Social factors in the assessment of mathematics: Students, teachers schools and political institutions

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This paper considers the broad purposes of assessment of mathematics with regard to the demands of society, the requirements of the institutions involved, and the perceptions of the teachers and the students. The relations between these different agencies are discussed, and it is demonstrated that there is a danger that assessment can be regarded as the principal means of control and regulation of the educational system.

Assessment and evaluation

> Assessment is at the heart of the process of promoting children's learning. It can provide a framework in which educational objectives may be set and pupils' progress charted and expressed. It can yield a basis for planning the next educational steps in response to children's needs. By facilitating dialogue between teachers it can enhance professional skills and help the school as a whole to strengthen learning across the curriculum and throughout its age range (TGAT, 1987, para. 3)

This is a statement made in the government document which was issued at the beginning of the process of the formation of the National Curriculum for England and Wales. The use of the term assessment in this quotation and in current writing found in English government sources requires some explanation. There is an underlying fundamental difference of view between the meaning expressed by government documents like this, and the term "assessment" as used in most educational practice.

Assessment is almost as old as mathematics itself. As long as mathematics has been taught, students have been assessed. Success in mathematics has traditionally been associated with the gaining of entrance to high posts in administration in societies throughout the world. Success in mathematics has also been used as an indicator of other intellectual powers, and has been used as a gateway to all kinds of professions. These uses of mathematics depend on two fundamental assumptions; one in classical faculty psychology, where high mathematical performance is seen as closely connected to other general cognitive skills; and the other, that someone who has been successful in a very difficult area like mathematics has a high level of ability and self discipline which will guarantee success in other studies or in posts of responsibility. Given the different cultural, social, economic and political systems in our societies, it is not surprising that there have been heated discussions over the role and function of mathematics and its assessment.

For the educator, the term "assessment" is applied to any means of obtaining the kind of information that will indicate the state of a pupil's knowledge, progress or potential, usually in a given subject area. In mathematics, this usually means judgments of the mathematical capability, performance or achievement of students as individuals or as groups. Hence the term assessment applies to the outcome of the teaching and learning process at student level. Clearly there can be good and bad methods of assessment, and methods which are more appropriate and useful in one context or another. This basic problem of gathering information on pupils is one of the important tasks of the teacher. The information is then used in a variety of ways to confine, direct, or to benefit pupils, according to the intentions of the teacher, the institution, or the society. These intentions are usually expressed as broad aims or specific objectives depending on the institutional level where they are intended to operate. The needs of society may be expressed as a "numerate work force" or "skills for economic development" whereas the school might have "increasing the success rate in the examinations" as a priority, whereas a teacher might be wanting the "understanding of mathematical processes" as her principal objective.

On the other hand, the term evaluation (in English) is applied to the judgments made about the educational systems whether they be at classroom level, or at institutional or governmental level. For example, the results of a class test given by a teacher may show that the pupils have not understood a particular concept, or are unable to apply a particular process. The teacher then has a number of options to consider: Is the material too advanced for the pupils? Do the teaching or presentation methods need to be changed? Does the order of presentation of this topic in the curriculum need to be reconsidered? Has the teacher been too ambitious in their

expectations of the pupils?, and so on. At institutional level it might mean examining the processes of assessment, and looking at the curriculum as a whole to decide whether the assessment methods are appropriate for particular kinds of subject matter considered with respect to the objectives for the different subjects. In mathematics, an example here is the debate concerning the difference between "product" and "process". We talk about improving students' "problem solving ability", yet It seems obvious that any test of the product (facts, conventions, use of algorithms, proofs of theorems, etc.) is not necessarily going to reveal very much about a student's thinking processes. Whether or not teachers can apply appropriate assessments in this case, may have implications for initial and in-service training. So, evaluation is the process of considering the aspects of the system that we value and coming to decisions about the broader aims and policies which could be implemented.

