

**COGNITION AND TECHNOLOGY IN EDUCATION:  
KNOWLEDGE AND INFORMATION — LANGUAGE  
AND DISCOURSE**

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**A. Knowledge and information in the advance of  
technology**

1. The two expressions *knowledge* and *information* are at times used, as if they were interchangeable. But significant motivations might be found for distinguishing the two concepts as complementary end-points on a scale. This distinction may prove insightful when assessing the prospects for productive applications of technology to education (cf. Gee 1992; Halliday 1994; Brown and Duguid 1995).

2. Knowledge is more *dynamic* and *integrative*. Its content is characteristically practical, and naturally acquired from lived experiences and directed intuitions among a cultural community (Toulmin 1972; Brown, Collins, and Duguid 1988; Lave and Wenger 1991). The operations for storing, retrieving, and using it are relatively effortless. When not in active use, it can undergo spontaneous evolution and elaboration in mental storage and generate more of itself. New knowledge being entered can reverberate through associated prior knowledge and update its specifications. Or, old knowledge can be creatively modified and adapted for

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unfamiliar or novel situations, often by relaxing degrees of approximation and goodness of fit (cf. Norman and Shallice 1980).

3. By contrast, information is more *static* and *compartmentalised*. Its content is characteristically theoretical, and consciously acquired from specialized activities. The operations for storing, retrieving, and using it are relatively effortful. When not in active use, it can undergo spontaneous conflation or degradation. New information being entered is unlikely to be integrated with prior information unless the mutual associations are expressly constructed. And old information can be rather difficult to modify or adapt to unfamiliar or novel applications.

4. I would advocate a parallel distinction between *cognition* and *information processing*, another pair of terms that have at times been used interchangeably. Cognition is centrally concerned with the natural acquisition and application of knowledge. It is the freely accessible sustainer of communal culture and social interaction. The sharing of knowledge increases not merely the range of knowledgeable people but also the richness and applicability of the knowledge itself (Calfée 1981; Bereiter and Scardamalia 1992).

5. In contrast, information processing is centrally concerned with the deliberate registration and regulation of information. It is the sustainer of specialized or professional expertise, but also of technical data configurations such as computer-readable program codes. The access to information may be restricted to particular circles of participants, such as owners of personal computers who are registered visitors of websites. But since the value of information depends precisely on its range of access, such restrictions are periodically lifted when higher levels of information have been achieved (cf. ¶ 9, 12).

6. We might broaden our account with another parallel distinction, this one between two *social classes*, each one actually being a cluster of roughly similar classes. The 'lower class' would comprise the 'working class' plus the large chronically poor or unemployed sectors at the bottom; and the 'upper class' would comprise the various groupings of the middle class (e.g. 'upper middle', 'lower middle') plus the small elite sectors at the top. The 'lower' class is more adapted to acquiring and applying knowledge, as in apprenticeship methods of learning on the job. The 'upper' class is more adapted to processing and managing information, as in academic methods of learning from textbooks. The borderline between the two classes could logically be sustained by requiring that aspirants to secured status in the upper class must perform strenuous information-processing tasks. Such could be noted in the formidable examinations for obtaining credentials to practice prestigious technical professions, such as medicine, law and engineering, where a fair portion of the information solicited on the exam is not directly relevant to performing on the job (cf. R. Collins 1979).

7. The differentiation of the classes gets worked out in steadily greater detail as a society becomes *specialised* and *modernised*. Cultural knowledge and practical labour tend to decrease in value, while abstract information and theoretical calculation increase. The speed and intensity of this process are closely controlled and monitored by the evolution of labour-performing technology in general and information-processing technology in particular.

8. The industrial revolution kick-started and propelled the key phase in this process by interposing multiple levels of technology. Whereas more practical tools like hammers and anvils, or ploughs and sickles, apply energy and force directly to labour, more theoretical tools like gears and pulleys, or drive-belts and levers, multiply energy and force before applying them to labour. Already, energy and force were partially becoming information, e.g., in being quantified and defined by the relative sizes of gears and pulleys. In exchange, the theoretical tools rendered labour itself more theoretical and abstract without the workers being involved in constructing or even understanding the theory. Their practical knowledge as builders or artisans lost its relevance and value as their work was shaped by fitting the human to the machine and by implementing out the theoretical information of the designers, engineers, and managers. This process has been called 'deskilling' (Braverman 1974):

The relative degradation of skill is the result of the fact that technological change means for the most part, transferring skills to machines, [and] a simultaneous process of employer-initiated re-organisation in which the operator's scope of responsibility is reduced by rationalisation, [...] while a much smaller number of highly trained technicians and managers enlarge their responsibility (Aronowitz and Giroux 1983: 188).

Deskilling makes the workers easily manageable and replaceable and supplies a cynical pretext for their penurious wages, whilst the profits from the dramatic rises in production have been channelled to the 'information-rich' jobs of the technicians.

9. Still, advancing technology eventually requires some wider circulation of selected information among the working class. The distinction between social classes gets periodically recalibrated to adjust the distinction between 'lower-level' and 'higher-level' information. As technology keeps on creating steadily higher levels, the working class is granted access to formerly restricted lower levels, which are now obsolete in a sense too precise and technical for workers to grasp. And this process etches an increasingly detailed and exact scale of values for ranking the theoretical over the practical.

10. The industrial revolution led to a giant leap in evolution by shifting technology from converting energy into labour, as with a steam engine, over to

converting energy into information, as with a transducer. This shift was sharply accelerated by the evolution from electric machines, e.g., a drill or a grinding wheel, over to electronic machines, e.g., a vacuum tube or a transistor. Electronic technology renders the practical construction of the device and its consumption of energy more and more irrelevant to the theoretical quantity and quality of information that can be processed.

11. Logically enough, the next shift enlisted technology itself for converting lower-level information into higher-level information, in cycle after cycle. If each higher level might plausibly be regarded as a theory of the construction of one or more lower levels, the proliferation of steadily higher levels would intensify the already dominant theoretical quality of the total process. Yet as the span between the higher and the lower levels keeps widening, this 'theoreticalness' grows more opaque and incomprehensible for the social classes nearer to the bottom.

12. When information is both the means of production and the commodity being produced, the relation between theory and practice can become exquisitely convoluted. Since the value of information rises by 'globalising' the access, continual breakthroughs are needed to enhance the marketability of the technology. Computers and their peripherals keep getting cheaper in proportion to their storage capacities and computational power. Yet this cheap technology is also just becoming obsolete. And however much consumers may save on an individual purchase, they spend far more in the long run on upgrading or replacing their technology at rising speeds.

13. The value of information is thus much enhanced by the current 'globalising' of information technology. The hierarchy of social levels may shift onto parallel dimensions, with the 'upper class' at the *centre* (Europe, North America, Japan) and the 'lower class' at the *periphery* (generally Asia, Africa, South America) (cf. Galtung 1971). Theoretical innovations are achieved mainly by technicians in the centre, whereas practical assembly is performed mainly by workers in the periphery wherever wages are lowest. The 'technological revolution' can thus afford to globalise information by keeping down production costs and paying minimal wages. Indeed, the same trends can render physical geography irrelevant to production when technology enables management to recruit their workforce anywhere on the globe by setting up steadily more sophisticated communication networks and by subdividing and deskilling multiple sectors of the production process. The distinction between the upper class and the lower class is constantly being regrouped and redistributed, all the while getting significantly wider. By inciting competition among workers everywhere, management can dictate conditions and wages no less high-handedly than in the early industrial revolution (Martin and Schumann 1996).

