Chapter #

QUIXOTE'S SCIENCE

public heresy/private apostasy

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Abstract:

This chapter is concerned with modes of authority and interaction in educational discourses and technologies. In particular, it explores, through an illustrative analysis of some of the assessment items of the Trends in International Mathematics and Science Studies, the construction of what may be referred to as *mathematicoscience*, a technology that may be associated with what may be publicly recognised as legitimate forms of relation to the empirical and legitimate forms of argument; it regulates, in other words, public forms of rationality. The globalising of this legitimating discourse through such mechanisms as international comparative studies of schooling performances, effectively privatises real concerns and seduces social criticism with its offer of an appearance on the global stage. The chapter also introduces two analytic frames (from Dowling's broader organisational language) that enable the organisation and constructive description of educational technology and discourse.

Key words:

Authority, interaction, technology, mathematicoscience, private discourse, public discourse, social activity theory

El Don Quixote was right, of course; windmills in Cervantes' Europe were monstrous giants, though wrong (as he eventually discovered) in his chivalrous crusade. If the enhanced performance of this new technology over hand milling didn't persuade the locals to pay the miller's fee, then the

destruction of their querns by or on behalf of the wealthy mill owners—local lords or the church—would chivvy them into the new era.[1] Did the introduction of windmills change people's lives? Even this brief account points in the direction of a division of labour.[2] There are entrepreneurs, shall we say (the owners of the mill), there are millrights (employed by the entrepreneur), there is the miller, and there are producers of grain, there are the henchmen who take a hammer to household handmills in a kind of Luddism in reverse. The millright's skills had been developing for half a millennium before Quixote took exception to them, but, essentially, all of these positions were in place, *mutatis mutandis*, before the building of the first mill. The appearance of the giant on the landscape signalled an enhancement in the organization of this division of labour that effected a movement in the demarcation of the public and the private; the deterritorialization of domestic flour production and its reterritorialization as a publicly available (at a cost) service.[3] So, people's lives changed, but the change constituted and was constituted by a developing sophistication in the division of labour of which the windmill stood as a material sedimentation. Quixote's error was in mistaking a signifier for the social organization that it signaled, though his lance would never have been a match for either.

This, essentially, was the line of argument that I offered in Dowling (1991a), although in that essay I was concerned not with 'the windmill', but with 'the computer' and, more than a decade later, I might want to replace the latter by 'the internet' which, of course, I can access via my mobile phone or my TV as well as my Powerbook and which can be imagined as a very visible sedimentation of the globalised division of labour. That is to say, I am conceiving of *technology* as a regularity of practice; the kind of regularity, indeed, that enables us to recognize the internet as such. This regularity is emergent upon the formation of diverse oppositions and alliances that we can think of as social action and that carries on at all levels of analysis from state activity down to the strategies and tactics of individual players (see Dowling, 2004a).

[1] See 'The history of flour milling' at http://www.cyberspaceag.com/kansascrops/wheat/flourmillinghistory.htm.

[2] Perhaps the term 'division of labour' is somewhat unfashionable in educational studies, these days. I retain it both to acknowledge a residual debt to Marx—a debt of the same character, perhaps, as that acknowledged by Foucault (I forget where)—and because it is now sufficiently anachronistic to stand out and thus allow me to avoid a neologism for that which brings together definable (and, of course, hierarchically organised) social groups with specific regularities in practice the articulation of which activities is constitutive of the sociocultural order.

[3] The terms, 'deterritorialisation' and 'reterritorialisation' are from Lacan via Deleuze and Guattari (1984) (see also Holland (1999)), whose position is not entirely inconsistent with my own in this essay.

A curriculum is a technology. It exists in at least two forms, an official or general form and its realization in local instances (cf Bernstein, 1996/2000). A technological determinist kind of argument might conceive of the local curriculum, in its enactments in classrooms and lecture theatres, as only relatively autonomous with respect to the official form. In this conception, emphasis would be placed on the effects on local practices of changes in the official form as well as, perhaps, the nature of and limitations upon the autonomy of the classroom. Consider, though, the push for modern or new mathematics in many parts of the world in the 1960s (see Cooper, 1983, 1985; Moon, 1986; Dowling, 1990). Here, the crucial bourbakiist message was ultimately dissipated as the central organizing language of set theory was recontextualised as a pedagogic resource in the primary classroom (hoops and chalk circles for organizing objects) and as merely another topic on the secondary curriculum. The strong classification in the division of labour between mathematicians and school mathematics teachers survived quite intact the intervention of the former in the activities of the latter.

Similarly in Higher Education, being required (by quality assurance scrutineers) to provide explicit lists of intended learning outcomes for postgraduate seminars results merely in the production of an official, local curriculum and has little impact on the local, local curriculum in which the professor is still established as author rather than relayer of knowledge, albeit within a tradition of discourse, a discipline, perhaps. Here, the division of labour closely associates the person of the professor with the institutionalised practice of the discipline so that they may claim what I refer to (after Weber (1964), *mutatis mutandis*) as *traditional* authority. This mode of authority action is most likely to be effective under conditions of relative stability. Thus, back in school, in a period of healthy supply of mathematics graduates, those appointing mathematics teachers are in a position to stipulate that a degree in mathematics is a requirement for a successful application. Such a stipulation brings together a particular category of person and a particular technology (the mathematics curriculum) in authorizing its appointee who may, of course, teach mathematics, but not science, which is the exclusive territory of graduates in that field. But, as an 'expert', the qualified mathematics teacher may claim a degree of authority over the mathematics curriculum giving rise to the dominance of the local over the official, the private over the public.[4]

In 1970s London the supply of mathematics graduates wanting to enter teaching had fallen below demand to such an extent that the possession of a mathematics degree was more of a rarity than a requirement for a

[4] Those teaching in England in the 1970s and 1980s may remember the 'mode 3' public examination syllabuses which were under the control of teachers and could even be established at the level of an individual school.

mathematics teacher. Indeed, I was appointed as a teacher of mathematics despite having only a degree in physics and no professional or academic teacher education. I was appointed head of department less than three years later. The crisis continued throughout that and much of the next decade and teachers from all sorts of academic backgrounds found themselves teaching mathematics. As head of department I found myself working with physical education specialists, language teachers and geographers as well as a fair number of fellow natural scientists. Clearly, authorizing strategies had reined back on the specificity of the author—the teacher. However, many schools in London began adopting a student-centred scheme of school mathematics called SMILE.[5] This was a workcard-based scheme that had been designed specifically in response to the shortage of specialist mathematics teachers. That which was principally demanded of the teacher was skill in classroom management and administration. In addition, local meetings at which workcards would be revised and new cards produced would also function as in-service training for the teachers. The effect was the constitution of an official curriculum over which individual teachers may be disinclined to claim individual authority. Rather, their role would be, to a substantial extent, defined by the curricular technology so that the authority would reside in the role or practice rather than in the person. I refer to this as *bureaucratic* authority (again recontextualising Weber). Naturally, with the weakening of the autonomy of the teacher, this mode of authority action is likely to be associated with an assertion (or reassertion) of the dominance of the official over the local, the public over the private.

