STATISTICS FOR VOCATIONAL, TECHNICAL, AND 2-YEAR COLLEGE STUDENTS

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Students enrolled in vocational, technical, or 2-year colleges need to have an understanding of statistics which is well grounded in practical applications. At the lower classifications of skill levels, process workers are likely to be confronted with statistical charts and warnings about non-conformity. Technicians operating at higher skill levels may be involved in conducting tests on samples which have major implications for human lives or company profits, or both. This paper will outline ways in which to address the challenge of making statistical theory, which is often conceptually sophisticated, come alive and take on real meaning for students who generally have poor self-concepts with respect to mathematics in general, and a publicly shared fear of statistics in particular.

INTRODUCTION

Since the mid 1980s in English-speaking countries there has been a trend towards conservatism in vocational education by governments of all political persuasions. Curricula are informed by instrumentalist philosophies, and are frequently required to conform to a competency-based training (CBT) format despite the fact that there has been no educational research over the last two decades in support of CBT improving educational outcomes or work productivity (Jackson, 1993).

In the Australian vocational education and training (VET) system, operators are graded at level one, while technicians are at level five in terms of the qualifications framework. This paper will compare and contrast aspects of the statistics education of a group of students at each level: the operators are employed by a pharmaceutical manufacturing company, while the technicians are currently, or hoping to be, employed in scientific laboratories.

GOALS

Surveys of international documents of the goals of school mathematics (Niss, 1996), indicate that fundamental reasons for including mathematics (and especially statistics, I assert) in the curriculum include: (a) contributing to the technological and socio-economic development of society; (b) contributing to society's political, ideological and cultural maintenance and development; and (c) providing individuals with prerequisites which may help them to cope with the various spheres of life, private and social, including democratic citizenship. Such goals are also appropriate for adult learners as they develop through access to lifelong education and are enhanced

> by engendering or enriching self-respect and self-confidence, independent and autonomous thinking (including logical thinking), the development of explorative and research attitudes, linguistic capacities, aesthetic experience and pleasure etc. (Niss, 1996, p. 32)

Vocational education has two major foci, the needs of the student and of industry. Scheaffer (1994) reported that the notion of teaching statistics to practitioners has been used with great success in Japan.

> These industries are “managed by facts,” and all personnel are educated in the statistical way of looking at things. This educational process emphasizes statistical sense, rather than techniques, application ability rather than systematic knowledge, and problem-oriented rather than technique-oriented learning. Since problems come from the real work of the learner, students are enthusiastic. (p. 287)

Our students need sufficient skills to make informed decisions about the data they are confronted with both in daily life and on the job. Whether as operators or technicians, they are unlikely to be making critical statistical decisions in the workplace, however they need to have an appreciation of what are reasonable parameters for the data they collect or observe as they monitor operational processes.

There is evidence from papers presented at ICOTS 4 that the situation as described by Shaughnessy (1992) of university level courses in probability and statistics as rule-bound, recipe-type courses is beginning to change in Australia (see, for example, Roberts, Martin and Pierce, 1994, and Martin and Roberts, 1994) and internationally. The following section provides an illustration of innovation in the VET sector.

STATISTICS FOR PHARMACEUTICAL OPERATORS

In the pharmaceutical industry the situation of being licensed to operate is critical. Audits are frequent; regular and random inspections take place. All operators are constantly reminded of the importance of the maintenance of the highest standards of practice and the ongoing need for accountability and traceability. This information is continually updated through the use of Standard Operating Procedures (SOPs) which operators must sign after reading.

The pharmaceutical company decided to pursue a policy of formally recognising and upgrading existing skills of its operators through a three-level certificate course run in conjunction with Swinburne. The subjects include calculations, introduction to computing, communications skills, and quality assurance (QA) as well as others specific to the work of production or warehousing. In particular the course in QA for level one requires that operators:

1. Identify the critical control points for a specific task.
2. Obtain representative samples according to instructions.
3. Prepare samples in a format required for transfer to designated location.
4. Perform inspections and tests as required to assure product quality.

Criteria for assessment include description of actions, and purposes, broad knowledge of relevant regulatory requirements, and explanations of problems which may arise from failure to correctly follow procedures, potential risk of loss or damage. This is what some of the operators do every day! Studies at higher levels require the use of process control charts to monitor and record performance, eventually to diagnose and rectify out-of-standard performance.