14. Meanwhile, information technology, like the Tower of Babel, has created a mega-scale hierarchy of levels that overloads human processing capacities. So new upper levels are designed to operate the technology and to globalise software and shareware for managing information about information; and the consumer is again impelled to keep upgrading. The tower gets periodically restabilised and reinforced until it once more outgrows itself.

15. My brief overview in this section suggests that the distinction between knowledge and information is most significant where information and information processing serve to differentiate social groups with greater precision and at wider distances, whether or not the overall hierarchical structure of a society is radically altered. The working class is not excluded but rather consigned to the currently lower (and technically obsolete) levels of information technology and thus cannot resist deskilling nor achieve material advancement in real economic terms.

16. At the same time, the middle class is being acutely destabilized by successively finer divisions among the levels of information to which respective groups are entitled. The emergence of higher and higher levels colonised by the super-rich elites who design and disseminate new technologies, automatically exerts downward pressures upon those sectors of the middle class who, unable to upgrade their technology and their processing capabilities, must stagnate in obsolescence. If left to run its course, this process could eliminate the middle class as defined by conventional economic indicators, even in centre countries. Just such an ongoing trend has been documented as early as in the November 1983 issue of *Fortune* magazine and in extensive research since then (esp. Martin and Schumann 1996). But so far, the close link between this trend and the hierarchical mechanisms of information technology has not been widely understood. Nor, to my knowledge, have serious initiatives been mounted by governments to control those mechanisms and their impact upon democratic and economic institutions.

## B. 'Knowledge' and 'information' in modern education

17. Standard dictionary definitions of *education* read like this: 'the process of imparting or acquiring general knowledge and of developing the powers of reason or judgement; the process of imparting or acquiring particular knowledge, as for a profession' (*Random House Webster's College Dictionary*, 425). Such definitions reflect an ideal theory of education rather distinct from its real practices as described by Halliday:

Current 'progressivist' education in the United States derives from a body of the doctrine which locates all learning in the mental makeup of the

individual, sets up a severe distinction between cognitive and affective processes, and interprets cognition as a kind of information processing (Halliday 1994: 78; cf. Tyack 1974; Gee 1992).

Halliday sees here an 'extreme form of middle class ideology and its hidden curricula of values and educational goals' (cf. ¶ 19, 39) (see also Gramsci 1991).

18. In the previous section, I suggested that specialising and modernising a society tends to raise the value of abstract information and information processing and to lower the value of cultural knowledge and practical cognition (cf. ¶ 7ff). I would suggest a corresponding evolution for education, which has been modernised chiefly by undergoing massive injections of information and a correspondingly receding interest in broader cultural knowledge.

19. Here too we might detect the impact of the industrial revolution, as when 'schools' are said to be 'consciously modelled on that most productive of all technologies, the factory' (Hodas 1993; cf. Tyack 1974):

For at least the last hundred years, schools have been elaborated as machines set up to convert raw materials (new students) into finished products (graduates, citizens, workers) through the application of certain processes (pedagogy, discipline, curricular materials, gym). This view [...] presumes that the limits of education are essentially technological limits and that better technology will remove them. It is the most generic and encompassing theory of 'educational technology', since it embraces all curricular, instructional, and material aspects of the school experience (Hodas 1993).

However, this modelling would not apply equally to all social classes. The dominance of middle class ideology noted by Halliday would logically be reflected in an emphasis upon information processing as a preparation for acquiring theoretical credentials rather than for performing practical labour (R. Collins 1979) (cf. ¶ 6). If so, most of those 'finished products' emerge out of 'raw materials' from the middle class.

20. I would go further and propose to model 'modern education' overall as a *vast technology for converting dynamic knowledge into static information* (Tyack 1974; Hodas 1993). This conversion too has multiple levels. One level applies to the learners. Rich knowledge about their individual personalities, talents, family, and cultural background, gets converted by educational records into sparse information about their 'achievement' or 'performance', represented in standardised 'facts' and 'figures' as expressed by numbers. The apparent objectivity of numbers masks the subjectivity entailed in assigning a closed, simple quantity like '1 - 2 - 3 - 4 - 5' —interpreted as 'excellent - good - fair - poor - fail'— to an open set of complex qualities. Officially, the numbers are the fair and

final measures of the educational outcome, explained from inherent 'intelligence' and 'aptitude', which learners cannot control; or else explained from 'diligence' and 'obedience', which learners can and jolly well ought to control. Although these two explanations are logically incompatible, education devoutly oscillates between them when affirming that each individual learner bears full responsibility (cf. ¶ 31). Yet ironically, education also works to marginalise the individuality of the learners in their social, temperamental, and emotional dimensions, which would stand out clearly if the focus were allotted to cultural knowledge rather than abstract information.

21. Another level applies to the content of education. Once a field, such as history or physics, has been selected to be a 'subject' in the standard 'curriculum', its knowledge is emblematically converted into neat batches of stable, free-standing 'facts and figures' waiting to be learned and reproduced with the greatest accuracy (Freire 1970; Apple 1985). These in turn constitute the 'information' for the information processing tasks deployed to assess the learners' performance.

22. The preference for such tasks thus interlocks with the emphasis upon facts, figures, and numbers. Each task is approached on the expedient assumption that the learners command precisely the information they have acquired from recent stages within the instructional process. Cognitive tasks, in contrast, would entail some responsibility on the part of the teacher to take account of the comprehensive prior knowledge stores of the learners, which would manifest substantial variation, and which would oblige teachers to become genuinely knowledgeable about their learners.

23. Quantitative assessment of each learner's 'achievement' purports to operate on a smooth and even playing field, yet entails a pungent paradox: all learners supposedly approach the task with the same preconditions and the same opportunities to perform it successfully; yet the actual performances must result in some significant and quantifiable differences. If, on the contrary, the performances were uniformly successful, the validity or appropriateness of the task would be called into question ('too easy!'). The playing field must be even, but the outcome of the game must not be. Sameness gets unsystematically commuted into difference in the name of fairness (treating all learners as equals) and objectivity (applying precise and uniform standards).

24. Information processing tasks are most suited to precluding uniform success, since they can readily be designed to impose limitations. Such tasks can ensure that the 'average' results will indeed constitute the average; and can elicit a proportion of total failures as a cosmetic counter-balance on the 'grade curve' for the proportion of total successes. Knowledge-based tasks, insofar as they are culturally appropriate and socially motivating, would yield large proportions of

high success and virtually no failures, and so be accused in administrative discourse as flagrant 'grade inflation'.

25. Interestingly, the outcome labelled 'average' is itself regularly construed as a symptom of disappointing limitations. Schooling seems to classify learners as typical and ordinary yet to imply that being so is inadequate. This ambivalence can hardly be accidental insofar as it serves the significant social function (or dysfunction) of limiting the learners' expectations and aspirations for the rewards of society in later life (Bowles and Gintis 1976; Apple 1985). This function in turn could be served by effective mechanisms for actually constructing and imposing those limitations upon a human potential that schooling purports to merely discover and reveal.

26. And that function too favours information over knowledge, this time in order to impose multiple bottlenecks. One bottleneck arises where schooling neglects to endow information with significance, interest, or relevance. These factors are largely bypassed when information processing tasks are programmatically dissociated from the activities of everyday cognition:

Such material in a world by itself, unassimilated to ordinary customs of thought and expression. [...] Those which have not been carried over into the structure of social life, but which remain largely matters of technical information expressed in symbols, are made conspicuous in schools, (Dewey 1916).

