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Paradigmatic Conflicts in Informal Mathematics Assessment as Sources of Social Inequity

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ABSTRACT *Mathematics teaching in the UK has undergone several major externally imposed changes during the last decade. Current practices display a range of epistemological and pedagogical assumptions and behaviours, depending on teachers' interpretation of, adoption of and belief in current statutory requirements for teaching and assessment. This paper examines in detail differences within the informal assessment practices of 30 UK mathematics teachers. It is found that these illustrate several of the paradigmatic differences that permeate studies of human behaviour on a grander scale. Since informal assessment decisions can lead directly or indirectly to differentiated access to the curriculum and high-stakes grading, the use of teacher assessment as a focus for examining differences illuminates the possible inequities which might arise for pupils. Examination of differences within one system and one society gives information about effects of different educational practices which, were they to show up between societies, might be attributed to other social and cultural factors.*

Introduction

The recent publication of the TIMSS report (1997) has generated much interest in international comparisons of the mathematical performance of school children. Many attempts have been made to make sense of different outcomes relative to features of national culture, such as predominant teaching styles, social structures, educational intentions and so on (Jaworski & Phillips, 1999). In this paper I will look closely at a subgroup of differences of practice within one highly structured national system, that of the UK National Curriculum (NC), in order to show a range which cannot be explained solely by national features. These differences reveal a collection of paradigmatic conflicts within one national culture, expressed as variations in classroom cultures.

In the context of educational research Gage (1989) suggests that 'paradigm differences do not require paradigm conflict'. He shows how it should be possible for three apparently unreconcilable perspectives, which I shall roughly classify *positivist, relativist* and *emancipatory*, to contribute three compatible forms of knowledge about teaching, learning and schools. The kinds of questions one can pose within each paradigm, and the ways one might answer, are different but the ultimate purpose of improving education is the same. However, Brown (1993) describes

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conflicts that arise when these different paradigms are used to design usable curricular and assessment systems. She collates the subjective and emancipatory paradigms and describes how an interpretivist/relative/subjective view of knowledge, such as one might need for the problem-solving aims of the mathematics NC, can be emancipatory for learners by allowing them to use pragmatic forms of knowledge they have developed outside school, or for the specific purpose of solving the current problem. These approaches inevitably clash with the absolutist/positivist/objective approach which led to the structures of the NC and require mathematics to be a formal, abstract, testable, hierarchical body of knowledge (Lawton, 1993). Cresswell and Houston (1989) examine contextual assessment tasks for mathematics, introduced in an attempt to reconcile these views, and conclude that the effect of context on performance led them to be 'less accurate, reliable and fair' in producing abstract statements of achievement than conventional assessment procedures, which are well known to be unfair (Gipps, 1994). Cooper and Dunne (1998) provide evidence of inequities created by contextual mathematics test questions demanding situational and linguistic flexibility which appears to discriminate along class and gender lines (see also Bernstein, 1990). In other words, some methods of summative assessment which have the appearance of supporting an interpretivist view of knowledge can be as unfair as positivist approaches, thus challenging Brown's implied collation of interpretivist and emancipatory approaches within the current system.

Individual classroom cultures are, however, created only in part by the external system within which teachers operate; teachers' interpretation of statutory requirements in practice varies according to their own beliefs and philosophies. As Thom (1973) said: 'All mathematical pedagogy, even if scarcely coherent, rests on a philosophy of mathematics', a point elaborated in Thompson's (1992) substantial review of the relationship between teachers' beliefs and their practices. Beliefs are expressed in a range of ways, most powerfully in how (and in what circumstances) the teacher evaluates and responds to students' attempts to express their mathematical understanding, for it is partly through these mechanisms that learners decide what mathematics is (Nickson, 1994). In recognition of the importance of classroom beliefs, Steiner (1987) has called for the development of:

> A meta-theory (of mathematics) which is based on a systems approach based on human activity and social interaction ... a system from the point of view of human object-related cooperative activities.

Similarly, Ernest (1998) has attempted to develop a philosophy of mathematics which includes an adequate account of how it is learnt, arguing that any philosophy which excludes such features cannot account for the development and use of the subject.