Now in a more recent paper (Dowling, 2001a) I offered some examples of current trends in the development in the division of labour that entail the production of disembodied analogues of competence in what I am referring to as technologies. The unification and codification of school curricula in England and Wales (see Dowling & Noss, 1990; Flude & Hammer, 1989) and the development of national qualifications frameworks here and elsewhere are examples as are spellcheckers and other software developments such as Adobe Creative Studio which (amongst a great deal more) allows me—a sociologist, not a photographer—to produce quite acceptable digital images from the rather amateur RAW files captured on my Canon 10D (a technology already obsolescent less than four years after its unveiling). These bureaucratising technologies are emergent upon the weakening of the esoteric control of the traditional expert over the form of institutionalisation of the practices to which they relate. The digital codification of these practices operates rather like the mass media, which, as

[5] Secondary Mathematics Learning Experiment—later, 'experiment' was replaced by 'experience' in the title. This was a teacher-led response to the changing situation, particularly in London; the state response was somewhat slower.

Becker & Wehner (2001) point out, serve as 'reduction mechanisms', rendering their messages accessible to the public.

What appears to have happened is not that technologies have been invented that are able to achieve this—the technologies still have to be acceptable to their audiences—but that changes in the division of labour have effected a shift in the mode of relationship between (certain) categories of traditional 'expert' and their audiences. With the 'expert' exercising traditional authority, this relationship is what I refer to as *pedagogic* (Dowling, 2001a). This means that the author in an interaction retains, or seeks to retain, control over the principles of evaluation of their utterance. The kind of change that I am describing here gestates as this mode of authority becomes increasingly non-viable and the 'expert' is increasingly held to account for their actions. The relationship takes on more of the character of an *exchange* mode (ibid.) whereby the principles of evaluation are devolved to the audience. The bureaucratic technology that facilitates this, through its 'reduction mechanisms,' signifies the presence in the division of labour of a mediating or competing authority: the state, in the case of curricula and qualifications frameworks; software houses etc in the case of spellcheckers. The significance of such developments is that to some extent (perhaps to an increasing extent) the voice of the expert may be heard only in terms of the public forms of their practice that are codified in and by the technology; I will return to this in the closing of this essay.

In the UK, the change in the field of education was signalled when, in 1962, the then Minister of Education referred to the school curriculum as a 'secret garden' (see Kogan, 1978). The invasion of this garden by politicians and capital over the ensuing forty years established the curriculum as a national park. The mathematical region of this park has been discussed in Dowling & Noss (1990).[6] However, with corresponding public spaces opening up in other national systems and being freely available on the internet, the impact of each national government's policies becomes comparable in terms of a further 'reduced', international curriculum. A key representative of this technology is to be found in the series of comparative *Trends in International Mathematics and Science Study* (TIMSS) carried out under the auspices of the International Association for the Evaluation of Educational Achievement (IEA) (see http://www.iea.nl/iea/hq/, also http://timss.bc.edu/ and http://nces.ed.gov/timss/). The results of this study and diverse reflections on the performances of participating nations[7] are available globally for recruitment in struggles relating to the bureaucratising

[6] Though this was published at a time when we had to rely on paper publication of the National Curriculum

[7] See, for example, Symmonds (2004) on the US and Wolf (2002) on Chile, both referring to poor performances on TMSS.

of education at national level. This is how it is put on the National Center for Educational Statistics (NCES) website:

> With the emergence and growth of the global economy, policymakers and educators have turned to international comparisons to assess how well national systems of education are performing. These comparisons shed light on a host of policy issues, from access to education and equity of resources to the quality of school outputs. They provide policymakers with benchmarks to assess their systems' performances, and to identify potential strategies to improve student achievement and system outputs.
> (http://nces.ed.gov/surveys/international/IntlIndicators/)

Given the trend towards the globalising of English (see Crystal, 2003), what we have in this technology is a globally visible public educational discourse; the secret garden has blossomed into a world heritage site.

The first point to note about this discourse is that its subject focus establishes mathematics and science as the global public face of schooling, relegating most other areas to a relatively private sphere. It is easy to see why this is bound to be the case. As the exponents of ethnomathematics and ethnoscience have been energetic in pointing out, mathematical and scientific knowledge has long been appropriated by the dominant and self-styled 'developed' nations as their own. At the same time, most other areas of school knowledge—such as history and art—are closely and enthusiastically allied with individual national identities. A study entitled, Trends in International Poetry and Painting would present engaging methodological as well as political problems and Trends in International History would certainly provoke belligerent uproar.[8] Comparative literacy rates are clearly of political interest (see, for example, the Progress in International Reading Literacy Study (PIRLS), http://www.iea.nl/iea/hq/, also an IEA study), but they do not (and, at the moment could not) specify the language (what with English, Spanish, Arabic and Chinese all legitimately vying for global hegemony). Perhaps sport comes closest to exhibiting the global status of (western) mathematics and science, but really only at the level of elite performance, which is clearly not the primary concern of formal schooling.