The teacher [...] expounds on topics completely alien to the existential experience of the students. His task is to fill the learner with contents that are detached from reality, disconnected from the totality in which they were engendered and which lent them significance, [...] This vision minimises or annuls the creative powers of learners and stimulates their ingenuity rather than their critical thinking (Freire 1985 [1970]: 45ff).

Under such conditions, 'education' can hardly fit the brisk dictionary definitions of being 'the process of imparting or acquiring general knowledge and of developing the powers of reason or judgement' (§ 17).

27. When learners conclude that their practical knowledge of life is inferior and irrelevant to the information transmitted by the discourses of schooling, they might experience *alienation*, defined here in its etymo-logical and most basic sense as the denial of one's individual identity and potential. Cognitive tasks enlisting the learners' prior knowledge, in contrast, would favour *actualisation*, defined as the affirmation of individual identity and potential (Maslow 1954). Alienation sets the affective dimension alongside the informational dimension of the bottleneck.

28. A closely related bottleneck arises because the remoteness from cultural experience renders static information substantially more difficult to learn and retain than dynamic knowledge. This factor has been documented by robust findings of experimental research in psychology: cognitive processing is poorly adapted for isolated items and bits, and richly adapted for integrative patterns and frameworks (surveys in Kintsch 1977, 1998; Bereiter and Scardamalia 1992). By transmitting information in 'facts and figures', education interposes a bottleneck upon the initial transfer and even more upon subsequent organisation, storage, and retrieval. Compared to ordinary cognition, this transmission is slow-paced, fragmented, and reductive. Long-term retention and productive application are threatened by conflation and degradation, as strikingly attested by the commonplace difficulties among adults of recalling or using what they learned in school as children.

29. The most damaging bottleneck, strongly abetted by these other two, is *overload*, where the strain to increase the quantity of information being processed flips over into a drastic decrease (Beaugrande 1984: 124f). Mental and physical processing enter a state of catastrophic degradation, whilst ancillary symptoms of stress and anxiety trigger a heavy drain on resources, which intensifies the degradation, and so on in a reverberating cycle. This stage becomes most conspicuous in breakdown and panic, when people become totally unable to access the information they have in fact acquired.

30. Taken together, such bottlenecks would materially reduce the learners' potential and marginalise their knowledge. If so, the 'grade curve' represents differences not merely in one's 'achievement' though 'intelligence' or 'diligence', but in one's capacities to operate through multiple bottlenecks and near the threshold of overload. From here we might account for the traditional format of the formal examination. Learners are deprived of operational support from even the more primitive educational technologies, such as notebooks, textbooks, and reference works; and are compelled to perform under physical and psychological pressure. Examination tasks are often more demanding and extensive than many learners can manage within the allotted time. Quality must be sacrificed by working rapidly and superficially, and by omitting deeper reflection and creative evaluation of alternative methods or solutions.

31. The numerical scores of formal examinations thus tend to represent work performed under signally artificial and adverse conditions. Yet these same scores are accredited to be the best indicators—and in some institutions the only ones—of the learners' 'achievement', or indeed of their 'potential' for achievement. This accreditation once again places the full responsibility onto the individual learner (cf. § 20). Ironically, the artificial quality of the formal examination as compared to most situations of assessment in real life is believed to even out the playing field

and to minimize individual differences extrinsic to the educational process (cf. ¶ 23).

32. As modernisation and specialisation continue their massive injections of information into education, the entire system eventually converges upon the threshold of overload; technology periodically overhauls the 'facts' without lessening societies faith in their value—quite the opposite (Veblen 1918). At that stage, poor performance and alienation may assume debilitating or even epidemic proportions. By a relentless inner logic, the system is propelled into an 'educational crisis', such as has in fact been diagnosed in the United States for over twenty years. The usual simplistic accusations that the schools are 'neglecting discipline' and 'lowering standards' are badly misleading; the crisis is the inexorable long-range outcome of the bias of modern education toward information processing. The multiple bottlenecks I have briefly described naturally render the system non-operational when the volume and complexity of the information surpass an unsustainable threshold. This threshold will be reached sooner in an alienating environment such as inner city schools whose learners come from disadvantaged families. It will be reached later in an actualising environment such as suburban schools whose learners come from affluent families. But only the latter schools are taking serious steps to shift their emphasis from information processing over to cognition (Anyon 1981).

33. The indignant calls for a 'return to higher standards' are equally misleading. Those standards could be sustained in former times only insofar as the information load upon the whole system was substantially lower. Equally misleading are the current campaigns for 'standardisation', a notion also descended from 'the machine-age thinking of the industrial revolution of the past century' (Romberg 1992: 768) and from the trend of 'modelling schools on factories' (Hodas 1993) (cf. ¶ 19). Standardisation paradoxically tries to legislate sameness even though the misguided imposition of sameness has been materially implicated in inciting the crisis. The hidden logic appears to be that the negative consequences of overloading the system should be equally distributed among all learners. Yet standardization itself increases information, due to the fastidious mechanics of quantifying and measuring, and so will deepen the crisis by intensifying the overload upon schools and their staff.

### C. Discourses of information and discourses of knowledge

34. The long-standing, popular notion of a language being a medium for the 'transmission of information' has passed on into science in general and into

'linguistic science' in particular. Predictably enough, one dominant model was derived from an analogy to technology. The operations of 'encoding information' in language by the 'sender' and its subsequent 'decoding' by the 'receiver' are briskly viewed as analogous to getting a message from English into Morse code (or some comparable code) and back out again. Yet the analogy could work only if information were static and compartmentalised, neatly arrayed as 'bits of information' in the series of 'meanings' of the individual words and phrases; and if the 'encoder' and the 'decoder', like machines, worked with uniform operations and reliable results.

35. This reassuring technological model is again deeply misleading. A message to be put into Morse code has already been organized as language, and the encoding is just a mechanical, predetermined substitution between two different systems of symbols. No such conditions apply when the message has not yet been formulated in language; indeed, the 'message' as such might not even exist at that stage. Nor can a message in natural language consist of the serial addition of isolated single meanings to be encoded one by one, which factor has posed serious problems for technology when it comes to 'understanding' such a message. Computers are strong in handling information and weak in handling knowledge; humans are just the reverse.

36. All the same, the notion of language being a medium for the transmission of information remains firmly entrenched in the discourses of education. Conventional textbooks or lectures are signally preoccupied with the presentation of facts and figures, along with technical terms and their literal definitions (cf. ¶ 21f, 28, 59). Reciting, recording, and reproducing discourses of information as literally as possible thus constitute the commonplace information processing routines of 'academic study', and the major medium for 'good performance' and 'correct answers' (Lemke 1990)—and one of its effects is the proliferation of sameness in language (cf. ¶ 23, 32). The value placed upon literalness in effect converts the wording of the text into a strenuous mode of information in its own right rather than just a medium for transmitting information. The task of learning the textual wording gets superposed upon the task of learning the subject matter; and confounding these two tasks acutely impedes the production of knowledge.

