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# TESTING AND EVALUATION AS POWERFUL AGENTS TO AID OR RETARD CURRICULUM DEVELOPMENT - WITH SPECIAL EMPHASIS ON THE IMPACT OF TESTS AND EXAMINATION ON AIMS AND SUCCESS IN TEACHING

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In devising any teaching system, we should look at the sociology of examinations: the interactions between examinations on the one hand and, on the other hand, teachers, teaching-methods, students' learning, students' opinions the field of study, parents' opinions,.... In addition to the dozen or more uses of examinations that we normally think of, there is one powerful aspect that we should consider in curriculum reform: the effect of examinations in telling students the aims of our teaching.

Suppose, for example, we aim at giving students an understanding of science, a feeling for the way science is done, a knowledge of science as a fabric of experiment and theory. If we end with a traditional examination that asks for memorized definitions and unthinking use of formulae, that will undo much of the good we hope to have done. Students infer our aims from our examinations and the next generation of students will hear and will be tempted to neglect our offer of good understanding, and will concentrate on memorizing.

Yet we can promote broader aims if our examinations ask for some critical thinking, using the material studied -- and sometimes some imagination, going beyond the material studied -- and ask for clear explanations in the student's own wording. (Think how often a good teacher says, "I never really understood that topic until I came to teach it", we can apply that to young students, asking them to teach the examiner, informally), we can make tests for understanding and even for enjoyment of science -- though we shall have to sacrifice some precision of marking (reliability) for the sake of this gain of relevance.

The interaction between examinations and teachers is equally important, if we want to encourage teachers to change their teaching style, we may have little success if we keep the same examinations; but we can persuade teachers strongly and happily in a new direction if we provide examinations that fit the new suggestions and offer homework questions of similar build. Thus, in curriculum development or renewal, a change of examinations enables us to tell students our new aims and enables teachers to change their teaching.

Examinations and the Beginning of Science for Children in Developing Countries

In a developing country, our primary problems, before we design a programme of science teaching, are: (i) to show parents and other members of the family something of the purpose of learning science; and (ii) to help (re-) orient incoming pupils, however young, towards scientific ideas in contrast with other world attitudes.

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The facts of science can be learned by rote and may then occasionally be put to direct use; but to put science to extensive use and to teach it so that the general educated public trusts science and scientists, we must first prepare the ground for the pupil's reaction to rules, laws, formulae, theories and "scientific explanations".

For example (at a later stage in physics) pupils meet the heating-up of air on sudden compression. We may say "a ball rebounds with increased speed from a moving bat; so do air molecules from the piston which is moving in: and faster molecules have more kinetic energy, which means the gas is hotter". Or we may take a classical Greek view: "The heating just does happen: it is natural". Or we may take a religious view: "Heaven arranges that". Or a child's superstition: "There are little creatures inside which get angry when the piston pushes".

Note that ANY of these can serve as a satisfactory explanation, to comfort people that the behaviour is reasonable, not quixotic. At first thought, the best choice may seem to be the one that is short and clear and fits the general attitude the child brings from home. The scientific version is longest and looks the most complex. It is not obviously the most satisfying: until one has sophisticated knowledge its value as part of an economical scheme can hardly be appreciated. Its only direct advantage is that it can help to predict: and we need to show that it thus offers practical use and a sense of personal power. (Note its use in diesel-engine firing).

The young child, bringing his outlook on the world from home, and conditioned from infancy to judging his own behaviour, and developing it, according to parental approval or disapproval, will judge his early school lessons partly by his world outlook from home, partly by his teacher's approval. Beginning science with acquaintance, when the teacher shows a delightful demonstration or provides equipment for enjoyable experimenting, that offers experience but it does not in itself provide the important element of approval/disapproval which will determine any lasting educational effect. Attention, encouragement, sympathy, praise: all these can reinforce early learning of science and they are in a way simple, informal acts of testing -- a judgment-exchange between child and teacher.

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As the teaching progresses, the teacher asks questions: these are both aids to learning and at the same time simple examinations. Making comments, asking questions, giving tests, setting examinations, providing external examinations: all these not only evaluate progress (satisfying some needs of teacher and school), not only act as mirrors (to reflect to each pupil a picture of his progress), but they also provide feedback to the pupil, telling him what kind of science we are trying to teach. This then influences the direction of his learning -- an influence so powerful that it may be the key to progress in changing the nature of science teaching. If, in early stages, the tests ask for simple facts alone (what I call "cheap recall") or for mechanical use of memorized formulae and definitions, the pupil may decide that success in science comes from prolonged obedient rote learning. If we ask for informal descriptions of experiments and, later, some reasoning and putting-together of several pieces of knowledge ("expensive recall") we are telling pupils insistently a different view of science.