In the current situation in the state schools of England and Wales the political view of assessment of mathematics is of an exercise limited to a narrow band of the curriculum using traditional "paper and pencil" tests, most of which are tests of "product' where results are supposed to be used by the teacher to decide on the level of pupils achievements (i.e. to grade them) and to plan the next stages of their learning. It is questionable whether these kinds of simple tests provide much useful information that the teacher did not already know from the normal activity in the classroom. However, the results for mathematics are aggregated with the assessment results from other subject areas of the curriculum, and used to rank the school in a public exercise in order to compare one school's "results" (and thereby it's performance) with another. In this situation, the processes of assessment and evaluation are conflated, and confused; in fact the assessment of pupils is used directly as an assessment of the school, and no real evaluation has taken place. While the "paper and pencil" tests are intended to be nationally standardised, each teacher contributes to the assessment of their pupils by their knowledge of the day to day process of classroom teaching, and what may be found out in the process of the teacher's assessment may also differ from pupil to pupil and from class to class, according to the ways (or modes) in which the questions are asked, the tasks are carried out, and the pupils responses elicited. Huge assumptions are made, when comparing pupils' performance from school to school, but even worse are those where national comparisons are used as political tools. What reasons are there to assume that we are comparing even approximately similar situations?

The three modes of a test

A test in mathematics may appear quite different, and produce very different results according to the way in which it is presented to the pupil. Not only this, but the way in which pupils are expected to work and the way in which they are allowed to respond can be different also.

The presentation mode

This is the method of asking the question. For example, a test in elementary arithmetic may be given as an oral question alone, a purely written question, an oral question about some apparatus like blocks or rods presented to the pupil, or a written question with visual demonstration or computer animation, etc.

The task mode

This term describes the expected method of working for the pupil. It can be mental only, or written, or a practical demonstration, as in moving the given blocks to another arrangement, or it can be operating a calculator, etc.

The response mode

Here the pupil may be required to answer in a particular way, oral, in writing, by demonstrating, or by another means, and the examples above indicate the many possibilities that are available.

According to the response the pupil makes, we make judgments about what we think they know and understand. In this sense, teachers interpret pupils responses and categorise them according to preconceived criteria, but the interpretation of the responses is often a problematic and delicate issue (For example see Labinowicz, 1985, pp. 395-397).

It is not only the obvious situations of handicapped pupils or those with specific learning difficulties where we may have to alter the modes of a test in order to give them a chance of making an answer, but there is plenty of research evidence to indicate that altering the mode of presentation, task, or response does in fact make it a different test, and so the results an individual pupil may produce can vary widely, and teachers not only have the task of interpreting them, but also of comparing the results with those of other pupils. (Donaldson, 1975; Hughes, 1985)

Criteria, norms and understanding the system

Ideally, assessment is intended to give information to three kinds of recipients in a number of different ways.

- *To the individual student,* with respect to the given course or subject matter, in order to give a picture of the students performance. This may include information on the quantitative aspects of the student's content knowledge, their strong and weak points, but also on the more affective aspects, like attitudes and working habits, etc.
- *To the teacher*, assessment gives information about individual students which can be used in many different ways; to deal with the student's difficulties, (diagnostic assessment), to advise the student or to plan the next stages of learning, (formative assessment), as a basis for reporting on the student to other teachers, to parents, or to provide references for further advancement (summative assessment). Also, the assessment provides information about the teaching in relation to individuals or groups of students for the purposes of evaluation.
- Assessment also provides information *to the system* about the performance of individual students in order to make decisions about selection for further courses of study or for other kinds of work (summative assessment). But also, it provides information about the performance of groups of students as a contributory factor for the evaluation of teachers, curricula and institutions.

All these judgments above can be made either in absolute or in relative terms. Often the same information is used in both ways. In absolute terms, we have criterion referencing where a set of (so-called) objective criteria are set up against which students' performances are measured. These criteria are typically expressed as aims of courses, objectives of lessons, or as specific targets which students are expected to achieve. These objective criteria are dependent on a range of factors like the traditions of the order of the topics in the curriculum, the beliefs of the teachers about the nature of mathematics or about students' learning processes, the ideology of the administrators about the purpose of mathematics, and so on.

