TEACHING, LEARNING AND ASSESSMENT: COMPLEMENTARY OR CONFLICTING CATEGORIES FOR SCHOOL STATISTICS

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Over many years I have been attempting to improve statistical literacy in the population by changing the school curriculum. All such attempts have to be put in the general context of teaching, learning and assessing the subject. Ideally these should complement and reinforce each other. In practice they often conflict - in particular assessment can distort the learning process. In this talk I consider the nature of these conflicts and how they might be overcome in practice, giving examples from a lifetime's experience.

INTRODUCTION

My views on teaching, learning and assessment have been shaped at least as much by my experience as they have by theoretical considerations. So to give you some idea of where I am coming from I will start by telling you some stories from my teaching career that have influenced my view of these three subjects. Only outlines are given in the printed version of the talk, fuller details were given at the oral presentation. I had only been teaching for about three years when, at a formal staff meeting, a parent's letter was read out saying 'in spite of Mr. Holmes not marking my son's homework, he passed'. My conclusions at the time were that it was because I spent time working through the assignments and looking at the nature of the mistakes, and did not give a mark, that the student gained a greater understanding that led to his passing. Recently this was reinforced to me by some research done by Butler (1987, 1988), reported by Williams (1999) in an article in *Equals,* on the effect of giving grades or just comments to make pupils think. The main conclusion is that putting a mark on a piece of student's work hinders rather than helps them to learn from their mistakes.

A year or so later I turned up to teach a bright class of 18-year old students for an impromptu lesson on Fourier series. I did not expect to find one of Her Majesty's Inspectors at the back of the class as I arrived but was surprised by his final complimentary comments on the lesson. Several years later I became an examiner for A-level Statistics. (A-level was designed for bright 18-year old students). The last part of many questions was of the style 'what are the implications of the significance of this result?' To which the answer was often along the lines of 'this result is significant because it is significant'. This led me, with Vic Barnett, to introduce assessed project work in A-level Statistics.

My first International Conference on Mathematical Education was at Exeter in 1972. I remember vividly a discussion with a Japanese colleague about 'what is mathematics?' The then joke Japanese definition was 'mathematics is what mathematicians use', in England it was 'mathematics is what mathematicians do' – a world of difference philosophically and with many implications for teaching and learning.

I had been teaching for 15 years when I went to do a taught Masters degree in Probability and Statistics. One of my tutors was Terry Speed who gave a course in statistical methods. He spent the lectures talking about the people and the background that led to the development of the particular techniques and gave details of the techniques themselves in duplicated notes. My reaction to this was very different from that of my younger fellow students. It was also on this course I realized how much a knowledge of examinations could enable you to get higher marks with no more technical knowledge. My talk is about the interactions between teaching, learning and assessment. Approaching what happens in the classroom through each of these ideas will lead to different emphases.

Teaching: emphasises what teachers do.
Learning: emphasises what the pupils understand.
Assessment: emphasises what pupils can show they know.

TEACHING

When we talk of teaching we tend to be emphasising the person and the personality. We concentrate on what the teacher does in the classroom. We look for clarity of exposition and the amount of preparation done, the work that the teacher prepares for the student and the atmosphere that the teacher engenders in the class. We often talk of what makes an excellent teacher and how to get excellence in teaching. Though Evans (2000) argues cogently that what we should be looking for is not excellence but continual improvement. Putting the emphasis on excellence implies that only a few can attain it.

Now this emphasis on teaching may help the teacher feel good, but does it actually attain the required effect? Do the pupils admire a great performance? More importantly, if they are so moved are they then inspired to learn? If inspired to learn do they then go on to explore and consolidate. Teachers need themselves to be learners, both of the subject and of the effectiveness of the teaching. One of the main tasks today is to motivate the teachers to improve. In Britain at the moment there is an inhibiting effect of the National Curriculum on teacher involvement and new ideas coming through. Teachers are not empowered to experiment and seek out better ways of teaching.

In the 1960's there was a primary school development project in England sponsored by the Nuffield Foundation. This project took as its motto 'I hear and I forget, I see and I remember, I do and I understand'. At one in-service course I heard a teacher say that it should be 'I hear and I forget, I see and I remember, I do and I get stuck!' Precisely! It is through working through the 'getting stuck' that you come to understand.