The aspect of classroom culture discussed in this paper is teachers' informal, ongoing assessment of students' mathematics. Assessment both contributes to, and is partly formed by, the classroom culture as a whole. The mechanisms of assessment reflect what is valued by teachers and others, explicate such values, bestow status and also shape classroom activities so that valued behaviour is generated. 'We interpret, theorise, teach, test, assume, expect, measure and thus confirm our initial expectations of children' (Lerman, 1994, p. 192).

In the UK educational system informal assessment practices contribute to discriminatory curriculum decisions from an early age through grouping, tracking and setting practices which, according to OFSTED (1994), are used increasingly. They

also contribute to grading decisions at 7, 11 and 14, which may be used for high-stakes decisions, and to high-stakes decisions at 16+. Teachers' assessments, as well as structuring and reflecting what is valued in school mathematics, therefore partly control access to the curriculum and hence to future educational and social opportunity. Indeed it is usually in-school assessments which generate the information used to place pupils in differentiated groups for mathematics teaching, groups which tend to fracture the student cohort in terms of class and ethnicity (Boaler, 1997). For these reasons it is important to look at informal assessment to see if, and how, inequities might arise in its associated practices.

Research

Thirty primary and secondary teachers were interviewed about their informal assessment practices over a period of 3 years during which they were using an early version of the Mathematics National Curriculum which was very prescriptive both in terms of what has to be studied, and in the detail of the accompanying assessment criteria. The sample was selected to represent primary, middle and secondary school teachers of years 6 and 7 in three local authorities. Early interviews were arranged through personal contacts and a balanced total sample was achieved by approaching other schools by letter, sampling from appropriate lists. To a certain extent all the teachers were self-selected as being interested in talking about their assessment practices. All the teachers had received some training in the objectives, content and assessment requirements.

The NC provides a framework for UK mathematics teaching which emphasises process as well as product, expects understanding as well as performance, and encourages the development of practical, problem-solving and investigative skills alongside knowledge of the conventional canons of the subject (DfE, 1995). Within this system of a prescribed curriculum, detailed assessment criteria and trained teacher-assessors it will be instructive to look at varieties of practice. However, it must be emphasised that the assessment criteria required by the NC were summative statements of capability, understanding and performance; while what teachers look for in their informal assessment includes, as well as these features, useful working habits and notions of 'ability' and 'potential' which help a teacher decide what to say, and how, to whom (Lorenz, 1982; Ruthven, 1987; Dunne, 1994; Watson, 1996).

Interviews typically lasted an hour, taking place after a day's observation and support in the teacher's classroom, and were semi-structured around a core question and a core prompt: 'How do you find out and recognise what children know and can do in mathematics? Tell me about <child's name>'s mathematics'.

Interview transcripts were analysed in several ways, including an analysis of the interviewer's role. Firstly, many features of the teacher's narratives about assessment were identified and coded. Then these were grouped into categories that describe assessment practices from various perspectives. The relevant process for this paper was the recognition of several levels of power in the practice of teachers-as-assessors. These were identified by looking for features of the reported assessment practices in which teachers exercised choice, explicitly or implicitly, and where they reported having to 'fit in' with real or perceived constraints, as they interpreted them, imposed by various authorities. In this analysis the teacher is seen as subordinate or superordinate to some of the components of teacher assessment, thus exercising power over or being subject to the power of others. For instance, the teacher is