In *relative* terms, we have *norm referencing* where an individual is compared to others within a group, or a group is compared to other groups or to the wider national (or even international) picture.

Again, assessment using both absolute and relative criteria are almost always conflated. Assumption is that the criteria are absolute and objective, and then this result is used to rank the student in relation to others in the same group; and possibly to others in different groups who may even have taken a different test.

If we consider this in relation to the popular misconception that the mathematics taught in schools and the methods of teaching are, (or even could be) similar enough everywhere, and that the tests we apply are also similar enough to allow these kinds of comparisons we see we have a highly complex problem. While the methods of assessment have these disadvantages, society continues to apply them in the belief that they are the best we can do at the moment. Tests used in assessment are public and formal. In that way they claim to be the basis of objective judgments and to prevent arbitrariness and favouritism. However, the marking of the assessment can vary greatly, and is open to the problems of differences of presentation and mode variation outlined above. If the tests are easy to administer, they probably do not address many of the things we would like to include as mathematics teachers; so what is not tested becomes invisible and disregarded as unimportant. Another factor which bears on the assessment process is that some students are better that others in understanding and complying with the rules that govern the assessment. Economic position, gender, family background, ethnic origin, linguistic ability, etc., all of these may or may not contribute to the ability of the student to understand what is required in order to pass the examination.

Cultural differences

The remarks above might be based on the assumption that the tests would be given in a "normal" classroom, but what does that mean? We know that girls do not react and respond to these tests in the same way as boys. (Isaacson, 1982) Do the results of the tests given to children of affluent parents from literate backgrounds mean the same as those given to pupils in a school in a country area or in a poor city area? Examples of differences between the normal discourse of the home and of the school are common. In the English primary classroom it is common to find teachers emphasising the use of the words "more" and "less" as comparative adverbs in order to establish transitive relations. (For example, A is more than B and B is more than C, so A is more than C.) However, in common language use, "Can I have some more?" that is, a request for more food, or sweets, etc. has a totally different meaning. (Walkerdine, 1988) Cultural differences arise in a "normal" classroom as well as where there are obvious groups of immigrant pupils or pupils from ethnic minority families already established in the host country. The problem of language is also one of extreme importance. Our thoughts and ideas are embedded in language and mathematics is not only communicated by ordinary language but also by specialised language structures. (Pimm, 1988, 1995) It is also well established that pupils who

do not speak the language of the host culture very well are disadvantaged in their learning; even in the learning of mathematics which has been regarded by many as universal and culturally neutral. (Bailey and Shan, 1991) The English National Curriculum for Mathematics requires teachers to discover "what pupils know, can do, and understand". We are well aware that the finding out and interpretation of assessment results can be highly problematic.

What is assessment for?

Having considered the range of difficulties in presenting, analysing and interpreting the tests, we now turn our attention to the purposes of assessment. Different purposes have already been indicated above, and range from the sensitive information gathering of the teacher, intended to benefit the pupil, to the use of results for social and political manipulation. Four broad areas can be identified: assessment for teaching, fro evaluation, for selection and for curriculum control.

Assessment for teaching and learning

Assessment for the purposes of improving a student's knowledge may be broadly either diagnostic or formative.

Diagnostic assessment as its name implies, is built on the assumption that the results of the task given to the pupil are able to help the teacher differentiate between particular aspects of a given situation where the mathematical processes appear to be misunderstood and to indicate which of these aspects is a significant weakness or difficulty for the pupil. There is also the assumption that like the doctor who diagnoses the patient's illness, the teacher has the knowledge to apply the remedy to the pupils's mathematical sickness. It is often the case that, having diagnosed the apparent problem, the teacher applies the remedial exercise to the symptoms and not to the cause of the difficulty. We know well that doctors can make wrong diagnoses, and the science of didactics is not yet As advanced as medical science.