37. The 'good students' are those who enlist their own discourses to 'process information' in static and compartmentalised modes. It is highly ironic that the human organism gets rated and rewarded in proportion to its mimicry of primitive information technology. This analogy between the human and the technological is disturbing insofar as information can be recorded and reproduced without ever becoming knowledge, in fact without even being understood (Darling-Hammond and Snyder 1992; Lemke 1994). Education that merely 'transmits information' in literal discourse and requires its literal reproduction is especially prone to foster

alienation and hinder actualisation as defined in ¶ 27. It might indeed be described as 'dis-education', insofar as it induces an artificial incapacity to organise, enrich, and apply knowledge (cf. ¶ 26). And methods for testing information by means of machines, particularly in 'multiple choice' formats, could justly be described as 'deskilling' the learners as readers and writers of natural language (cf. ¶ 70, 74, 76).

38. Paradoxically, discourses of theoretical information constitute a language variety that is not taught in its own right, yet its mastery remains a key requirement for educational success. Learners are left to their own devices for acquiring it from repeated exposure and imitation. Among its 'stylistic norms' observed by Lemke (1990: 133) in his classroom fieldwork were: 'use technical terms in place of colloquial synonyms and paraphrases'; and present 'statements' 'in the form of propositions that seem to have universal validity' and 'make no reference to here and now' or to 'human action'. These norms 'mainly serve to create a strong contrast between the language of human experience and the language of science' and 'to exempt science from social processes and real human activity', much like the contrast I have described between knowledge and information. And Lemke's work confirms a bottleneck effect: 'the stylistic norms' 'impede the communication of the thematic content of science to students'; and 'pitting science against common sense undermines the students' confidence in their own judgement' (1990: 134). In contrast, his 'systematic comparison' found that the 'less alienating, more colloquial, more humanised ways of talking science' rendered the 'students three to four times as likely to be highly attentive' (1990: 135f). Yet he also observed classroom occasions of 'students directly and indirectly commenting on a teacher's deviations from how they expect scientific language to sound' (1990: 132). Evidently, discourses of information are considered proper or obligatory even by students who are thereby subjected to a bottleneck.

39. Lemke ascribed his findings to the '*mystique of science*'; it rests upon an 'ideology of objective truth', of 'established, permanent, incontrovertible fact' 'taken out of the context of science as a human social activity' (1990: 137). It also rests upon an 'ideology of special truth' 'available only to experts' possessing 'special talents and exceptional intellects which the average student does not and never will have'. 'No one points out that science is taught in very restricted ways favouring people whose backgrounds have led them to already talk a bit more like science books' (1990: 138) —here too, distinctions are sustained among social classes, with the usual middle-class bias toward information processing (cf. ¶ 17, 19).

40. Yet we might recognise a more general *mystique of education* which aspires to apply these same two ideologies of 'truth' to the content of every subject matter.

Just when the information to be transmitted is remote from the knowledge of practical life, an aura of 'permanent fact' and 'special truth' offers the prime justification for teaching it at all (Gramsci 1991). Science stands out because it suits this mystique best, but other subject areas do their best to construct their own discourses of information.

41. The effect of such discourses is a double-tracking between offering information and withholding it. Learners are left to their own devices both when acquiring discourses of information, and when actually extracting information from those discourses and converting it into knowledge. Exactly how these two tasks can be accomplished is arguably the greatest unknown factor in the whole of modern education, which, I am claiming, works in the opposite direction — converting knowledge into information for transmission in discourse (¶ 20ff).

42. Under present conditions, the heavy reliance upon discourses of information will continue to entrain 'education' in a maze of paradoxes. Massive transmissions of information may overload the learners and leave them uninformed. Insisting on literal statements of static 'facts' may weaken rather than strengthen the contact with the dynamic real world. Giving 'correct answers' may simulate rather than demonstrate understanding. Formal examinations may give a false measure of the meaningful knowledge of individual learners. And so on.

43. I can briefly illustrate with some samples from the discourse of geography on sand dunes (posted without authorship on the Internet in 1998). The 'definition' given for the 'dune' is shown in sample [1].

[1] A dune is defined as a body of coarse sand shaped by ambient wind conditions and the grain-by-grain deflation of sand.

Some stylistic norms along the lines observed by Lemke can be readily confirmed: (a) overly specialised terms like 'ambient' meaning 'in the environment', and 'deflation' meaning 'erosion'; (b) gratuitous specifications like 'ambient conditions' (where else could the winds do the 'shaping?') and 'grain-by-grain' (sand normally occurs in grains); (c) remoteness from ordinary knowledge, which would interpret 'deflate' as 'remove the air from inside' —nonsense in this context. Besides, 'grain by grain' misleadingly suggests that sand might also be eroded in some other formation such as blocks or conglomerates; 'body' is an oddly organic term for an object that frequently changes or disintegrates; and 'coarse sand' is plain wrong —I have encountered dunes, near my home at the edge of the Empty Quarter in Arabia, formed from sand so fine it gets in around the edges of firmly closed windows. All these features illustrate the dangers of a discursive bottleneck upon the transmission of information. I would propose a counter-strategy of *critical rewriting*, as shown in [1a]. Such a version should be

more readily understood and integrated into the learners' store of environmental knowledge, especially of non-native speakers of English.

[1a] A dune is defined as a mound of sand shaped by the motion and erosion of wind and sand grains.

I would draw the same contrast between samples [2-4] and my critical rewritings in [2a-4a].

[2] Mesoscale dune wavelength is strongly correlated with sand grain size.

[2a] On medium-sized dunes, the waves get longer when the sand grains are bigger.

[3] Transverse dunes are characterized by low length:width ratios and marked asymmetry, where windward slopes are much gentler than the slip faces associated with lee slopes.

[3a] Dunes formed at a right angle to the wind are very short but very wide. They rise gently on the side facing the wind and drop sharply on the other side.

[4] Barchans are crescentic dunes confined to directionally-constant annual wind regimes; [...] where sand is sparse, barchans become the expressed dune morphology.

[4a] Barchans are crescent-shaped dunes appearing where the wind blows in one direction all year and especially where sand is sparse.

In the same strenuous discourse, rainfall is a 'precipitation event'; extreme dryness in a small area is 'localized hyperaridity'; and sand grains that blow away again from their dune 'become wind re-entrained'.

44. A special motive for this gratuitous informativity might be inferred from these stilted admissions in the same discourse:

[5] How dunes first form and then replicate are issues that remain unclear.

[6] the formation mechanism of dune characteristics remains hypothetical.

Such limits are uncomfortable if science is expected to present 'established, permanent facts' and 'truths' (cf. ¶ 39f). So a strenuous discourse of information can be deployed to camouflage a lack of deeper knowledge.

45. Compare now this passage from Wilfred Thesiger's (1994 [1959]: 130-133) *Arabian Sands* about the lived communal experience of crossing an immense dune in the Empty Quarter:

[7] It seemed fantastic that this great rampart which shut out half the sky could be made of wind-blown sand. [...] It was now that Al Auf [the Bedouin guide] really showed his skill. He picked his way unerringly, choosing the inclines up which the camels could climb. Here on the lee side of this range a succession of great faces flowed down in unruffled sheets of sand, from the top to the very bottom of the dune. They were unscalable, for the sand was poised always on the verge of avalanching, but they were flanked by ridges where sand was firmer and the inclines easier. It was possible to force a circuitous way up these slopes, but not all were practicable for our camels, and from below it was difficult to judge their steepness. Very slowly, a foot at a time, we coaxed the unwilling beasts upward. Each time we stopped I looked up at the crests where the rising wind was blowing streamers of sand into the void, and wondered how we should ever reach the top. [...] In that infinity of space I could see no living thing, not even a withered plant to give me hope. 'There is nowhere to go', I thought. 'We really are finished'.