This observation is consistent with, at the global level, a *public* curricular sphere consisting of mathematics and science in which context other curricular areas are relegated to a national, which is to say comparatively *private* sphere; there is an important exception to this division to which I will

[8] See, for example, the furore in South Korea and China over a Japanese school history textbook that, it is claimed, downplays Japanese militarism and war crimes committed by Japanese troops http://news.bbc.co.uk/2/hi/asia-pacific/4678009.stm.

return later. Stanley Fish localises in time and place the hegemony of science:

> ... in our culture science is usually thought to have the job of describing reality as it really is; but its possession of that franchise, which it wrested away from religion, is a historical achievement not a natural right. (Fish, 1995; p. 72)

Now I do not, in any case, subscribe to a theory of natural rights—here, at least, I am a happy (perhaps unhappy) positivist[9]—and so I will certainly go along with Fish in understanding western science as a cultural arbitrary.[10] This particular cultural arbitrary, however, is now constituted as one key element in a global hegemony. Furthermore, the contrast in modes of authority that are deployed by religious and scientific practices, respectively, is also consistent with the public ownership of the latter at the expense of the relative privatising of the former. Specifically, religious practices commonly involve the development of a traditional priesthood in one form or another. The developments in science and mathematics curricula that I am referring to here, on the other hand, facilitate bureaucratic authority which tend to render individuals interchangeable: we can all be scientists to the extent that we can have public access to the principles of evaluation of scientific texts; but only a Catholic priest may hear a confession.[11]

Rather than tilt at my windmill, I want to explore it further to determine just what kinds of relationships (between author and audience) and practices it privileges. As my empirical object I shall take the US government TIMSS website at http://nces.ed.gov/timss/ (see Figure 1)[12]. I have no space for a detailed analysis of this site. Rather, I shall use aspects of it to illustrate the points that I want to make. Firstly, concerning the form of the technology, this is fairly conventional hypertext site, so that each page consists of a set of common elements—a standard header, a menu to the left (including links to the parent NCES site), page-specific text (which may or may not contain links) to the right, below all of this are plain text links to the NCES site, and above are links to a site map, the US Department of Education site, the NCES site, and a search engine. The righthand section of the home page contains a graphic link (a cartoon frog) to some of the questions used in TIMSS, 'For Students!' Below this are two windows, one showing 'What's

[9] See Crotty (1998) for a discussion of naturalist and positivist philosophies in the fields of research and law.

[10] 'Arbitrary' in the sense of Bourdieu & Passeron (1977).

[11] There is a corresponding contrast between the modes of authority deployed as, in Western culture, science replaces literature as the apogee of erudition. The origins of the humanities in British universities was predicated upon a sense of embodied literature and other artistic faculties as the necessary prerequisite of a cultivated English gentleman.

[12] All screenshots were made in September 2004.

New' and the other 'International Fast Facts', the content of which changes when the page is refreshed, apparently on the basis of a random selection from a file of 'facts'.

Figure 1
TIMSS(USA) Home Page

This design presents, on each page, the key claims to bureaucratic authority—established by the links to other government sites in the page header and footer[13]—and the structure of the site—principally in the menu—

[13] The authority action is bureaucratic because government *per se* is bureaucratic insofar as its authority is taken to reside in the office (practices) rather than in individuals. Of course, other modes of authority may be deployed in establishing the legitimacy of government.

which consistently frames the page-specific content. On this site the page-specific content is generally linear, discursive text. In addition, this page-specific content is, in most cases, marked, which is to say that it carries one or more links. These links are generally to other pages in the same site or the parent NCES site.[14] The design conforms to what Michael Joyce (1995) has described as an 'exploratory' rather than a 'constructive' hypertext. James Sosnoski succinctly describes the difference as follows:

> The exploratory (or expository) hypertext is a 'delivery or presentational technology' that provides ready access to information. By contrast, constructive hypertexts are 'analytic tools' that allow writers to invent and/or map relations among bits of information to suit their own needs. (Sosnowski, 1999; p. 163)

In my terms, the site establishes pedagogic relations between its author and audience; this is unsurprising, of course, in a government publication. It is, however, worth pointing out that even were the site to include multiple links to other, non-governmental sites, this would itself remain a pedagogic action insofar as it is a privileging of marked over unmarked text; the TIMSS site asserts a stronger pedagogic claim by additionally retaining control over the targets of links to marked text. Unmarked text is, of course, open to interrogation—any term or terms may be copied into a non-governmental search engine. However, such alternative readings are privatised by the TIMSS site. Similarly, the reader may formulate alternative structures for the site—this is essentially what I am doing here. Again, though, such strategies are privatised by the pedagogic site, which deploys bureaucratic authority strategies and essentially privileges an explicit taxomony and marked text over contingent organisation and unmarked text. So, the educational technology that I have been discussing signals (which is to say, is arguably emergent upon—see Dowling (2004a)) the establishment of a public/private partitioning of educational discourse that locates mathematics and science and strongly institutionalised modes of reading within the public sphere and other areas of knowledge and alternative modes of reading in the private.

The next question to be considered relates to the nature of the public mathematical and scientific knowledge. In order to address this I will click the frog link on the TIMMS homepage (Figure 1). This takes me to a page on another site parented by NCES, the 'Students' Classroom' (http://nces.ed.gov/nceskids/index). The particular page is titled 'Explore Your Knowledge' (http://nces.ed.gov/nceskids/eyk/index and see Figure 2). The page gives access to assessment items from the TIMSS study and also

[14] Although it is possible to exit the NCES site by following some of the links as I will illustrate below.

from the Civic Education Study (CivEd) to which I shall return later. From the page in Figure 2 I select my subject, grade and the number of questions (5, 10, 15 or 20) and am presented with the required number of test items; examples of these are shown in Figures 3-12. After making my selections from the multichoice radio buttons I can click 'show me the answers' and my page is replaced with an answers page including a score given as a percentage—Figure 13 shows part of an answer page. Clicking on the globe button—one is given for each item—opens a pop-up window (Figure 14) showing the US national performance and the international average for the item; buttons in other country locations on a world map[15] will replace the US flag and performance with that of the relevant country.

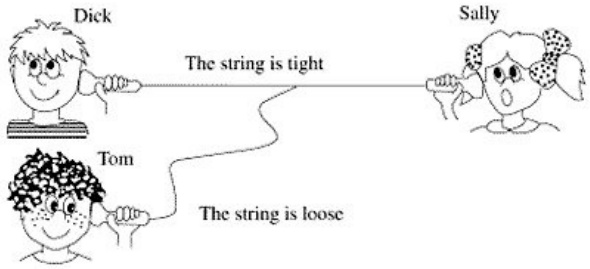
Figure 2
'Explore Your Knowledge' page, NCES site

[15] The full list of TIMSS participating countries is given at http://nces.ed.gov/timss/countries.asp. Each information map shows only a small selection, though the US is always included (it being a US site).

2. Some children were trying to find out which of three light bulbs was brightest. Which one of these gives the best START toward finding the answer?