Formative assessment is said to be where the teacher considers the results of the tests, and then plans the next stage of the student's learning. While this activities often regarded as the principal task of the teacher, it also has many hidden assumptions. The first, is that teachers interpretations of the pupils responses give a reasonably accurate version of the actual state of a student's knowledge. As pointed out above, this is a highly uncertain business. Next, we assume that given the present state of knowledge of the student, the teacher is able to determine the best way to improve

and develop that knowledge. For each different student this would mean that the "best " way of reaching the next stage of learning would have to be suited to each individual's cognitive style, and a range of methodological and pedagogical considerations become relevant. Finally there are assumptions about the structure of mathematics, and of school mathematics in particular, that mean what is written as the next stage in the textbook or the programme is more likely to be based on traditional practices or some received logical abstraction, than a heuristic which is suited to the individual student.

Assessment for evaluation

In this context, "to evaluate" means to examine the results of our assessments for the things that we value. A teacher might look a the results of an exercise given to the students in order to see if her teaching has been effective. Interpretation of the results might meant that a different pedagogical approach would be of benefit to most of the students; perhaps the teaching has been to abstract, perhaps it is clear the students already know the material, or perhaps a different organisation of the students activity or of the classroom would encourage a more obvious achievement of the educational goals. In any case, the results of the assessments are examined in relation to the objectives of the course, and adjustments made to the teaching, the content, or to the objectives themselves.

Assessment for selection

This is a very common use for assessment, her the assessment is often called summative because the results are used as a statement of an individual's achievement at a particular point in time. We are selected for a wide range of academic and non-academic occupations by testing of all kinds of abilities and aptitudes. We take medical tests for insurance, aptitude tests of computer programming, we take a course in order to pass tests of competence for driving, or for playing the piano. In all these situations we are selected, and given a grade or not, as the case may be. Mathematics in some form or other has traditionally been used as the principal test for selection for all kinds of occupations. Because mathematics is regarded as the domain for the most abstract thinking we can perform, and because it is supposed to train the mind in the processes of methodical organisation and logical thinking, it has been regarded even from before the time of Plato, and in other non-European cultures, as the supreme test of intellectual prowess. Mathematics thus plays a dual role in many societies; as an indicator of intellectual quality, and also as a selector

for those aspiring to responsible positions in society. Classic examples from the beginning of the last century are the status of mathematics in the education systems of France and Germany

Assessment for curriculum control

This last consideration brings us to the problem of curriculum control. Governments desire an educated work force in order to achieve and maintain economic power and the place of mathematics in this scenario is agreed to be obvious, central and unquestioned. Thus the political agenda is set, and all students must be taught some form of mathematics. Success in Mathematics together with Science and Technology (for which mathematics is essential) seem to be the most important indicators of economic potential in the educational field. not only is the content determined politically (at least in some sense), but also the results are taken as indicators not just of the students success rates, but also of the effectiveness of the teachers teaching and the efficient organisation of the school. In this way, unsuccessful teachers and schools can be identified and appropriate action taken. (The stress on individuals as this process is applied to teachers and schools England and Wales is well known.) Since it is generally agreed that democratic governments have a responsibility towards their citizens, both in terms of the well-being of the state, and of the individual, the efficient organisation of education seems an obvious duty. However, in order to gather the information required to make these decisions, the indicators themselves need to be relatively simple and easy to gather. (Hacking, 1990, pp. 16-34) So, in contrast to the complexity of information that the individual teacher may have to deal with, the information the administrators require must be relatively uncomplicated and easy to handle. For example, the numbers or grades which rank pupils are collected, and by some process of aggregation of these results, the teachers and eventually the schools may be classified.