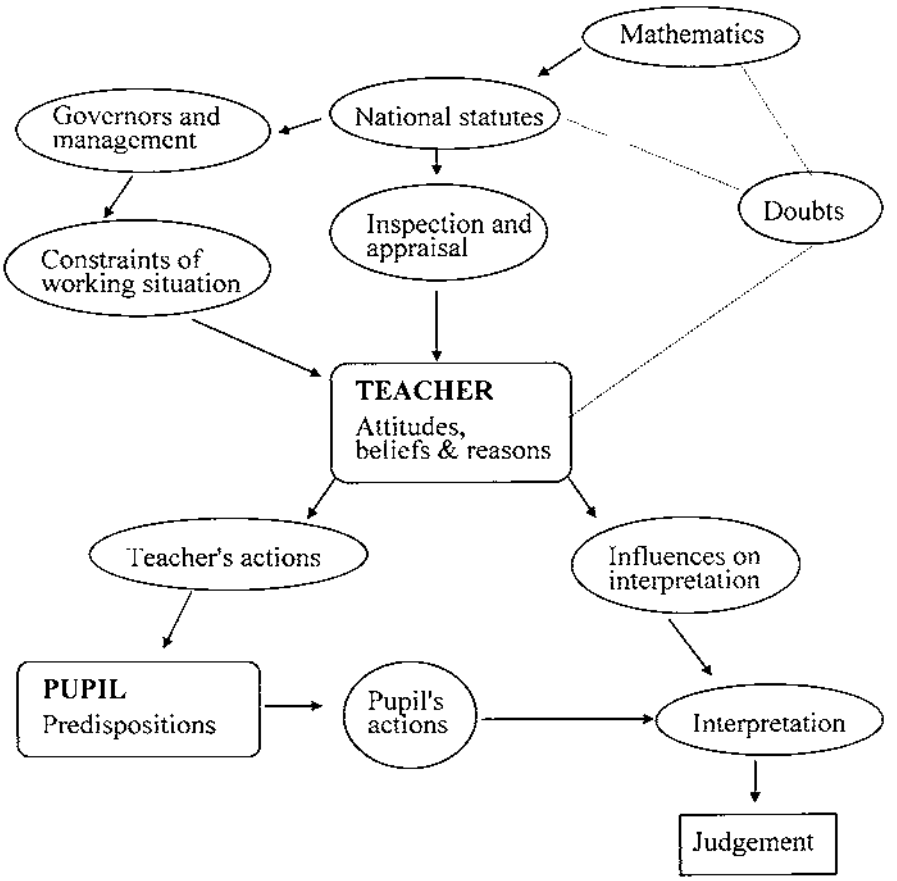

FIG. 1. Power relationships

subordinate in the NC assessment structure, being the servant of the government and answerable to it through inspection. The teacher is subordinate to the school governing body, carrying out its policies, working within the staffing structure it provides, and answerable to it through league tables and appraisal. The teacher is superordinate to the pupils; they are expected to learn through her actions, obey her, fulfil her expectations, and will be assessed by her and have certain decisions about futures made by her, and yet they also bring aspects of other parts of their lives and other knowledge into the classroom.

Figure 1 describes these power relationships, producing a network of relations in the classroom. It is not a complete picture of power relations in the classroom, because it only sets out to describe those that affect the actions and intentions of the teacher-as-assessor. For the purposes of this illustration I have taken 'mathematics' to be an academic structure in which the teacher is servant to a higher notion of mathematics as an academic subject; this is represented to the teacher by the NC and the statutory assessment requirements. I have selected this view of mathematics so that Fig. 1 presents the maximum possible power superordinate to the teacher, and hence describes the teacher as under most pressure to conform to outside influences. The final powerfulness of the teacher is expressed through interpretation of the

pupils' work, leading to an assessment judgement. Of course, the teaching process does not end there; such judgements then affect teachers' actions, pupils' dispositions, and possibly, eventually, teachers' own attitudes.

This structure having been suggested by an initial analysis of the interviews, the transcripts were then re-analysed with this framework in mind. Statements about actions, methods, systems, beliefs from the 30 interviews were sorted within the structure of relationships, and the reported practices then examined for similarities and differences within each grouping. This proved to be an effective method of exposing differences within the collected practices of all 30 teachers, showing how far intentions and actions were shared between the teachers, and what sort of differences could occur. The differences I report here are those which emerged from this analysis and might lead to inequity. By inequity I mean the making of different decisions and the offering of different opportunities, in similar circumstances, by different teachers, in ways which might affect pupils' futures. Operational differences which were explicitly mentioned by the interviewees are dealt with elsewhere (Watson, 1998). Similar contradictions appeared in several places in the data, so I will report them under the following headings rather than as features of the power relationships:

- differences in perception of how students can change;
- differences in teaching practices which can affect assessment;
- differences in assessment practices which could lead to different outcomes;
- different learning styles of students;
- differences in desired learning outcomes;
- different views of mathematics; and
- different personal experience.

Differences in Perception of How Pupils Can Change

Teachers differ in their perceptions of stability of certain traits in their students. For instance, impoverished socio-economic background was sometimes given as a reason for underachievement, yet some teachers had high expectations as a norm and did not mention background as relevant. For some teachers motivation, interest, boredom, confidence and preferred learning styles were treated as given, but other teachers regarded it as part of their job to affect these through their expectations or teaching styles.