Teaching is measured by learning, not on ground covered. In a real sense less can be more. It is better to have a deeper understanding of a smaller amount of content, and to appreciate underlying principles, than to have covered shallowly a larger amount of content with little understanding.

LEARNING

Learning emphasizes what the student understands. One definition of a teacher is someone who causes someone else to learn. We need to consider whether our methods of teaching are genuinely causing our students to learn. Are we encouraging deep or shallow learning? At tertiary level many of us make a lot of use of lectures. This may not be the most appropriate form of teaching, especially for a practical subject like statistics. Bligh (1998), summarizing research into different forms of teaching, concludes that the best that can be said of lectures is that the lecture is as effective as other methods to transmit information. Lectures are not as effective as discussion methods to promote thought. Lectures are ineffective to teach behavioural skills and changing student attitudes should not normally be the major objective of a lecture.

At the school level many years ago Holt (1990) argued that for many pupils the motivation for their behaviour in the classroom was not learning but survival. A corollary of this is that the easiest way to survive is not necessarily to learn. Over the years teachers have often developed a system of rewards from gold stars at the primary school to giving marks later on. Kohn (1993) argues strongly that this strategy can be counterproductive; we can effectively punish learning by giving rewards dissociated from the fruits of the learning. The best incentive to learning is for the subject itself to be the reward. This has strong implications for teaching and learning statistics. Recently I was at a national conference for mathematics teachers. In talking to the organizers of the conference, all mathematicians, it was noticeable that they all said that they came to be mathematicians through enjoying mathematical puzzles, paradoxes and problems. The mathematics was itself the reward.

One implication of this for learning is that we may best try to motivate our students by getting them involved with the statistics, having their active participation and attempting to feed their curiosity and build on their desire to know. The constructivist approach to learning means that real work is required on the part of the learner and the role of the teacher may best be to stand back but make sure that the student gets on with the work.

ASSESSMENT

Assessment is the single most important element in deciding what and how to teach for most teachers most of the time. It is a case of WYTIWYG (What You Test Is What You Get). We live in a society unhealthily preoccupied with assessment. Different purposes of assessment have different aims, different philosophies and different effects on teaching and learning. Four different purposes of assessment are:

- Formative, so that the positive achievements of a pupil may be recognised and discussed and the appropriate next steps may be planned,
- Diagnostic, through which learning difficulties may be scrutinised and classified so that appropriate remedial help and guidance can be provided,
- Summative, for the recording of the overall achievement of a pupil in a systematic way,
- Evaluative**,** by means of which some aspects of the work of a school, or other discrete part of the educational service can be assessed and/or reported upon.

Putting it another way, assessment can be done to enable:

- The student to know what (s)he knows and does not know (formative),
- The teacher/lecturer to know what the student does and does not know (formative, could be summative depending on the purpose);
- The teacher/lecturer to know how effective is the teaching (formative);
- The institution to give a grade (different levels of pass or fail) linked with an award such as a certificate or a degree (summative);
- Society to assess the effectiveness of the institution or the teacher (evaluative).

The essential difference is between those forms of assessment where it is for the improving of student learning (formative and diagnostic) and those where there is to be a grade/mark given. The first category requires information in time for corrective action to be taken; the second can be done at any time but is better biased towards the end of the course. It is the summative results that usually form the major part of any evaluative assessment of the course and the tutor. Evaluative assessment is imposed from the outside and is a distortion of the other forms of assessment. It will make teacher and administrator do what they can to get a good evaluation. Remember survival is the name of the game. It makes the teacher a pig in the middle with very little direct power. The teacher needs a great deal of inner security to concentrate on making better learners. But it is important that we do this and not let the survival instinct make us take short cuts. It is NOT possible to do all of these forms of assessment at the same time. In particular, to be effective they need different psychological approaches as described below. Effective assessment requires us to make many decisions. The following is adapted from Garfield (1994). We need to decide:

- *What* it is we are going to assess. This includes the content; it could also include attitudes.
- *Why* we are assessing it. Is it for formative or summative reasons? Is it the appropriate thing to be assessing?
- *Who* is to do the assessing? Is it by the teacher/lecturer? Is it by an external agency? Is it done by the student or peers?
- *How* is it to be assessed - the method of assessment. Written, oral, closed, open, individual or group etc.
- *What* is to be done with the results? What is the feedback to all concerned?
- *When* is it to be done?