The assessment dilemma

In this way, a particular set of assessment results may be put to a range of different purposes. On the one hand, for assessment of the individual student, the teacher often finds a large number of specific attributes useful and even necessary; on the other hand, the administrator requires a small number of global attributes as indicators of present situations and future trends. The teacher wants information about specific criteria, like whether a student can perform two-digit subtraction or integrate a

particular function, where the task is intended to analyse particular mathematical procedures. In this context, criterion referenced tests might produce a grade based on a judgment of the quality of the student's performance. The administrator wants to know about norms, and whether students or schools are performing better or worse that some supposed average. Norm referencing compares students or schools with each other, and from this a ranking list is often produced. Politicians will boast or complain about rising or falling standards, but often we have no idea what the real criteria are, nor whether the groups being compared are in any way even comparable in principle. (Denvir and Brown, 1987; Denvir, 1988) Standards are social norms vested with some kind of apparent objectivity and which are often used by politicians to castigate teachers for failing students, or for failing society by "allowing standards to fall". In this situation there is often a reference to past performance as being better in some way than that of the present. However, it is difficult to see any real justification for this claim. How can we compare even the recent past to the present with any degree of reliability? Standards are inevitably linked to social beliefs, ideologies and expectations which change with time and occasion. These beliefs, ideologies and expectations include school mathematics. For example, we only hall content is different and therefore the expectations of the examiners with regard to the students' knowledge would be different as well. We may be able to identify a common core which apparently stays the same (perhaps elementary arithmetic?) but since the methodology of the teaching processes change, the way students approach what are apparently the same problem must differ, which has implications for possible differences in results. To say that standards are changing might be true, but to say they are rising or falling has no real meaning. The other problem about testing is the conflict between reliability and validity. "Standardised" tests have been used over large numbers so the population, and are said to be reliable. That is, they exhibit consistency when the results are placed in the context of the overall population. However, while a test may produce highly consistent results, it may not actually be testing what it sets out to test. A good example here are the tests which call themselves tests of "mathematics" which consist largely of written arithmetic, where students are given a "mathematical age" which little account of their spatial or algebraic ability. (This is similar in intention to the more familiar "reading age" which compares individuals with the average expected performance in a population.) On the other hand, the problem of validity is just as acute. Assessments which are valid deal with individuals. They are supposed to tell us something about the knowledge, learning patterns and personality of individual students. These assessments may contain elements of standard tests, but they also contain highly subjective judgments

by teachers. The obvious examples are the contexts of diagnostic or formative assessments given above. The assessments in this case may be valid in the sense that they clearly apply to an individual pupil, but unreliable in the sense that they cannot be applied with any certainty in exactly the same way to other pupils in a different context to produce comparable results. This has been recognised for a long time, (ATM, 1988; Donaldson, 1975; Labinowicz, 1985) and a mixture of the two approaches can be constructed to try to alleviate the problems.

Considering the social aspects

From the discussion above, it is clear that we have a number of conflicting interests at work in the current educational system which can be highlighted by looking at the ways in which students are assessed, and the ways in which the results of the assessments are used by different groups in society. In countries with a centralised administration system which has control over the content of the curriculum and the testing of the students, the hierarchy is more clearly determined than control is delegated to intermediate bodies like local government organisations or school boards. nevertheless, the different interests can be identified, and the means by which each group establishes and uses its power can be examined. It would appear that those with the least power are the students. However, the pressures of growing up in modern society give today's students more maturity ant greater expectations than ever before even though they are hardly ever consulted about what they want out of their education, it is clear that as far as mathematics is concerned, they are no longer in general willing to accept the traditional diet of teacher-determined instruction and exercises. Demands for interest, motivation and relevance of content Are allied with expectations of pedagogical approaches which acknowledge their maturity. The culture of the classroom is slowly changing and while many adults try to hold on to "traditional values", these values are being questioned and many of them are being discarded by young people of today. For example, calculators and other kinds of technological devices are being used outside the school in a wide variety of contexts, yet may schools teach arithmetic as though the calculator did not exist, almost denying that the world outside the classroom has any relevance. Where this is the case, young people often see the mathematics they are taught in school as irrelevant, and exercise their power by opting out in various ways. (Harris, 1992) Assessments are regarded as obstacles to be surmounted rather than ways of improving students' own self-knowledge. The current situation in the fall in recruitment to pure mathematics courses in universities in the UK shows an alarming