Although Thesiger had extensive experience of deserts and sand dunes, he sensed his abject ignorance alongside his Bedouin companions whose home was the desert. In his lack of knowledge, he desperately scanned the environment for information and, not finding any, relapsed into panic.

46. His Bedouin guide, in contrast, had the practical knowledge for getting the caravan across a dune that must seem impassable to a less knowledgeable person. He did not command the sort of information presented in a discourse like [1-6], which he could hardly have recognised to be a description of the dunes he knew.

#### D. 'Knowledge' and 'information' in discourses of 'technology'

47. I was intrigued to find the term *technology* defined by recent dictionaries in close association with the term *knowledge*, viz.: 'the application of knowledge for practical ends'; or 'a particular area of activity that requires scientific method and knowledge' (*Random House Webster's College Dictionary*, 1371); or again, 'the branch of knowledge that deals with applied science, engineering, the industrial arts' (*Collins COBUILD English Language Dictionary*, 1501) But when I queried my corpora of authentic discourses about 'technology', I found relatively few collocations linking *knowledge* and *technology*. The collocation 'knowledge technology' did not occur at all. At most, a few data suggested that the one might produce the other, as if the direction of the causality is reversible:



[8] Investments in science and technology drive economic growth, generate new knowledge, create new jobs, build new industries, ensure sustained national security, and improve our quality of life.

[9] technology has become a major engine of economic growth, a significant contributor to our national security, a generator of new knowledge, and a critical tool in protecting our health and environment.

[10] These partnerships enable the private sector to translate new knowledge into novel technologies that benefit society at large.

[11] Integrative research is needed to combine fundamental discoveries and thus gain the comprehensive knowledge required to develop more targeted technologies.

We can notice a pervasive optimism that technology will 'benefit society' and 'improve our quality of life' in every way (cf. Cohen 1987).

48. In contrast, I found a high rate of collocation with *information*. *Information technology* figured as a favoured collocation in bureaucratic, commercial, and academic discourses, viz.:

[12] The revolution in information technology has increased productivity by helping people work faster and smarter. It has created jobs, rewarded entrepreneurs and investors.

[13] The Administration has used advances in information technology to serve customers faster, more accurately, and more reliably.

[14] Congress reformed the way Government acquires information technology as part of the Information Technology Management Reform Act.

[15] the Administration would work with 75 of the Nation's most congested metropolitan areas to develop modern information technology for highway and transit systems.

[16] Establishing Information Dominance: Information is power. U.S. pre-eminence in information technology helps us to field the world's premier military force.

'Information technology' is also presented as showering modern society with myriad benefits. The commitment of the US 'Administration' is correspondingly intense [13-15], especially in aspiring to 'field the world's premier military force' [16] —though projects like 'Star Wars' signal a dangerous misunderstanding of such technology.

49. The collocation *information technology* was also highly prominent in my data corpus from the discourses of education, whose limitations are to be 'removed by better technology' (Hodas, ¶ 19).

[17] Information technology has a role to play in delivering higher education in flexible ways [...] to promote curricular innovation, and to help raise the profile of teaching in higher education.

[18] Information technologies now present colleges and universities with opportunities to transform the teaching and learning processes that are at the heart of their educational missions, and their business processes and decision-making capabilities.

[19] On the issue of students acquiring information technology skills, there is a widespread sense that such skills are becoming a necessary condition both of employment in many sectors of the economy and of improving international competitiveness.

Undeniably, high hopes are pinned upon *Exploiting the Full Potential of Information Technology in Higher Education* (the title of one report). The university is to be changed, perhaps radically transformed:

[20] Our analysis has uncovered continuing technology training and retraining requirements for this University's information technology community.

[21] the leadership must quickly develop a 'human-centred' information technology infrastructure to respond to the changing needs of faculty, administrators, professionals, clerical staff, and technical staff.

[22] there might be founded a new kind of university which exploited fully the potential of multi-media information technology with all its interactive capacities and opportunities for global networking: the names televarsity or virtual university are offered. [...] This could be a university for the twenty-first century, which places learning much more under the control of the individual student but which also involves a new and exciting realisation of the learning community.

Yet the integration of steadily more information technology might only reinforce the prevailing dominance of information, and drive knowledge even further toward the margins of the educational experience (cf. Hodas 1993; Lemke 1994). Merely enlisting technology to intensify the transmission of facts and figures could tighten the bottlenecks and increase the perils of overload.

50. I would argue that significant progress can be achieved only if technology gets strategically enlisted for knowledge management (Brown and Duguid 1995;

Bobrow 1998). Specifically, the goal of education would be expressly reconceived in an expanded scope as the *development of skilful and creative strategies of discourse for converting information into knowledge, as well as knowledge into information*. Confronted by the flood of information in education and electronic media, 'educated persons' would be those who can integrate and elaborate it into a productive unity that is relevant and applicable to significant human issues, such as ecological modes of progress. Also, they can communicate their knowledge to a wide range of audiences, especially to ones who need it for achieving a better life. In return, they can provide information at any appropriate degree of specialisation, e.g., to perform in a skilled profession.

51. Such an 'education' would mediate powerfully against the sameness that currently predominates (cf. ¶ 23, 33) (cf. Lemke 1994). Instead of being mechanically recited and reproduced, information gets dynamically expanded and transformed, leading into a range of personalised constellations of knowledge. These would not be identical with the knowledge that originally got converted into information for educational purposes, as described in ¶ 20ff. And if such a constellation were used to generate information, the product would not be identical with the information previously presented in the educational setting. The learners' performance would accordingly not be assessed by their literal accuracy in reproducing discourses of information, but rather by their skills in relating a specific issue or problem to its cognitive and social context and proposing effective and useful means of dealing with it (Lemke 1993). The more difficult or novel the issue, the greater the skills that can be demonstrated.

52. Here is a vital assignment for a genuinely 'human-centred information technology' (to quote sample [21]): to support human processes for mediating between information and knowledge, and to provide opportunities for managing information in the production of knowledge. A key condition is to unblock the multiple bottlenecks and open up free access and application of information. Learners can then perform at their best in dynamic episodes of actualisation.

### E. Technology in education 1: Blackboard, notebook, textbook

53. Looking back over history, our three oldest technologies in education are so familiar and commonplace that most people would not even call them 'technology' —the blackboard, the notebook, and the textbook (Cohen 1987; Hodas 1993). And they served the 'transmission of information' long before any such term was invented. Quite plausibly, these simple graphic media were introduced just when the content of education was starting its long-term move

from knowledge toward information by becoming more 'technical' —more abstract, formal, and theoretical— than the content of ordinary life.

54. When the 'lecture' was adopted for presenting such information, the blackboard handily served as the teacher's visual display and the notebook as the learner's memory bank. The information could be studied, memorised, and reproduced on a test, and then forgotten until some later need arose. These basic technologies may owe their long life-span to their instrumental role for direct and centralised control of the teacher over the discourse of education (Hodas 1993) (cf. ¶ 74).

55. Today, they might be described as bona-fide technological fossils that entail their own informational bottlenecks. Class time gets retarded by the brute-force operations of writing down words at whatever rate can be accommodated by the mechanics of the bodily movements of recognition and inscription. Legibility and orthography assume a vastly exaggerated importance, as if clear and regular handwriting were by themselves valid proof of good performance (cf. ¶ 83).