The accredited CBT curriculum is atomised and assumes a deficit model of the learner. Although my brief was not specifically to teach QA but calculations and computing, I decided to provide as much integration of subject areas as possible. I was mindful of the social and educational needs of the learners as well as the goal of their employer for increased productivity. One activity involved a dice-rolling exercise, where students were required to collect 100 items of individual data, make observations about their data, use a calculator to find the means of groups of five and make observations about these, and then enter the 100 results a computer spreadsheet. We used *Minitab* to analyse the data numerically and graphically, to simulate comparable data, and to generate control charts for sample size five. We also viewed relevant selections from the video series *Against All Odds* (COMAP, 1989) to compare the operators' work situations with those of the Frito-Lay company.

The quality of discussion was extremely high because of immediacy of the operators' experience. In fact the level of awareness was as high or higher than for many students enrolled in the technician course who have either not been in the workforce or whose job requires minimal knowledge of QA. Students gained technical skills in using a calculator and computer, reinforced and developed existing knowledge and skills, both statistical and social (e.g. randomness, social consequences of gambling), and gained a deeper understanding of industrial processes (e.g. sampling, process control charts). The operators at level one were familiar with the control charts from production meetings and they expressed their satisfaction at knowing how they were created, even though it was not appropriate at this level to focus on the mathematics of the setting of control limits.

The qualities listed by Niss (1996) of self-confidence, logical thinking, the development of explorative and research attitudes, linguistic capacities, aesthetic experience and pleasure were enhanced. This exercise was also in line with the US standards for intellectual development of college students, which include problem solving, modelling, reasoning, connecting with other disciplines, communicating, using technology, and developing mathematical power (Cohen, 1995). At the same time the opportunity was provided for the operators to see industrial work from a broader statistical perspective (Schaeffer, 1994), even though we started off utilising an everyday, non-industrial example.

STATISTICS FOR LABORATORY TECHNICIANS

Following a similar philosophy I try to make the more difficult theoretical concepts required at this level as concrete as possible, greatly inspired by Zayac (1991). Students have a greater facility with mathematics and more time allocated to enable a greater range of activities at much greater depth. *Minitab* is an integral part of the course as is the *Against All Odds* video series, in spite of its age. Where possible and appropriate I use data drawn from the people who attend class or their workplaces. I also use different types of dried beans, which are inexpensive and model natural variation fairly well, for a variety of purposes such as being weighed for comparative boxplots, averaging different sized sample weights for the sampling distribution of the mean, and drawing samples from discrete distributions with given parameters. Zayac’s quality control activity has been modified so that beans are loaded onto a plastic fork handle, and students form their own QC charts before replicating the charts after loading data on *Minitab* and then, finally, evaluating their “scooping performance.”

Another activity uses a bag of oranges to develop the concept of confidence intervals. The lesson begins with each student being handed an orange and asked to guess its weight. Given that technicians are generally dealing with weighing and measuring as part of their jobs, this part is very revealing of the lack of basic physical awareness of commonplace objects. In general only experienced shoppers or students from families in fruit retailing have any good idea of the weight. A stemplot is made of the guesses, revising earlier work. The fruit is then weighed to the nearest gram and another stemplot made, with discussion about both plots. Students are also asked to estimate the average weight of oranges and then to calculate the mean and standard deviation. The question is then posed: “If all the information you had was the mean and standard deviation of this one bag of oranges, what could you say about the population of single oranges?” “What could you say about the mean weight of all such bags of this kind of oranges?” These bring about discussion of underlying assumptions, and also revises previous lessons on the sampling distribution of the mean as well as the 68-95-99.7% rule. Following the video there is also an opportunity to reflect on the possibilities and implications of increasing the sample size, in terms of ethics and appropriateness. The lesson is concluded with a *Minitab* session to enhance technological skills as well as confirm our findings. Of course the oranges are offered to those who would like them!

CONCLUSION

In this paper I have provided illustrations of ways in which statistics can take on meaning for vocational and college students in concrete ways which could be further developed to meet the needs of different student groups. This paper has built on the work of previous presentations at ICOTS conferences, as well as constructivist theories of learning, lengthy experience of teaching adults returning to study, and an ongoing effort to stress the social dimensions of statistics education in spite of narrow, instrumental curriculum documents prevalent in the VET sector.

Adult learners frequently exhibit signs of anxiety in mathematics-type courses and one of my goals has been to overcome these feelings. Adults also bring a variety of preferred learning modalities and the practical activities, together with videos, various computing tasks, as well as lecture-style theory and textbook examples provide a range of experiences from which learners can draw their own learning. The major problem in vocational classes seems to arise not from the subject matter, but from lack of continuity in class attendance due to family and/or work responsibilities.

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