The influence of the teacher's existing knowledge of a pupil is important. Some teachers were aware that they would react differently to different pupils doing the same thing because they had formed judgements about the capability in advance. The expectation that pupils will follow patterns of learning behaviour, and that the teacher can get to know these patterns thoroughly enough to spot when an incident is a manifestation of normal behaviour, and when it is an aberration, is high. One teacher was sure he would know whether an error was evidence of misunderstanding, or merely a 'slip-up', because of who had made it. The question here is whether real changes in learning behaviour will be interpreted as such by a teacher who already has a strong opinion of a pupil.

Differences in Teaching Practices Which Can Affect Assessment

All teachers used investigative activities for assessment of mathematical processes, although some only used them for assessment purposes. Some teachers gave regular tests and practice sessions for national tests, while others did not. Some teachers give practical tasks as an assessment tool, believing application to be the ultimate demonstration of understanding. Others give practical work first to motivate the topic. Those students who are encouraged often to work investigatively or practically, or have practice tests will, presumably, be better at working that way when being assessed, or applying their knowledge with different strengths in different circumstances.

Teachers talked of different groupings and expectations of pupils, offering different levels of challenge and expecting different outcomes. It is well known that this approach creates or confirms difference as well as responding to it (e.g. Nash, 1976). For instance, a teacher's actions generate similar behaviours for most pupils who conform to a notional norm, but noticeably different behaviour in those who do not fit the norm (Walkerdine, 1984). The tension here could be between individual and group approaches to education, but could also be between the maintenance or improvement of past standards.

In teaching interventions some teachers prefer to show similar examples, similar explanations to the ones which have previously failed to help the pupil understand, while others look for different approaches and examples. The teacher who uses a transmission model of teaching offering pupils opportunities to fill in gaps of a message previously received, and the teacher who expects the pupils to construct their own meanings offering a variety of metaphors to aid construction, encourage different learning styles. The former may lead to a solely procedural view of mathematics, the latter to a broader, more adaptable view of mathematics.

Many teachers acknowledged that working from written texts is difficult and they have to mediate frequently, very often the difficulty being with the text and not with the mathematics. It was found that often the same teachers use texts not just as sources of questions and ideas but as a major teaching method thus further disadvantaging pupils already recognised as having difficulty.

Differences in Assessment Practices Which Could Lead to Different Outcomes

Many teachers were doubtful about the use of tests: they are 'limited' and 'not the be-all and end-all'. Others regarded them as a way to verify what they already knew in a way that would be acceptable to outside eyes. Many teachers referred to well-known problems with regard to national tests, for instance, they believed that use of contexts could bias results for certain students; some students reacted badly to test pressure; tests could only test certain things and not tell you about the whole of a students' achievement; test questions can be ambiguous, and so on. But they did not raise the same issues about their own 'home-made' tests.

Time was a huge problem; teachers frequently said that assessment of individual pupils required time to be done accurately, and time was not realistically available. Therefore they had to prioritise. Teachers vary in how they prioritise what they want to find out about new pupils. For instance, some wanted to know first how pupils work, especially in investigative situations. Others wanted to find out what pupils already know by using specially designed assessment. Thus teachers gain different

kinds of knowledge about individuals during the early lessons of a course and may therefore base their initial assessments on different kinds of evidence.

Different Learning Styles

Teachers talked of achievement and display of understanding as an exploratory, discursive and reflective practice which nevertheless could cause frustration in some students. They described students who are goal oriented and dislike explaining before moving on to something else; who prefer a conformist approach and linear progress through textbooks; who aim for mastery; who need to see how a concept could be useful. In contrast, teachers used words like 'imagination' and 'intuition' to describe good learners of mathematics. But in general there was more concern voiced about those who could not work in unstructured, relational or creative ways, than those who could not work in structured or instrumental ways. Learners with some preferred styles of learning may not be encouraged to develop a repertoire of other ways to learn (Scott-Hodgetts, 1986).

Differences in Desired Learning Outcomes

One difference in desired outcomes is the perceived importance of pupils' own methods. Almost all teachers valued these, but traditional layouts are taught and given higher status by teachers because they believe these to be the desired artefacts of the prevailing assessment culture. Teachers have largely adopted the aims expressed throughout the NC, of understanding, explaining and valuing own methods. But these aims cause problems with some pupils, especially those who find writing about their mental processes hard, and conflict with a perceived aim of producing traditional algorithms.