- "One bulbs looks brightest to me, so I already know the answer."
- "All the bulbs look bright to me, so there cannot be an answer."
- "It would help if we had a way to measure the brightness of a light bulb."
- "We can take votes and each person will vote for the bulb he or she thinks is the brightest."

Figure 3
TIMSS Test item for Grade 4 Science



14. The picture shows Dick and his friends playing with a string-telephone. Sally is speaking. Dick and Tom are trying to listen. Which of them can hear her speak?

- Both of them can hear equally clear.
- Neither of them can hear.
- Only Tom can hear clearly.
- Only Dick can hear clearly.
- Both of them can hear equally faintly.

Figure 4
TIMSS Test item for Grade 4 Science

16. Four children can feel and smell an object inside a bag, but they cannot see it. Which of the following is NOT an observation about the object?

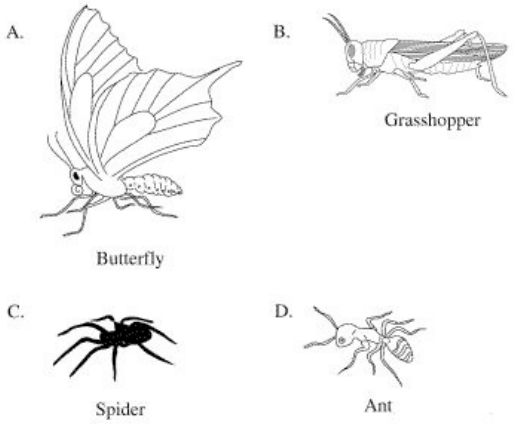
- "It is flat at one end and round at the other."
- "It smells like peppermint."
- "It has a bump on it."
- "I hope it is candy."

Figure 5
TIMSS Test item for Grade 4 Science

17. Alexander Fleming noticed that bacteria growing on a plate of agar did not grow next to a mold that was growing on the same plate. He wrote in his laboratory report: "The mold may be producing a substance that kills bacteria." This statement is described as:

- an observation
- a hypothesis
- a generalization
- a conclusion

Figure 6
TIMSS Test item for Grade 8 Science



1. Which picture does NOT show an insect?

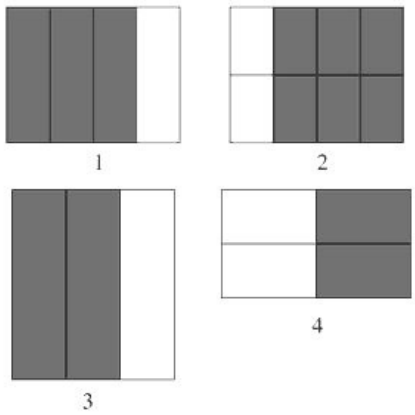
- A
- B
- C
- D

Figure 7
TIMSS Test item for Grade 8 Science

13. Two open bottles, one filled with vinegar and the other with olive oil, were left on a window sill in the Sun. Several days later it was observed that the bottles were no longer full. What can be concluded from this observation?

- ◯ Vinegar evaporates faster than olive oil.
- ◯ Olive oil evaporates faster than vinegar.
- ◯ Both vinegar and olive oil evaporate.
- ◯ Only liquids containing water evaporate.
- ◯ Direct sunlight is needed for evaporation.

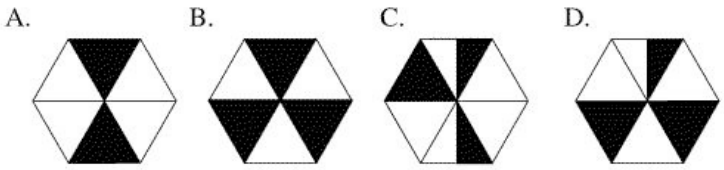
Figure 8
TIMSS Test item for Grade 8 Science



9. Each figure represents a fraction. Which two figures represent the same fraction?

- ◯ 1 and 2
- ◯ 1 and 4
- ◯ 2 and 3
- ◯ 3 and 4

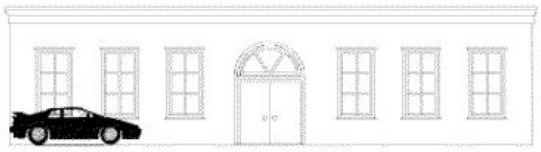
Figure 9
TIMSS Test item for Grade 4 Mathematics



4. **Samantha drops a stone onto each of these targets. The stone has the best chance of landing on a shaded space in which target?**

- A
- B
- C
- D

Figure 10
TIMSS Test item for Grade 4 Mathematics



14. **The car is 3.5 m long. About how long is the building?**

- 18 m
- 14 m
- 10 m
- 4 m

Figure 11
TIMSS Test item for Grade 8 Mathematics

x	y
2	5
3	7
4	?
7	15

18. The table represents a relation between x and y. What is the missing number in the table?

- 9
- 10
- 11
- 12
- 13

Figure 12
TIMSS Test item for Grade 8 Mathematics

Figure 13
Answers page

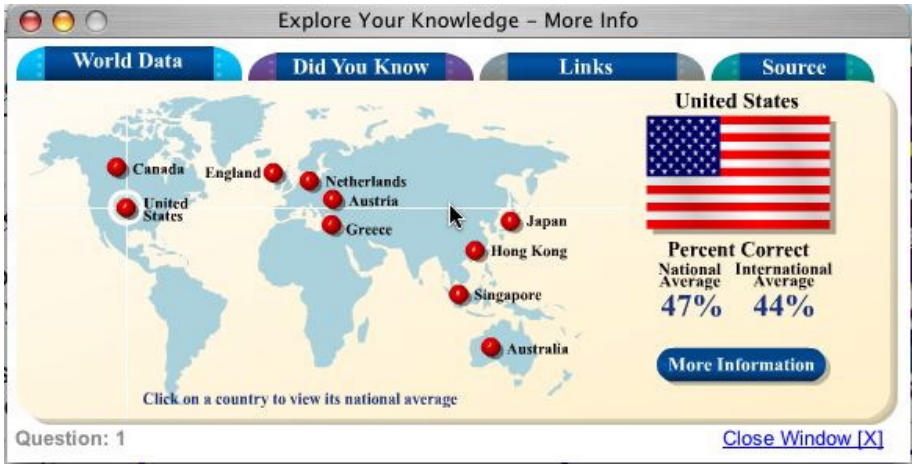


Figure 14
Information about international performances on selected TIMSS test item

Before proceeding to look at some items, I will briefly make two preliminary observations based on the description thus far. Firstly, the provision of the world map and clickable international comparisons is a good illustration of my point that we are talking about global public discourse here, even if only in its larval stage. Secondly, the combination of multichoice radio buttons and definitive 'correct' answers is a particularly effective privatising of alternatives by a strongly pedagogic technology. The multichoice test item (and the precoded questionnaire and countless other digitisings) is a technology that is emergent upon a drive to render all commensurable, all accountable to a public discourse via the exclusion of the private.

