Mean percentage of correct responses for each test question, averaged over all trial classes. Bars are colour-coded according to anticipated difficulty: easy, medium and difficult.

Validation of the instrument

In order to assess the reliability of the test, it has been administered to a trial cohort of over 1200 students, encompassing all UK undergraduate years from 1st to 5th. The test was deployed in 10 institutions across the UK and Ireland (see Figure 2), in 7 physics and 4 chemistry departments.

Figure 1 illustrates the trial student responses, and is colour-coded to highlight the intentional stratification of difficulty of the test items.

The trial responses were analysed using a standard battery of statistical tests [2]. The diagnostic was found to perform satisfactorily on the appropriate tests; four questions required some refinement, and were amended using input from expert faculty and trial student feedback.

The Data Handling Diagnostic (DHD)

The test consists of 23 MCQ items, targeted towards a variety of data-handling topics. These include precision & accuracy, approximations, lines of best fit, errors & uncertainties, and the derivation of quantitative relationships from graphical data. The test is intended to be applicable at all undergraduate levels and across the physical science disciplines (physics, chemistry, engineering, etc.)

In addition to the diagnostic instrument itself, we are developing additional supporting learning resources. These will be made available on-line and will be specifically targeted towards the topics featured in the test. Students who discover weaknesses in certain areas can be directed to these resources for immediate and focussed learning support.

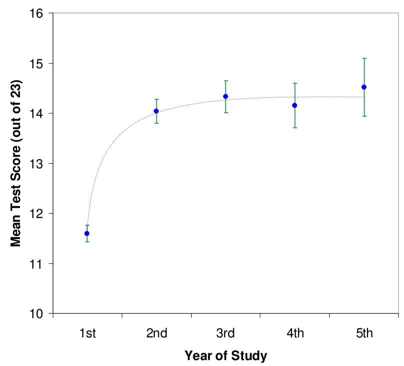

Figure 2: Trial deployment institutions (including Edinburgh).

Figure 3: Variation of the mean test score with year of study for physics students at Edinburgh.

Results from the trial deployment

The mean score for all trial students was 53%, with a standard deviation of 13%. The variation between the mean scores for each trial class was found to be less than the typical variation within a class, indicating a surprising consistency of average skill level across the institutions and years of study.

Figure 3 illustrates the latter point in more detail: Edinburgh physics students show a significant rise in score between 1st and 2nd year (between which they complete two courses covering data analysis skills), but thereafter their scores do not improve. Data handling skills are not explicitly taught in these later years: our findings (in conjunction with similar profiles seen in the other institutions) suggest that student abilities in these topics are not being developed to their full potential.

References
[1] Rees C., Forbes P. and Kubler B. (2006) "Student employability profiles: A guide for higher education practitioners", The Higher Education Academy (UK)

PERC / AAPT Summer Meeting 2010, Portland OR

References
[2] Ding L., Chabay R., Sherwood B. and Beichner R., (2006) "Evaluating an electricity and magnetism assessment tool: Brief electricity and magnetism assessment", Phys. Rev. Spec. Top. Physics Education Research **2(1)** 10105