Encouraging the learning of Science: Early acquaintance Experiments

In some countries, in ordinary life there is much weighing at home -- babies are weighed, food weighed in the kitchen, parcels for postage, butter in shops. Then if in early science we give children blocks of different materials to compare, they will naturally try weighing them if there is a balance nearby. To children in other communities where weighing is less common, that is not such a natural move, and even the idea of comparing materials may not be attractive or interesting. How can we encourage children to want to compare? A good teacher does that by asking a question or by an informal word of praise -- both methods a very simple form of examining.

A big balance in the form of a see-saw to weigh each child can be used at first for random play: then used for a guessing game which gives personal excitement and can even begin to make the idea of scientific devices important. This is using "pleasure in successful doing".

As motives we cannot be sure the child will want to be scientific, or even to do experiments or make measurements or enjoy finding a law. The only emotion I think we can be sure of, world-wide, for our purpose, is pleasure in success. For that we should provide games -- tests in a happy form -- such as

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the following. (Readers will hardly notice the element of an examination -- yet in the broad sense it is there, ready to help):

mending a toy, leading on to discovering how to mend a toy specially designed to need a sequence of repair-acts (A hope of the idea of a rule, or at least some scheme that is not arbitrary, is concealed here)

guessing how many beans are left in a bag: e.g. 5 beans are placed in an empty bag, and 3 are taken out: how many still there? (This is not just an introduction to subtraction: there is a hint of conservation-principle here)

after being shown how to connect a battery switch and lamp, can pupil teach a younger pupil how to do it?

make and use a very simple camera (lens and box and slow film) in contrast with the mystery of Polaroid camera.

Even games that only give acquaintance can be turned into chances for pleasure in success <u>if the pupil has to show other pupils</u> how to make them work. E.g.,

simple camera (above)

making a "microbalance"

making a small firework

clapping hands (as a simple clock, with pupil's back turned) to predict the return swing of a long pendulum

protecting one's hand from sunshine with bright metal leaf.

From the point of view of (concealed) hints towards a knowledge of how scientific work is done, these may be even more valuable than the simple collecting of biological specimens that is usually suggested for a start -- that latter may just be taken for granted by children in a rural community as something too much like daily life.

<u>Later Physical Science: Laws</u>

At a later stage, when in formal physics we want to use laws and formulae, we may find that such things are easily memorised but are unfamiliar and difficult to understand in any way that promises lasting knowledge and good uses. (In the last century, in some countries, we might well blame examinations such as the Cambridge Local, crammed-for energetically and taken at a distance by post, for a grave lack of understanding science. Such examinations could be passed by

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memorising and following instructions. Their neat, clearly worded, syllabus, thought to be a legal safeguard, may well have been a legal barrier cutting the student off from reasoning, imagination and understanding in his picture of science).

Nearly all physical laws can be stated with the word "constant" as the key to their nature. That expresses some belief in the uniformity of nature, and it exhibits our scientific approach in contrast with beliefs in arbitrary powers in nature, Above all, conservation laws (of mass, electric charge, momentum, energy,...) play a very important part.

When we want to introduce conservation laws we may first have to convey an understanding of conservation and a feeling for its value. To students in a country with flourishing technology, conservation may seem a naturally useful principle; then we can proceed at once to teach conservation of momentum or energy. But in other countries the basic idea of a constant total may need careful introduction, as something important even if it seems uninteresting. Perhaps that can be done by simple games -- in which winning the game depends on believing that a certain total remains constant. Even illustrations such as conservation of cash in an island community may be ineffective, because the student does not feel a need to use a conservation law -- that is after all a sophisticated pattern of modern science.

However enthusiastically we have tried to build up the idea of laws or conservation principles, we shall not give it a genuine place of importance unless we ask questions about it in examinations. If there are not such questions in public examinations, students will doubt its importance and teachers will easily be persuaded to neglect it. We might ask:

"(i) From the following data for a collision, calculate the final speed of....."

We may well get only an unthinking form of success unless we add:

"(ii) Say what general principle you trusted in calculating the answer to (i)

(iii) Does the principle you mentioned in (ii) apply in all collisions or only in some kinds?"

This form of question with separate parts to insist on reasons being given is more potent than just "Explain your working" because that admonition does not say clearly enough what aspects of the answer the examiner thinks important.

<u>Specimen Questions for tests or Examinations</u>

Look at some traditional examination questions:

1. A man in a high building leans out of the window and drops an electric light bulb. How far will it fall in: (a) 3 seconds from rest, (b) 10 seconds.

The candidate brings a memorised formula from his head and calculates a reasonable answer for (a). For (b) he ploughs on with the same formula, little caring that the lamp will need a well hundreds of metres deep to fall into, and perhaps not knowing that it will have approached terminal speed long before that.