The TIMSS test items construct scientific and mathematical knowledge in a familiar way, perhaps. Firstly, they constitute formal modes of expression (see Figure 6) and content (see Figure 7, which invokes a taxonomy) that represent what I refer to as the *esoteric domain* (Dowling, 1998) of mathematical or, in these cases, scientific knowledge. The esoteric domain consists of discourse, which is strongly marked out from other areas of practice and contrasts with the *public domain* which is weakly marked out.[16] Thus, contrasting with Figures 6 and 7, the item in Figure 4 refers to a

[16] I have been referring, throughout this essay, to public/private divisions; this use does not correspond to the esoteric/public domain distinction that I am making here although there is clearly some relation between them. For the sake of clarity here it is best to think of 'public domain' as a single term rather than an adjective-noun pair.

children's game using a tin can phone—a public domain setting. The item in Figure 10 also employs a public domain setting and it is significant to note that the term, 'probability' is substituted by 'chance'. This is consistent with my findings in my analysis of a major British textbook scheme that the theme of probability was (at least at that time and in that place) very substantially taught within the public domain (Dowling, 1998).

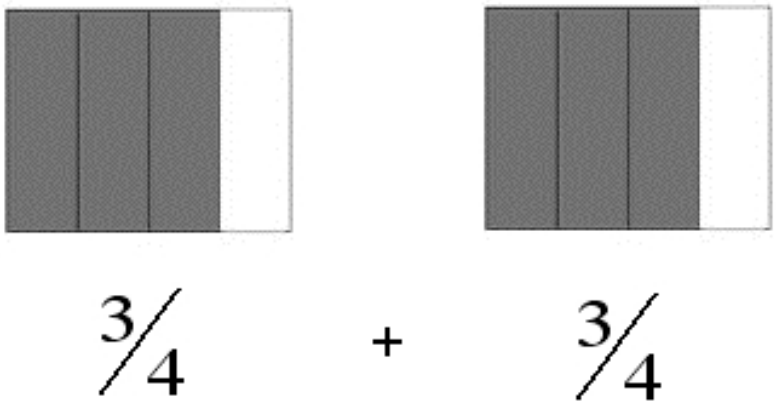


Figure 15
¾ + ¾ =?

School science and, especially, mathematics constitute esoteric domains that are strongly institutionalised. This is to say that scientific and mathematical language are deployed with a high degree of regulation—far more so than in most other areas of the curriculum. If I may gloss mathematics, as such, as the study of formal systems, then it is clear why its esoteric domain must be strongly institutionalised. Science, then, might be thought of as the study of partially- or to-be-formalised systems and its esoteric domain language emerges out of (induction) and is projected onto (deduction) the systems that are to be formalised. Science too, then, is predicated upon a strongly institutionalised esoteric domain. However, public domain text renders invisible the esoteric domain structuring that makes a task mathematical or scientific rather than something else. In the item in Figure 5, the response, 'I hope it's candy' is indeed an observation

about the object in the bag,[17] but not in the scientific sense which must exclude the subjective. 'Intensity' has been replaced by 'brightness' in the item in Figure 3; which bulb is 'brightest' may well relate to colour (frequency) as well as to intensity and so call for a subjective response; again, subjectivity must be excluded from formal school science. The item in Figure 8 is particularly interesting in that the most likely public domain response—someone has been making salad—is not offered as an option; there is a sense in which this item might be thought of as teaching rather than assessing.

Some of the mathematics test items (Figures 9-12) may be interpreted as tending to undermine esoteric domain mathematics and science. The Figure 9 item represents a standard teaching metaphor, which may be glossed as 'a fraction is a piece of cake'. The correct answer is the first one on offer because both diagrams 1 and 2 conventionally represent the fraction $\frac{3}{4}$. However, as I have previously pointed out (Dowling, 1990), this metaphor pedagogically challenges the esoteric domain constitution of a fraction as a number—that is of $\frac{3}{4}$ as a number between 0 and 1. Thus, if we use diagram 1 from Figure 9 to illustrate the sum $\frac{3}{4}+\frac{3}{4}$ as in Figure 15, then a perfectly reasonable (though, of course, mathematically incorrect) answer would be $\frac{6}{8}$.[18] The 'correct' response to the item in Figure 11 is the second radio button, 14 m. However, this appears to discount the width of the car (and its distance from the building). If the visible side of the car is a little under 2 m from the building, then a viewpoint 7 m away from the car in line with the rear of the car and the lefthand end of the building would make the first option—18 m—a better answer. The item appears to be testing estimation skills, but the public domain simulation renders it ambiguous.[19] The item in Figure 12 appears to be an esoteric domain text. However, there is a unique answer only if we qualify 'relation' with the term 'linear'. If the nature of the relation is not specified then there is no limitation on what might replace the question mark in the table. We may take the reference to a 'missing number' as indicating that the relation is between two numerical variables, but, even

[17] The statement may be reformulated as, 'the object in the bag is something that I hope is candy', thus making the object in the bag the subject of the principal clause.

[18] This is because the metaphor, 'a fraction is a piece of cake', invites the student to take the number of shaded pieces to be the numerator and the total number of pieces to be the denominator. It is also the case that the total amount of shaded cake in Figure 15 is $\frac{6}{8}$ or $\frac{3}{4}$ of the total amount of cake. That we frequently find students making this error does not affirm that they are interpreting the diagrams as I have suggested, but their error is at least consistent with this interpretation.