56. The textbook (or, in earlier manifestations, the scroll and the manuscript) offers an alternative technology for extending inscription and recognition beyond the classroom. This technology can control classroom procedures not just by setting the pace when read aloud, recited, or discussed, but, on a larger scale, by determining the content and design of lesson plans —what must be 'covered' in which sequence. The textbook reinforces the authority of education, and complements the teacher in sustaining centralised control —and so is rarely questioned or challenged. The textbook can also incorporate at least some new technologies for information transfer, such as colour graphics and complex charts and tables.

57. The bottlenecks here are of a different nature, this time reducing the information flow that arrives in the classroom at all. The textbook typically mediates a view of the field that is at least five years out of date, due to the phlegmatic pace of production, review, publication, and adoption, especially if, as is common practice, the textbook gets reprinted or cosmetically 'revised' for continued re-use. Moreover, the aspiring producer of a new textbook is usually pressured by publishers and their reviewers to include materials which were featured in earlier textbooks and to exclude conflicting or unfamiliar materials (cf. Beaugrande 1985; Lemke 1990).

58. A further bottleneck arises from the static, compartmentalised layout of most textbooks, which impedes a conversion into dynamic, integrative knowledge (cf. Venezky 1992). The subject-matter is arranged in conventional chapters and sections, as when textbooks on 'linguistics' conform to the standard sequence 'phonology – morphology – syntax – semantics', and offer no chapters on such

humanly relevant knowledge as discourse and communication in cultural life, or language variation as a key factor in educational success or failure.

59. Moreover, textbooks intensify the drive to convert the knowledge of a community (e.g. historians or lawyers) into information in the form of 'facts', 'figures', and 'correct answers' (cf. ¶ 21f, 28, 36). Consider this sample passage from a lower-division English-medium textbook used as part of the curriculum in Islamic law (Shari'ah) in the United Arab Emirates:

[23] The Babylonian Code of Hammurabi is the most complete collection of ancient laws yet discovered, and is one of the most important ancient codes of law. A stone slab with the code written on it was discovered in Susa, Iran, in 1901. Hammurabi was king of Babylon around 3750 years ago (from 1792 BC to 1750 BC). He reorganised the administration of justice and established an orderly arrangement of written laws. The Code of Hammurabi consisted of 282 laws. These laws were systematically arranged under such headings as family, labour, personal property, real estate, trade, and business.

The quiz on this passage contains these questions:

[23a] 1. When and where was the stone slab with the Code of Hammurabi on it discovered?

2. How long ago was Hammurabi ruler of Babylon?
3. For how many years was he king?
4. How many laws were there in the Code of Hammurabi?

These questions pick out specific bits of information which are patently irrelevant to a knowledge of legal tradition, but which enable a quick and easy division between right and wrong answers. Besides, the dates of Hammurabi's reign (given in Western, not Islamic, reckoning!) aren't facts at all, but pure conjectures.

60. Textbooks are also signally prone to impose the bottleneck of 'stylistic norms' deemed appropriate for discourses of information in educational settings (cf. ¶ 38, 43). This is all the more pronounced when the field itself consists mainly in managing discourses of information, as is the case with accounting. This field is defined by one widely used textbook as shown in sample [24]. Highly conspicuous here is the long, repetitious, and pedantic style, as in the sequences 'information - informed - information' and 'judgements and decisions', and in the gratuitous mention of 'users': who else could be meant, and what else should they be but 'informed' after getting all that 'information'? Perhaps the author wanted the style to suggest the sheer quantity and importance of the 'information' as motives for hiring accountants.

[24] Accounting is most widely defined as the process of identifying, measuring, and communicating economic information to permit informed judgements and decisions by users of the information.

As in sample [1], the style masks some inaccuracy in the information itself. Accountants do 'communicate information', but they can hardly be said to 'identify' and 'measure' it. And the 'information' is not just about 'economics' but about quite specific economic concerns, such as assets and losses. The definition would be more likely to generate knowledge in a rewriting like this:

[24a] Accounting consists of gathering, organising, and communicating economic information to users who need it for making sound decisions about their financial concerns.

To appreciate how far the academic discourses of information in textbooks can misrepresent information, consider this example from the same textbook:

[25] Net realisable value means the estimated amount that would be received from the sale of the asset less the estimated costs on its disposal. The term 'exit value' is often used as it is the amount receivable when an asset leaves the business. A very important factor affecting such a valuation is the conditions under which the assets are to be sold. To realise in a hurry would often mean accepting a very low price. Look at the sale prices received from stock in bankruptcies —usually very low figures. The standard way of approaching this problem is to value as though the realisation were 'in the normal course of business'. This is not capable of an absolutely precise meaning, as economic conditions change and the firm might never sell such an asset 'in the normal course of business'.

The difficulties of establishing an asset's net realisable value are similar to those of the replacement value method when similar assets are not being bought and sold in the marketplace. However, the problems are more severe as the units of service approach cannot be used, since that takes the seller's rather than the buyer's viewpoint. (194 words)

This passage purports to inform you of the 'meaning' of 'net realisable value', but leaves you uninformed. You are counselled to 'value' by assuming you are selling the asset 'in the normal course of business' and are not in any 'hurry', even though the asset might in fact 'never be sold' or else only under highly non-normal conditions such as 'bankruptcies'. Such a 'valuation' is purely hypothetical.

61. Moreover, you are restrained from following the buying price you would pay to 'replace' the asset, because you are in the role of a hypothetical seller, not a buyer, and you obviously cannot sell a used asset for the same price paid for a new one. This restriction gets oddly obscured in the final paragraph, which compares 'net realisable value' with 'replacement value'. Since the first of these two

'valuations' is the theme of the whole passage, the proximate reading would be that 'net realisable value' creates 'more severe problems'. But that reading would work only if the terms 'buyer' and 'seller' have been accidentally interchanged. The whole passage has prominently adopted the seller's viewpoint, whereas now the text says 'the seller's viewpoint' 'cannot be used'.

62. Sample [25] trenchantly illustrates how discourses of information get in their own way, even without a substantial proportion of technical terms. I also would point out the casual interchanging of terms for the same practical transaction: 'sale - disposal - exit - amount receivable - leaves the business - sold - realise - prices received - realisation - sell'. Several of these are unintentionally ironic, since the asset may never really 'leave the business.'

63. A counter-strategy for producing knowledge against the grain of such discourse would be *critical rewriting*, which I have demonstrated before (cf. ¶ 43). We might obtain:

[25a] Estimating the net realisable value or exit value is done by calculating the sum that would be left after selling an asset and subtracting the costs of the sale process. Because the conditions for selling can affect the price in unpredictable ways, as when stock gets quickly sold off after a bankruptcy, you can base your estimate on the value you would presumably receive selling the asset at a time when the business is operating normally.

Estimating the *replacement value* is done by calculating the sum that would be spent to actually buy the asset again. Problems naturally arise if the asset is currently not on the market. Also, you cannot calculate by units of service, which would be adopting the seller's viewpoint rather than the buyer's.

This streamlined rewriting (down from 194 to 127 words) introduces the distinct terms in italics and in parallel topic sentences of two paragraphs; and eliminates the redundant series of partial synonyms for 'selling' noted in [25]. We also dispense with the repetitions of 'net realisable value', 'estimated', 'low price/low figures', 'in the normal course of business'; and replace 'not being bought and sold in the marketplace' with 'currently not on the market'. Finally, we associate the 'problems' with the term where they seem more virulent.