There are different views about written work: some only accepting it if accompanied by discussion or other oral work, others seeing it as the summit of achievement. In the end, disembodied written communication is important in exams and tests, yet most teachers say that there is a gap between understanding, successful doing of mathematics and being able to write it appropriately. The order in which teachers expect work done (oral–written or written–oral) varies. Quality of written work may be confused with good presentation, and very messy work is not always a demonstration of failure to understand. These differences may lead to different classroom practices for similar pupils, and different judgements being made about the mathematics represented by written work.

Teachers make judgements about pupils' normal achievements in classrooms, and these are influenced by their own values in mathematics. Several different aspects of doing maths in classrooms have to be balanced. For instance, ad hoc problem-solving skills and replicable mathematical skills, memory for rules and ability to adapt rules, may be valued differently by different teachers. Even with similar views of mathematics, teachers may interpret evidence differently because their idea of how mathematics should be represented may differ. If the ultimate aim of an activity is an algebraic expression in correct form, other forms of that expression (diagrammatic, verbal, unconventional algebra etc.) may or may not be valued, depending on the teacher.

Language weaknesses may mask the level of understanding. Some teachers might

say that if a pupil understands they will be able to communicate it, others that these are separate processes and understanding may precede communication.

Different Views of Mathematics

Strong links exist between teachers' views of mathematics, how they teach it, how they interact with pupils about mathematics, and therefore how the pupil views mathematics, does mathematics and achieves in mathematics (Thompson, 1992; Nickson, 1994). Hence there is an inevitable link between views of mathematics and ideas about its assessment. There are differences in views about order in mathematical learning so that a display of understanding will lead to different assumptions, made by different observers, about what else the pupil knows. Also views of understanding may vary. For instance, a teacher with a *utilitarian* view of mathematics may see successful use as indicative of understanding, where one with a *logicist* view might require a full explanation of meaning or deduction (Ernest, 1990). Hence achievement may be 'measured' differently.

Different Personal Experience

Some of the interviewed teachers seemed implicitly to be assuming that those who could follow their expectations, or communicate in a way they understood, or responded well to them in class, were the 'able' ones. One teacher, a highly qualified and articulate mathematician, described the 'good' ones as 'The ones who always answer, and have the right answers', but another teacher believed that struggle and discomfort were an essential part of her learning, and that work should be difficult. A third teacher pointed out that some of her students do not answer, but follow painstaking, insecure, logical pathways that demonstrate their mathematical ability. Yet another teacher knew from her own experience that one can make leaps into the abstract that are so different from the way others work that one can be ridiculed for doing so. So different teachers' own experience of learning leads them to value, and devalue, different kinds of effort.

Summary

To summarise, therefore, there are several differences in the practices of teachers-as-assessors. One might query whether there exists a professional understanding of common practice. In terms of political positioning there is; it is at the interface between politicians, assessment authorities, industry, parents and pupils. Teachers form a clear group who administer the wishes of the first two groups, have to fulfil the desires of the next two groups and do their best for the last group. There is no reason why such a community should not have its internal tensions and contradictions, but those described above affect the futures of the pupils because they all contribute towards assessment decisions which would lead to different pedagogic, organisational and social choices. It would be possible for the same pupil producing the same work in different circumstances with different teachers to have the work, and her future, assessed differently.

Underlying each of the differences described above there appear to be six major contrasting beliefs and perceptions which are manifested in various ways. These may

look like dichotomies below, but should really be seen as spectra represented by two ends of a range of views:

(1) *Personal change is a result of natural maturation, or education*. The sections above on perception of change, teaching practices and learning styles show differences between teachers who think they can affect change, that it is part of their job to influence change, and those who accept personal traits and learning habits as 'given'. This is a manifestation of a 'nature versus nurture' debate, a version of the difference between psychology and anthropology, or of the difference between positivist and emancipatory views of education.

(2) *Mathematical knowledge is universal and transferable, or situationally specific*. The discussions above about teaching practices, assessment styles and desired learning outcomes show contrasts between those who see mathematics as generated in and for a specific situation and those who expect it to be transferred without problem to other situations; this is most marked in cases where the assessment styles differ markedly from usual teaching and learning styles, and in the suggestion that number is easiest to assess. This is a manifestation of the difference between positivist and relativist views of mathematics, and of Brown's demonstration of the emancipatory power of valuing ad hoc approaches to mathematics.