[19] South Africa—quite easily the lowest scoring country in both mathematics and science—scored 26% answers correct on this item as compared with the 74% international average; It would be interesting to see which responses dominated in South Africa (and, of course, to ask the respondents why).

so, all five offered answers are equally acceptable, mathematically. Here, it is not the construction of a public domain setting that has generated the ambiguity, but a reduction of the complexity of the esoteric domain.[20]

This brief analysis of ten test items[21] suggests that mathematics and science—and the difference between them, here, is not as great as one might suppose—are constructed as laboratorised or, shall we say, laboratorising practices. These laboratorising practices operate on the phenomenal world in much the same way as a hypertext author operates on text, which is to say, by marking that which may legitimately be operationalised; the unmarked, extraneous, subjective regions of the text are methodologically excluded. In both mathematics/science and hyptertext, this marking may often be invisible. In hypertext, however, we are well practiced in scanning the text with the cursor so as to reveal the links; no similar divining rods are to be found in mathematics or science and that is why, of course, my revealing of the ambiguities introduced by the public domain contexts does not challenge the items as suitable for their purpose—I obtained 'correct' answers on my first attempt on all of the items, despite my recognition of their 'flaws'. This is presumably consistent with my standing as a physics graduate and, more to the point, one-time teacher of high school mathematics and science.

So my point is not to criticise the validity or reliability of the test items, but to illustrate the kind of practice that hegemonises the global public educational discourse.[22] To the extent that mathematics and science exhaust this discourse, then we might infer that they define, firstly, the legitimate mode of relationship to the empirical and, secondly, the legitimate form of argumentation. In both cases, legitimacy is established by principles of exclusion that are governed by the esoteric domains of mathematical and scientific practice that exclude, in particular, the subjective and the contingent thus relegating them to the private sphere. As I have suggested

[20] A feature that is particularly common in texts directed at lower performing students as is the prevalence of public domain settings (Dowling, 1998).

[21] The site notes that there are about 130 items available, presumably these cover ninth grade civics as well as fourth and eighth grade mathematics and science.

[22] Indeed, critics of multichoice test items tend to limit their criticisms to issues of face and content validity. However, to the extent that the authors of the test have established a strong measure of convergent validity of these items with respect to, shall we say, measures derived from clinical interviews, then there is no reason why they should not be used in large scale surveys, such as TIMSS (see Brown et al (forthcoming). In their exploration of Piagetian stages, Shayer et al (1992) precisely did take steps to affirm the convergent validity of their experimental tests in relation to clinical interviews of the type used by Piaget himself. This precaution was ignored by McGarrigle's much cited challenge to Piaget's findings reported in Donaldson (1978). I have not studied the validity tests used by the TIMSS authors, because the point, in this essay, is to examine the workings of this global public discourse and not its convergence with local forms of assessment.

above, we may tentatively distinguish between the two esoteric domains by referring to science as a formalising discourse and mathematics as a formalised discourse.[23] Given this distinction, we might speculate that science takes the dominant role in respect of the constitution of the first legitimate mode and mathematics in respect of the second. The blurring of the distinction between mathematics and science in their high school forms also blurs this division of discursive labour. In any event, mathematics and science taken together do seem to define the legitimate form of rational action so defining, on a global stage, the bureaucratic public voice,[24] so I'll refer to the public global technology as *mathematicoscience*. Now, clearly, mathematicoscience is not the only public forms of discourse. However, apart from the operational matrix[25] of the internet itself, it is arguably the principal form of discourse for which globalised regularity or institutionalisation might be claimed and this is signified by its prominence in the global curricular technology to which I have been referring. Insofar as there is a globally prevalent aspiration for universal schooling and insofar as mathematicoscience, more or less as I have described it here, territorialises the globally public content of schooling, the significance of this discourse should not be understated.

So what are the implications? Well we might begin by considering this essay. I am certainly laying claim to both bureaucratic and traditional authority. My affiliation to the Institute of Education, University of London establishes that I hold an office that authorises me to speak academically about educational matters. This is a very weak claim, however, as the

[23] I am reminded here of Foucault's comment on mathematics: '... the only discursive practice to have crossed at one and the same time the thresholds of positivity, epistemologization, scientificity, and formalization. The very possibility of its existence implied that [that] which, in all other sciences, remains dispersed throughout history, should be given at the outset: its original positivity was to constitute an already formalized discursive practice (even if other formalizations were to be used later). Hence the fact that their establishment is both so enigmatic (so little accessible to analysis, so confined within the form of the absolute beginning) and so valid (since it is valid both as an origin and as a foundation); hence the fact that in the first gesture of the first mathematician one saw the constitution of an ideality that has been deployed throughout history, and has been questioned only to be repeated and purified; hence the fact that the beginning of mathematics is questioned not so much as a historical event as for its validity as a principle of history: and hence the fact that, for all the other sciences the description of its historical genesis, its gropings and failures, its late emergence is related to the meta-historical model of a geometry emerging suddenly, once and for all, from the trivial practices of land-measuring.' (Foucault, 1972; pp. 188-9)

[24] This seems to be consistent with Max Weber's (1968) remarks on the increasing prevalence of *zweckrationalitat*.

[25] I define 'operational matrix' as a technology—a regularity of practice—that incorporates, non-discursively, the principles of its own deployment: a supermarket and the World Wide Web would both be examples.

practice of peer review (or clubbing, as I tend to think of it), for example, ensures that the *ex officio* authority of academics is limited, generally to that which they may hold over their students. My recruitment of what I may hope is a familiar academic style and terms also constitutes a bureaucratic action in the way that I (*pace* Max Weber) have defined it: I am, in this sense, allowing (or pretending to allow) the discourse to ventriloquise me. Traditional authority is claimed in terms of my yellowing PhD thesis and also through the community of celebrated academic authors to which I affiliate via my egocentric bibliography (clubbing in the imaginary, perhaps). But I am clearly trying to do more than that. Bureaucratic and traditional authority strategies both invoke institutionalised, which is to say, stabilised practices. Such strategies are appropriate in the context of schooling insofar as the authority of the teacher or of the curriculum rests on a training or on a construction that has already been completed. In this respect, at least, schooling is structurally conservative as is illustrated by the recontextualising of set theory, which I mentioned earlier.

The authority of the academic, on the other hand, is established dynamically. The output of research is valued only insofar as it is original (a necessary, but, of course, not sufficient condition for acceptability). Academic discourse, then is structurally dynamic. The academic may rely on traditional authority strategies by, for example, establishing originality only in terms of the empirical setting and not in terms of theoretical framework—replication studies would be of this form. However, work of the highest status must contribute to the development, the construction and/or discovery of the language of the discourse, which is to say, theory.[26] This, of course, entails a destabilising of the institutionalised practice that affirms the two modes of authority action that I have introduced. I need a third mode. This has, fortuitously, also been provided by Max Weber (1964). As with the first two modes, I shall retain his term, but redefine the category: *charismatic* authority is predicated on the closure of the category of author and the opening of the category of practice. In establishing the originality of this essay I am at least in some respects attempting to deploy a charismatic authority action. I am served in this respect by the facility to refer to my own previous publications, establishing myself as an author of already accepted (and so publicly acknowledged as original) practice.