64. That college-age learners can, with suitable training, do their own critical rewriting, was shown by my pilot course in Business English at the University of Botswana in 1997, where English is a second language after Setswana. During the initial training, I acted as a model critic and rewriter, presenting the samples, explaining the problems, and displaying my solutions. The learners soon understood the process, and some of their products were quite impressive. My student Modibedi chose sample [26] from the same textbook:

[26] We have seen that every transaction affects two items. If we want to show the effect of every transaction when we are doing our bookkeeping, we will have to show the effect of a transaction on each of the two items. For each transaction that means that a bookkeeping entry will have to be made to show an increase or decrease of that item. From there you will probably be able to see that the term 'double entry' bookkeeping is a good one, as each entry is made twice (double entry).

The original text leads up to the main concept of the 'double entry bookkeeping' in a verbose and patronising manner, e.g., repeating 'item' three times, 'entry' four times, and 'transaction' five times. Modibedi produced a radical revision, reducing 91 words to a mere 32:

[26a] The 'Double Entry System' is the basic system of modern bookkeeping by which each account has two sides, a debit side and a credit side, and each business deal is entered twice.

He adroitly moved the key term up into the strategic topic position of his sentence and highlighted it in upper case, so that the reader knows at once what is to be explained. He invested his own knowledge by replacing the terms 'increase' and 'decrease' with the correct bookkeeping terms 'credit' and 'debit'.

65. My student N!ko!ko chose a more global and challenging discourse on 'bad debts', again from the same textbook:

[27] With many businesses a large proportion, if not all, of the sales are on a credit basis. The business is therefore taking the risk that some of the customers may never pay for the goods sold to them on credit. This is a normal business risk and therefore bad debts as they are called are a normal business expense and must be charged as such when calculating the profit or loss account for the period.

When a debt is found to be bad, the debt as shown by the debtor's amount is worthless and must accordingly be eliminated as an asset account. This is done by crediting the debtor's account to cancel the asset and increasing the expenses account of bad debts by debiting it there. Sometimes, the debtor will have paid part of the debt, leaving the remainder to be written off as a bad debt. The total of the bad debts account is later transferred to the profit and loss account. (163 words)

N!ko!ko's rewriting, going from 163 words down to 106, read like this:

[27a] Many businesses sell a large proportion of their goods on credit, although it's a risk because some of the customers may never pay. The amount which is not paid at the end of a year is called bad debts. They are an expense and therefore must be charged to the Profit and Loss for the period.

When a debt is found to be bad, it must be removed as an asset. To do this, the debtor's account is credited and the bad debts account is debited. If the debtor has paid off part of the debt, the remainder will be written off as a bad debt. (106 words)

She vigorously trimmed away the patronising excess verbiage from [18]: 'for the goods sold to them on credit' (what else would they not 'pay for?'); 'as shown by the debtor's amount' (where else?); a 'bad debt' is 'worthless' (obviously); plus the entire last sentence about 'the profit and loss account', which just repeated what had been stated already. She also saw no point in including 'if not all', or in designating 'bad debts' twice over as a part of 'normal business'. Finally, the repetitions have been dramatically reduced: 'business' from 5 times to 1, and 'debt' from 7 times to 4.

66. If the conventional textbook is indeed a faulty technology, users need skill in adjusting and repairing it. And if authors resist adopting new strategies on the production side, then readers require counter-strategies for converting information into knowledge on the reception side. Critical rewriting, though not a new technology, is an innovative new use of an old technology to offset its bottleneck tendencies. The practice compels an integrative understanding of the content and thus supports knowledge, although the original author may have written carelessly or misleadingly. Far from treating the wording of the text as a mode of information in its own right (cf. ¶ 36), learners approach the wording as a potentially inefficient reflection of knowledge, and they take the initiative in improving it.

## F. Technology in the classroom 2: The 'teaching machines'

67. For most people, 'technology in education' is associated with the use of machines. The provision of this technology has been chiefly sporadic or adventitious, e.g., leaving geometry and literary studies with their notebooks and textbooks whilst giving physics and chemistry their 'laboratories'. And those 'labs' have been almost exclusively utilised for proving or disproving information whose status has long been decided in the field (Papert 1980: 139). Consistent, detailed policies for technology all across the curriculum were not even envisioned until recently, and in most places are still in their rudimentary stages. Meanwhile, some institutions evidently believe that just introducing technology will automatically solve their problems (cf. Hodas 1993; McKenzie 1994).

68. Back when prevailing theories of education were conceived in terms of highly general learning processes, as in orthodox behaviourism, technology was expected

to support or perform the basic operations of teaching and learning, independently of content. 'Teaching machines' were predicted to kick-start an 'industrial revolution in education', beginning with an 'apparatus which gives tests and scores and teaches' (Pressey 1926: 373; long-range surveys in Cuban 1986; Benjamin 1988). Pressey's machine, demonstrated at the Ohio State University, presented one from a set of multiple-choice questions inscribed on a rotating cylinder. If the learner chose the correct answer by depressing one of four keys, the drum would rotate to the next question. If all 'answers' were 'correct', the student would be rewarded with a piece of candy.

69. Though Pressey's primitive 'apparatus' did not become popular in ordinary schools, it dramatically illustrated the most literal mode of an 'industrial revolution in education'. Just as in the early factories, the dominant strategy was to fit the human to the machine, rather than vice-versa (cf. ¶ 8). Yet this time the human and the machine were interacting not to produce a tangible product, but to rehearse a behavioural pattern. In terms of sheer behaviour, the pattern was hardly one the learner would need to perform in real life, except to operate the ubiquitous vending machines that sell candy.

70. In terms of information transfer, the machine was far more primitive and restricted than the blackboard and notebook and imposed a far tighter informational bottleneck. Whereas those older technologies easily allow for multiple sets of information to be entered, altered, or revised, the machine could only handle a single set of brief questions and answers in any one session. The learner's performance was far more rudimentary than copying from blackboard into notebook, and no long-term record of the information was preserved. Nor could learners get any broader information about why a given answer is or is not 'correct'. The session could easily be conducted by simple trial and error—you press keys randomly until you get the right one—and without bothering to read or understand the questions and answers. Such technology fostered the 'deskilling' of learners, much as it had previously done for workers in industries (cf. ¶ 8, 37).

71. The concept of 'teaching machines' became a life-long advocacy of the doctrinaire behaviourist B.F. Skinner (e.g. 1958, 1961, 1963), who boldly foresaw them 'supplanting lectures, demonstrations, and textbooks' (1958: 69). Through an unconscious irony, when actually hired by Harcourt Brace Publishing Company to design such a machine, he drew its information from a printed textbook, thus reverting to an ancient technology he vowed to 'supplant'. In this case, it was a high school grammar textbook (published by Harcourt). Its contents were industriously rewritten into 2600 steps whose formats would be suitable for the clumsy technology of the time, namely for transferral to punched paper tape. But Skinner withdrew from the project in 1959, and—again through an

unconscious irony—Harcourt just published the 'programmed' materials in a textbook entitled *English 2600*, which sold over a million copies.