(3) *Students learn through transmission, or through construction*. The discussion about teaching practices, assessment methods, desired outcomes and views of mathematics shows contrasts between actions which 'fit' a transmission metaphor of teaching and those which 'fit' a constructivist approach (e.g. Jaworski, 1994). However, the above discussion of learning styles shows a strong understanding of constructivism as a learning approach, but this is not necessarily carried through into the assessment practices which may function as if knowledge is transmitted in unchanged forms. This is a manifestation of a conflict between positivist and relativist/transformative views of learning.

(4) *Education is for development of individuals, or for the development of the group*. Contrasts in teaching and assessment practices reflect this confusion of purpose. Most marked is the expectation that students will have different assessment outcomes, rather than a description of successful teaching as 'everyone achieved the objectives of the lesson'. As well as illustrating differences between a psychological and social approach to education, this also questions whether individual emancipation will be more likely in private or social domains.

(5) *Thought and language develop consecutively or together*. This contrast is manifested through the role oral work plays in assessment, and how much it is encouraged and deliberately developed in lessons. Again, here we have a difference between the private and the social domains of learning.

(6) *Mathematics is a set of rules and correct procedures, or is a way of thinking*. This contrast shows itself in teaching and assessment methods, and in teachers' own experience; most often it is manifested in the different weighting given to processes or products by teachers explicitly or implicitly. Here is another manifestation of the positivist/interpretative difference.

It is not the case that each teacher is positioned similarly on each of the spectra. For instance, a teacher may believe that her role is to educate individuals, but may see mathematics as a set of tools to be used in the socio-economic activities of the community. However, this is not to say that Gage's (1989) vision of co-existing

paradigms is possible. Differences in assessment lead to social inequity and can thus more usefully be seen as conflicting than as co-existing. Conflicts and inequities partly result from positivist, summative, assessment outcomes (used mainly for accountability and selection purposes) being applied within a NC framework which purports to value discussion, reasoning and mathematical thinking. Furthermore, national targets for minimal cohort achievement (social) are applied to an education system which is constructed to provide differentiated expectations and differentiated outcomes (individual). Further conflicts result from teachers' different interpretations and adaptations of the system, as shown above.

Conclusion

This research revealed differences in assessment practice which could result in social inequity, i.e. that students acting in similar ways might be assessed and treated differently by different teachers so that future opportunities which are available to some are not to others. Inequities due to measurement, labelling and irreversible decision-making which arise from one end of each of the six spectra above are often in accordance with the operation of NC assessments and league tables. These might therefore be avoided to some extent by a change of assessment policy. Inequities arise because of the social effects of assessment, so those which appear to be due to unavoidable factors (there is no single right way to view mathematics or bring about its learning) could be separated from inequitable decision-making by a review of the purposes and uses of assessment. In particular, one could hope for a separation of assessment for pedagogic purposes from assessment for the purposes of selection, management and accountability. However, policies do not solely determine systems.

It should be remembered that all the differences in belief and practice described above take place within one system which has a detailed national curriculum, universal assessment criteria, frequent national testing, frequent inspection, with competition between students, teachers, schools and regions structurally encouraged. Yet fundamental conflicts between different paradigms of human endeavour still run through this small but important subset of teachers' actions. Psychological, linguistic, sociological, and epistemological arguments about the nature of knowledge, its universality and situatedness, and the determination of human behaviour individually or in social groups all emerge in the above analysis of teachers' assessment, even in such a highly regulated system. This analysis confirms the centrality of the classroom culture created by the teacher's interpretation of roles and policies, seen through her own beliefs and perspectives, in influencing children's futures (Thompson, 1992; Lerman, 1994). The teacher acts out the summative assessment requirements of the state while valuing, selecting, and advantaging according to local and personal beliefs. In the absence of shared philosophies about the teaching of mathematics, such as those advocated by Steiner and Ernest, inequities can therefore occur which may be exacerbated by the apparent formalism of the system, rather than removed by it.

The overarching finding of this research is that a highly regulated national system, with closely defined curricular and a universal testing regime, does not result in a monoculture of mathematics teaching and assessment. An obvious final question is whether such a monoculture is desirable at all, given that it is not achievable.

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