2. State Newton's Laws of motion, and calculate the acceleration of the system sketched (loads on a rope hung over a pulley-wheel, assumed massless and frictionless).

The candidate must give a formal wording of the laws in textbook form and then solve the problem -- quite likely using a memorised formula, but in any case proceeding without any real feeling for the mechanics of it.

If we must examine those rather formal matters -- and the modern tendency is to replace them by realistic questions that ask for constructive thinking -- we should start by printing formulae on the front of the question paper. (That is already done in some systems, and it produces the intended change of attention.) We might ask:

1.* In the relation $s = ut + 1/2\ at^2$,

(a) What does <u>u</u> represent? _ _ _ _ _ _ _ _ (two lines for the answer, on the examination paper) _____

(b) What does <u>ut</u> tell us? _ _ _ _ _ _ _ (two lines for answer) _ _ _ _ _ _

(c) Explain how the 1/2 arises _ _ _ (3 or 4 lines) _ _ _ _ _

(d) If the formula above is used to calculate the distance an electric light bulb falls from rest in 3 seconds the calculated result agrees quite well with experiment. If we calculate the fall in 10 seconds we find the experimental measurement does not agree. Suggest reason(s) _ _ _ (5 lines for answer) _ _ _.

2.* Here are Newton's Laws of motion (printed in formal wording on question paper) Explain what they mean, in your own words, so that another student could learn from you what they mean.

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The formula for the acceleration of the system shown is:

$a = g\ (M_1 - M_2)/(M_1 + M_2)$, if the system has no friction, and the pulley and rope have negligible mass.

(The sketch shows loads $M_1$ and $M_2$ connected by a rope hung over a pulley) Suppose the rope does have a lot of mass. Describe the motion you would expect to observe if the system is now released.

Examiners reading candidates' answers to 1* and 2* will certainly be able to decide whether a candidate understands the acceleration formula and its use, and whether he has some feeling for the nature of mass -- though the examiner will have to accept a variety of answers. As well as that, candidates will see from the questions that they need to know what they are doing and to understand the physics they use for answering. That message to the candidates is a very valuable contribution from examinations.

For easier, but equally searching, questions the examiner may imagine a kindly adult, Mr. X, who asks the candidate to tell in his own words how or why something happens -- e.g., cooling by evaporation, or success of some pulley system in reducing the force needed for a job. Mr. X is clearly described as kindly, intelligent, but ignorant of physics. It has been found easy to train students to expect questions from a Mr. X and to know that they must explain in ordinary language. (In fact in one project where two groups of students took the examination with a "Mr. X" question the Examiners found that they needed to adjust their reading to quite a different vocabulary from the less able group -- but then found that group also, many of them, successful in explaining.)

## A Strategy in Curriculum Reform: Examination-Manufacturing Seminars for Teachers

Since a new curriculum or new aims or ways of teaching will need consistent homework problems, tests and examinations, it is important to offer teachers some training in making questions or problems that fit the new teaching. But I have found that such a seminar goes far beyond its immediate aim: it provides a very powerful way of educating teachers in all aspects of the new scheme.

We invite a group of teachers (perhaps with a few administrators) say a dozen in all, to a conference to manufacture questions for examinations (also for homework or other teaching uses). After a first meeting to set forth the aims

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and needs, and to give some suggestions about types of questions, members of the group disperse to make up one or two questions each. When they reassemble, one starts by reading his question: then neighbors start objecting, criticising, defending, changing, and adding to it. After an hour or more we have only discussed two or three questions, because then we have ceased to be a question-factory and have become a philosophical discussion group, vigorously exposing, comparing and discussing our teaching aims. I shall have acted as a chairman at first to encourage the discussion and criticism of questions; but later I retire into a less active position, merely adding a few comments on aims and feasibility of methods. In practice this turns out to be one of the most powerful methods of briefing teachers in new and different teaching programs from its initial activity in encouraging participants.

Since participants are encouraged to tear each other's questions critically to pieces, I call this gathering a "shredder". The name has proved useful in encouraging frank criticism from the start, and in concealing the philosophical aspect which will appear - and which is a major use of the gathering.

Teachers invited to discuss their philosophy of teaching in a conference usually hesitate, or else launch into unrealistic aims. But teachers invited to an examination-making shredder soon discuss realistic aims -- discovering new ones and re-examining old ones, while a chairman can guide the arguments in useful directions.

Subjective Judgments

The questions asked and methods used in evaluating a new programme can be helpful if they take full account of the programme's aims; damaging if they measure and magnify outcomes that are not really sought, but happen to be easy to measure. Unfortunately, some of the most valuable and lasting benefits that we hope can be conferred by learning science are difficult to evaluate. How can we measure a young student's delight in doing his own experiment, or enjoyment of success in using simple theory? In such essentials we may have to forego some precise evaluation and place our trust in subjective judgment by teachers.

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