I would summarise the connection between formative and summative assessment in the following four aphorisms.

- *Since students learn to value what they are tested on we should test what we value.*
- *Formative assessment implies that the student wants to know rather than wants to pass.*
- *Good summative assessment will ensure that the student knows as well as passes.*
- *If formative and summative assessments do not match up then generally the summative assessment will dominate because students are more interested in passing than knowing.*

Generally students and teachers will look at the nature of the summative assessment to deduce what is important. This is particularly so if the assessment is being done externally. Revision time will usually be spent on preparing to get the highest marks on the summative assessment. From the external examiner's point of view it is clear that this scenario leads to a sort of game in which the student is under pressure to gain as many marks as possible, and this can be detrimental to encouraging a student to gain a deep understanding of the subject.

These have implications for examiners. Garfield (1994) draws out two principles that are often overlooked by examiners but should be taken seriously because of the effects summative assessment has on learning. These are the *Content* principle and the *Learning* principle. The *Content Principle* says that assessment should reflect the statistical content that is most important for students to learn. The *Process Principle* says that assessment should enhance the sound development of statistical concepts, insights and ways of thinking. Often these principles are not followed because it is easier to assess what is simple than what is important and the methods of assessment that develop insights and personal skills, such as team project work, are more labour intensive.

In considering school A-level examinations in England at the time of introducing project work we were led to ask whether what we had been doing was best and decided that it wasn't. We needed to sharpen up our aims in these courses and try to gear the assessment to reinforce the aims. It was clear that we needed to consider again what it meant to be a statistician at this level and what were the appropriate levels of statistical expertise we are trying to develop? There is a different pressure psychologically on the students between formative and summative assessment - provided that these are clearly kept distinct. If the assessment is purely for the purpose of giving the student and/or the teacher insight into levels of understanding for the purpose of improving it then there need be no sense of judgement. In Deming's phrase we are driving fear out of the system. As soon as there is an idea of summative - giving a grade - then fear comes in.

There are two ways in which this can happen. One is when the teacher is also the summative assessor (at some stage, not necessarily at the time of the formative assessment). In this case the student may be anxious that the formative assessment will colour the later summative assessment. And there may be good reasons for this since it is difficult for the teacher to forget completely what has been seen at an earlier stage. I will close with a question that has been widely used in England, first as a test example and then as a teaching example. As a summative test example it includes too much detail - the sort of detail that is appropriate for getting insight into detailed weaknesses that may be put right. As a teaching example it leads to very bad statistics in that it writes in a context that must not be taken seriously if you want to answer the question as the writer intended.

> *I can either catch bus 1 or bus 2 on my way home from school.*
> *This is how long I had to wait for bus 1 on my last 5 journeys: 10 min, 8 min, 5 min, 9 min, 8 min.This is how long I had to wait for bus 2: 16 min, 1 min, 2 min, 15 min, 1 min.*
> *The mean waiting time for bus 1 is 8 min and bus 2 is 7 min. The range for bus 1 is 5 min and bus 2 is 15 min. Use the mean and the range to choose which is the best bus to catch.*

(This was initially written to test Objective 5/4c of the English Mathematics National Curriculum. This objective stated *Pupils should understand, calculate and use the mean and range of a set of data*).

1. This should be formative not summative information. It is very atomistic. Such testing encourages atomistic teaching.
2. It does not encourage critical thinking. The data have nothing to do with the question - catch the first bus that comes (unless you also know something about the time of the journeys home).

SUMMARY

Teaching, learning and assessment. If we integrate them properly with a focus on deep student learning, then we can improve the statistical education experience of all our students. If we don’t then we have three conflicting categories

Teaching	Summative Assessment	A sage on the stage
Learning	Formative Assessment	A guide on the side
Assessment	Evaluative	A tool in the school

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