Naturally, there is a general level of resistance in the field to charismatic claims to originality because they must stand in competition with others. My essay, then, must extend, even distort and transform the discourse, but I do not have free license. So how might my essay be challenged? Well, on precisely the principles that are established in the terms of the public global discourse that I am referring to as mathematicoscience—though I have now

[26] Only theoretical objects may be discovered; an empirical object is merely encountered.

moved higher up the academic ladder. So: have I deployed appropriate principles of exclusion in my engagement with the empirical and in the construction of my syllogisms; have I deployed an objective methodological apparatus with sufficient rigour to exclude subjective noise or distortion? My critic may point out, for example, that my sampling strategies are inadequate to my grandiose claims and that my analysis and argument are tendentious. Within the context of the public global discourse of mathematicoscience my critic would be entirely justified as I will authoritatively affirm as the co-author of works on research methodology (Brown & Dowling, 1998; Brown et al, forthcoming). Insofar as my essay is recognisable in the public sphere, it can be recognised only as heresy.[27]

It is the thrust of my argument, however, that the lance of my quixotic critic cannot penetrate me, precisely because it misses the point, which is as follows. All technologies—including mathematicoscience—are here being regarded as emergent upon the formation of alliances and oppositions in social action; they are the public visibility of these alliances. However we know from our respective experiences that the work that goes into social action is very substantially conducted in private—in the lavatories, not the boardroom. Furthermore, the opening up of private spaces to public scrutiny—ethnography, perhaps, or the ungendered toilets in *Ally McBeal* and the Belgo restaurant in London's West End—will simply resite the private, not eradicate it,[28] just as the zero-tolerance policing paving the way for the gentrification of London's Kings Cross produces assaults on hapless students in Bloomsbury. The private, in other words, is for the most part where, for good or bad, things get done.

Let me complete my schema for authority strategies[29]. I have, in effect, introduced two variables, the category of author and the field of practice and

[27] A point illustrated by the Sokal/*Social Text* affair (see http://www.physics.nyu.edu/faculty/sokal/#papers). Sokal complains: 'In short, my concern over the spread of subjectivist thinking is both intellectual and political. Intellectually, the problem with such doctrines is that they are false (when not simply meaningless). There *is* a real world; its properties are *not* merely social constructions; facts and evidence *do* matter. What sane person would contend otherwise? And yet, much contemporary academic theorizing consists precisely of attempts to blur these obvious truths—the utter absurdity of it all being concealed through obscure and pretentious language.' (Sokal, 1996a, no page reference in the WWW version). Whilst he may have grounds to complain at the editorial strategies of the journal, *Social Text,* in which he managed to publish his parody of a cultural studies paper (1996b), clearly he just does not understand the positions that he ridicules—this is frequently the case with ridiculers (though I offer no evidence in support of this statement).

[28] *Ally McBeal*, see http://www.imdb.com/title/tt0118254/maindetails. The toilets in the Belgo restaurant actually have gendered sets of cubicles, but in a single space and with communal washbasins.

[29] See Dowling (2004b) for further elaboration of this schema.

each of these are binary nominal scales, open/closed. The product of these two variables gives rise to the space in Figure 16. It will be apparent that there are now four modes of action, three of which have already been introduced. The fourth mode, which I have termed *liberal*, is essentially a mode of action in which authority is negated. In liberal mode, persons are interchangeable and practice is mutable. Piaget's paradise, perhaps, but a mode of action that does seem to characterise the licence of a private audience: unless you intend or are required to respond to this essay in public, then there are no necessary constraints on the way in which you read and make use of it (or choose not to). The essay stands as a resource or reservoir of resources for recruitment by the audience and, in this aspect, the relationship between author and audience is one of *exchange*. But I will conclude the essay by offering some suggestions.

	Field of Practice	
Category of Author	Open	Closed
Closed	*Charismatic*	*Traditional*
Open	*Liberal*	*Bureaucratic*

Figure 16
Modes of Authority Action

This essay is written for an international collection, which is managed by an international editorial group. Those of us submitting chapters also had to submit to a peer review process and face the threat of required revision or exclusion. The structure of this practice—also a feature of the most respected academic journals—would appear to militate for some level of adherence to a public discourse which will include, as in this sentence, the genuflections of hedging, because the authority of our utterances must reside, bureaucratically, with the discourse, our mastery of which is yet to be finally affirmed. To read my analysis of the TIMSS test items as literal criticism within the field of the assessment of school science and mathematics would be to sublimate the essay on the level of this public discourse. This would be to render it legitimately open to revision in respect of the necessary exclusion of subjectivity and, incidentally, tricky language which can only be obscuring the clarity (or fallaciousness) of its syllogisms.

Interaction in this mode is *equilibration*[30] and, in this mode, an acceptable piece of work must contribute or potentially contribute to the coherence of public rationality to which it stands in synecdochic relation. But if my overall analysis is persuasive (for whatever reason) then, as private intellectuals and teachers, we may be sharpening the sword of our own executioner.

Academic engagement does not always work like this. In the club mode of peer review (including the audiencing of papers at conferences and the recruitment of 'the literature' in our own papers) we may also be familiar with the facility to read or listen politely and with at least apparent interest and to withhold equilibrating action on the grounds that contingency insulates us from the other author. I call this mode the *exchange of narratives*. Its inspirational metaphor comes from the telling of stories in a group of holiday friends at a bar in Mombassa (don't ever tell them what they're doing, sociologists are *personae non grata* in bars). Each narrative stands in relation of contiguity—metonymy—to the next. But as an audience this is at best voyeurism (onanism); it passes the time and avoids confrontation.