trend; fewer students are taking the mathematics examinations for university entrance, and of those who do, many are opting for courses like computing or business studies. Students' lack of interest and the drift away from mathematics produces different reaction from those in authority; some sympathisers try to accommodate to the changes, while those who feel threatened try to reinforce their fading authority. Teachers have the task of preparing young people for their role in society, and particular sections of society have expectations of what the pupils ought to know when thy leave school. Besides satisfying the needs of society, which are often very ill-defined, teachers as professionals are often caught between what they perceive is best for the pupils, and the demands of the institutionalised education system within which they work. Teachers can exercise their power on a number of levels; as members of a national trade union, as members of a professional organisation which acts as focus for their subject expertise and possible innovations in pedagogical processes; as a member of the school staff, and as intermediary between students and parents, and as a class teacher. These different roles can lead to conflicting situations. For example, research in didactics can show that a particular pedagogical approach may be more beneficial to students and produce more secure understanding of particular mathematical concepts; this can often mean that well-established beliefs are challenged, and attempts to change the situation may threaten other colleagues or the school organisation. Maintaining the ability of the institution seems to be a very important consideration and helps to explain why schools and teachers are generally very slow to change their practices. Examinations and other forms of assessment can be regarded one of the principal regulators of the school system and a barrier to teachers' action. How the mathematics curriculum is defined is a significant factor in the exercise of power. For a national curriculum which is centrally defined and implemented through prescriptive guidelines or a single set of texts, there seems little chance for the individual to make any changes. (Wu Dawei, 1992) Most curricula have certain degrees of flexibility either in local variations, variety of interpretation, or choice of texts. However, even with these variations, when the tests or the examinations are directly linked to the curriculum guidelines or the texts the possibilities for autonomous action may only be apparent. Also, introducing a new aspect of assessment into the mathematics programme may have unwanted effects. For example, the official introduction of "investigations' as an element of the school leaving examination at the age of sixteen in the UK was intended as a way of examining the "process' aspects of mathematics. However, contrary to the intentions of the reformers, there is evidence that the spirit of the reform is lost, and what were intended as original creative pieces of work are in many

cases now reduced to routine exercises. This is a danger in any institutionalisation of reform, good or bad. It is clear that teachers, mathematics educators, publishers, inspectors, and government officials all influence the mathematics curriculum to a greater or lesser degree.

The control of the curriculum is exercised through the various agencies indicated above, and assessment can be regarded as the regulator of the agencies themselves. If a school is not performing well according to the results produced, changes are demanded. (Burkhardt, 1988; Dowling and Noss, 1990). If a nation is not performing well economically, it can change its school system, and the first challenge is often to change its mathematics. This happened in France and in Prussia in the early nineteenth century, in the United States with the 'New Math" in the 1960s, and in England and Australia in the 1980s and 1990s. In each case assessment, centrally or locally controlled is used to monitor the performance of the schools that have been given the responsibility of improving the level of pupils achievement. The considerations here form only a brief introductory view of the complex factors surrounding the purposes of assessment and the ways in which the results may be used. According to the methodology of our analysis of the situation, we see how the different agencies involved each have their own agendas which are often conflicting and sometimes obscure. The peculiar position of mathematics not only as the traditional key indicator of intellectual ability but also as the tool by which the assessments are quantified, aggregated and made public, puts the mathematics educator in a unique position. We have available detailed analyses of the contents of assessment, and we also have the technical knowledge to warn our colleagues about the pitfalls involved in naive interpretation of the results. It remains to be seen whether we can really find ways of exercising the power we may have to educate our students and colleagues in the use of mathematics to expose the false assumptions of administrators and politicians.

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