But the public discourse will not go away. Perhaps the arbitrary nature of public discourses may be made more apparent (or perhaps not) by the introduction of the third set of test items that is made available by clicking the frog on the TIMSS USA website. Perhaps surprisingly, perhaps not, this set of items is from the Civic Education Study (CivEd). The CivEd homepage notes that:

> All societies have a continuing interest in the ways in which their young people are prepared for citizenship and learn to take part in public affairs. At the turn of this new century this has become a matter of increased importance not only in societies striving to establish or reestablish democratic governments, but also in societies with continuous and long established democratic traditions. (http://nces.ed.gov/surveys/cived/)

Here is not the place (and I will not be allowed the space) to produce even a brief analysis of the CivEd text items. However, the 'International Fast Facts' box in the screen shot of the TIMSS USA home page that I have presented as Figure 1 presents what is presumably a finding from the study:

> In 1999, about 90% of 9th-grade U.S. students reported that it is good

[30] A mechanism that is, interestingly, associated more with the first than the second and third wave of cybernetics. It is the latter two schema that have had greatest influence on the position being developed here giving rise to my preference for autopoiesis and emergence (see Hayles, 1999; Dowling, 2004a).

> for democracy when everyone has the right to express opinions freely.
>
> Year of the Data: 1999[31]

It would appear that the discourse of liberal democracy is a second key component of the public global technology alongside mathematicoscience. Jean Baudrillard (talking about Saddam Hussain and the first Gulf 'War') offers a rather different take on democracy:

> ... as with every true dictator, the ultimate end of politics, carefully masked elsewhere by the effects of democracy, is to maintain control of one's own people by any means, including terror.' (Baudrillard, 1995; p. 72)

It's not altogether certain that the masking is everywhere very substantial.

Again, here is not the place to engage in an explicit critique—which would, in any event, be quixotic, a quixocritique—of liberal democracy as a universal aspiration and absolute good. All that I should do here is to point to the alignment of discourses associated with the TIMSS site. Alan Sokal (see note 29) would (should he consider an assault on this little piece to be worth the effort) no doubt berate me for making anything at all out of the juxtaposition of the language of democracy with the language of scientific rationality other than that, perhaps, they are *in fact* properly aligned: the one seeking the optimizing of the exigencies of social organization in the context of liberal values; the other seeking the optimizing of our engagement with the empirical world in the face of imperfect knowledge. I am easily defeated in the public discourse that emerges out of social alliances that must overwhelm me. Indeed, even Sokal's far more celebrated public victims must often appear to be skulking back into the privacy of their arcane, alchemic worlds in the face of his dazzling crusade.

The invoking or the awareness of a public/private duality seems to provoke hegemonic or counter-hegemonic, metaphorical action, but to engage in this way is either to play the game of the dominant alliances or to falter. To the extent that the bureaucratized public technology constitutes the language by which expertise is defined, the traditional expert—insofar as their expertise stands in excess of the bureaucratically defined practice—or the charismatic or liberal innovator may participate only as heretics; and heretics always get burned eventually (in this world or a next).

I have introduced three modes of interaction: synecdochic *equilibration*; metonymic *exchange of narratives*; and metaphoric *hegemony*. The first two

[31] It is not helpful to provide a reference as this appeared in a box on the site, the contents of which vary.

of these modes presume an alliance of similars—we all speak the same public language. They differ in that equilibration seeks a discursive closure whilst the exchange of narratives deploys contingency to avoid closure. Hegemony contrasts with both in recognition of the public/private partition. Here engagement is between disimilars. But like equilibration, the target is discursive closure. The product of the two variables, alliance (similars/disimilars) and target of discursive action (closure/openness) gives rise to the space shown in Figure 17. As with my analysis of authority action, I am left with a residual category. In this case, the category, *pastiche*, defines an interaction between disimilars—public/private—under conditions of discursive openness. I have offered corresponding tropes for the other modes. The characteristic trope for pastiche is catachresis (see Burbules, nd). I want to suggest that it is precisely in this mode that private action in non-bureaucratic mode is most productively elaborated. Here, apostasy in relation to the global public technology of mathematicoscience (and democracy) may be sustained whilst still recruiting from it that which may be of practical value in our local pursuits. We have, in other words, to recognize, that very few of us are going to change the world in any sense at all and that those of us who do may well not welcome the outcome: some people change the world, but not in ways that they themselves choose.

	Target of Discursive Action	
Alliance	Closure	Openness
Similars	*Equilibration*	*Exchange of Narratives*
Disimilars	*Hegemony*	*Pastiche*

Figure 17
Modes of Interactive Social Action

So what does this mean in the context of mathematics and science education? I ought, in righteous exchange mode, to say, 'I don't know,' but then, I'm a teacher. I suppose that it may well come down to paying close attention to the matter at hand and, in particular, to the nature of the local relations that will tend to dominate any given intervention or interaction. Very little will be served, I think, either by total submission to the hegemony of mathematicoscience or by opposition in quixocritique. The whole point of pastiche interaction is that the integrity of the participating discourses must be maintained—catachresis must not be permitted to degenerate into metaphor or, perhaps worse, the literal discursive identity of equilibration or

exchange of narratives. As has been demonstrated by a wealth of sociological and sociolinguistic work,[32] the predisposition to accept public forms of discourse is itself emergent upon structuration that can be described in socioeconomic terms. As I have demonstrated elsewhere (in relation to school mathematics at least), public forms of discourse necessarily serve to recontextualise and transform and so subordinate private forms where the latter are introduced into the *public domains* of the former (Dowling, 1991b, 1995, 1996, 1998, 2001a). As the bureaucratized spokesperson of mathematicoscience the teacher may draw their students into their own game, but they will not solve any of the problems, address any of the concerns of their students insofar as these problems and concerns are constituted within localized, private discourses and one suspects that most of them are. Essentially, school is a very bad place to learn anything beyond how to survive as a school student (or teacher).[33] Yet, knowing all of this, my erstwhile[34] mentor, Basil Bernstein had this to say in 1974:

> It is an accepted educational principle that we should work with what the child can offer: why don't we practice it? The introduction of the child to the universalistic meanings of public forms of thought is not compensatory education—it is education. (Bernstein, 1974, p. 199)

Thirty years and two Gulf 'wars' on, you'd think we'd know better. But I fear not; *viva el Don*, it seems.

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[32] See, for example: Bernstein (1974), (1999); Bourdieu (1991); Bourdieu & Passeron (1977); Gee et al (2001); Hasan (1999); Heath (1986); Moss (2000)—though not all might concur with my formulation of their findings; see also Dowling (2004b).

[33] Cf. Lave & Wenger (1991).

[34] And, despite all, fondly and gratefully remembered—see Dowling (1999, 2001b).

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