72. Radical behaviourism should find attractive analogies in the operation of machines. The basic model of the 'organism receiving a stimulus' and 'emitting a response' had originally been inspired by laboratory experiments on animal conditioning (cf. Skinner 1935, 1938), which neatly matched the mechanics of seeing a display and pushing a key. The animal was not explicitly 'taught' how to behave, e.g., how to run a maze and find the 'food reward'; the 'learning' was 'conditioned' and 'reinforced' through brute-force trial and error (cf. Thorndike 1911). When the same model was transferred from animals to humans (e.g. in Thorndike 1931), the resulting approach actively discouraged explicit teaching, such as giving information in discursive explanations. Instead, the whole process got broken down into minimal steps, each one centred on a brief, immediate event where stimulus and response were realised as question and answer. Again, information was transmitted largely by trial and error —another 'deskilled' operation imposed by the technology.

73. One mechanism unmistakably inspired a dominant model in behaviourist theory. The 'black box' was an electric circuit whose sole function was to receive an 'input' signal and to transmit a modified 'output' signal. The internal construction and operation were not specified for the user, who could not regulate or alter them anyway. By analogy, the behaviourist model envisioned an organism, whether an animal or a human, getting 'conditioned' by receiving a 'stimulus' and emitting a 'response' which gets either 'reinforced' or 'extinguished' as required by the 'learning objective' of 'habit formation'. This model made no reference to the inner operations; it merely addressed the link between input and output. The model implied a radical isolation both of the individual organism and of the single stimulus-response event. The organism was envisioned as an aboriginal blank slate, with no prior knowledge except whatever rudimentary 'habits' had already been established. The capabilities of the organism to acquire and apply knowledge were assessed at the absolute minimum; no prospects were envisioned for knowledge to be actively elaborated, integrated, or created. Nor do the 'habits' seem relevant to real life, where rats don't run mazes and humans don't press keys on brief, meaningless tasks.

74. These 'teaching machines' too did not become popular in ordinary schools, partly because the real machines of the 1950s and 1960s were still too awkwardly mechanical. Nonetheless, the idea of 'teaching machines' massively influenced education through the closely allied ideas of 'programmed instruction' or 'programmed learning' (Glaser 1965; Skinner 1968, 1986). These methods were modelled upon the 'step-by-step' programs of machines, but did not require real machines —or real proficiency in the operation of machines. The method was

supposedly 'automatic', but did not need automation; in return, the learners were deskilled by being treated much like automatons. As shown by the success of Harcourt's *English 2600*, materials expressly designed for a machine could readily be accepted just as a printed textbook. No new technology was introduced; the teachers could retain central control over the educational process without having to acquire new technological skills.

75. For the present discussion, the salient point is the reinforced breakdown of knowledge into bits of information. The steps in machine operation were kept small by the technology; the steps in 'programmed instruction' by the need for continual proofs that the teachers were dutifully 'delivering the programme' (cf. Hodas 1993). These bits of information were perhaps expected to generate knowledge by sheer accretion on the learners' part, who were once again left to their own devices (cf. ¶ 38). Improvements in small results could be easily shown, since the method handily generates favourable statistics across a large number of episodes. But in the long run, reviewers have concluded that programmed instruction has not lived up to expectations (cf. Schramm 1964; Kulik, Kulik, and Cohca 1980). Since then, it has been relegated to the status of a 'remedial tool' to supplement the process of traditional education (Mitra and Mitra 1996), which ironically points up its primitive qualities.

76. The advent of the 'computer' predictably inspired the next generation of teaching machines under the label of 'computer assisted instruction' ('CAI') (survey in Niemiec and Walberg 1987). At first, the technology was unaffordable for all but major institutions; widespread applications had to wait for the appearance of the small, fairly cheap personal computers ('PCs'). Yet this technology too was still primitive in ways not too dissimilar from Pressey's 'apparatus' described in ¶ 68ff. A PC with the minuscule memory spaces of those days and no hard disk at all must follow a linear sequence in a program hardly less rigid than his inscriptions fastened to a rotating cylinder. The learners could control only the rate of the presentation, but not the content, and could not contribute their own content or enter a discussion (Hodas 1993). The PC thus resembled an 'electronic page turning device' or a 'tutorial drill-and-practice machine' (Mitra and Mitra 1996). Most programs again adopted the 'multiple choice' format, where the learners first read a brief passage, then read a question (the stimulus), and press a single key to select an answer (the response). The learners were forcefully deskilled as readers and writers; they were compelled to process information superficially rather than process knowledge deeply, and had no motive to integrate and use it later (cf. ¶ 30, 37).

77. Especially in early stages, 'CAI' expanded beyond earlier teaching machines by drawing upon the conventional textbook. Most CAI materials were transposed from textbooks onto computers and rendered amenable to multiple-choice tests.

The only real refinement here was to enhance the complexity and flexibility of the machine's presentation, aided by colourful graphics and cheery icons. In one 'reading' programme I reviewed, the screen scrolled out a patently insipid story; periodically, the story text disappeared and the learner got a multiple-choice question about who had what for dinner, who lost and then found the dog, and other profoundly intellectual matters. The learner would type in just a single letter from A to D. A 'correct answer' was rewarded not by candy, but by a cartoon face of an ecstatically smiling female teacher. An 'incorrect answer' merely looped back and repeated the story, thereby inflicting a novel but no less effective punishment than being corrected by a teacher before a class.

78. Still, the PC of this era was in some ways a step forward from the technology of the blackboard. The presenting of information was far quicker and more plentiful and legible; and previous displays could be recovered without effort. But the PC was still a step backward from the notebook, which animates the learners to produce their own-written records for further use. As with Pressey's 'apparatus', the learner's 'response' was a single movement; other than the letters for the several choices, the keyboard was superfluous. Once the 'learning session' is over, all the data is lost; you don't even have a candy bar, only the fond memory of ecstatic cartoon smiles. So the PC of this era relaxed the informational bottleneck on the side of the machine but tightened it on the side of the learner, who was still fitted to the machine (cf. ¶ 8, 69).

### G. Technology in the classroom 3: The 'language laboratory'

79. The 1950s and 1960s also witnessed the introduction of 'teaching machines' in the popular 'language laboratory'. This technology was the first to gain widespread adoption. A heightened priority was allotted to education in 'foreign languages' during the global post-war situation of competing for economic markets and political influence; and substantial funding was provided.

80. Most of what had been formally presented in language teaching, both native and foreign, was information in the sense I have proposed here, and so had proven notoriously difficult to convert into the mode of knowledge sustained by skilled native speakers. The lab was hailed as the ideal means to shift the emphasis from talking *about* the language over to talking *in* the language. In tune with behaviourism, talking was conceived to be a mode of 'verbal behaviour', a set of 'habits' to be 'conditioned' and 'reinforced' (Skinner 1957; but compare Rivers 1964). The predominant 'audio-lingual method' (e.g. Brooks 1960) bore a portentous name which incorporated the 'audio' label from machines like

'audiotape' or 'audiovisual aids', and evoked an efficient mechanical linkage between hearing and speaking—etymologically, going straight from the ear to the tongue of the learner.

81. Whereas all other technologies, from blackboard to PC, were in visual media, the lab was in an acoustic medium. The standard equipment was a set of microphones and tape recorders wired for teachers and learners to 'monitor their performance' and exchange 'immediate feedback'. The major activity for learners was to imitate native speaker samples, which seems eerily reminiscent of trial and error. Some information was given on how to manipulate the vocal apparatus, but whether this is workable for naive learners whose phonetic habits do not include the target sounds has remained unclear. Normal articulation is not consciously manipulated, and efforts to do so may retard or distort the production of sounds (cf. MacNeilage 1980).

82. Because acoustic information is more linear than visual, still another informational bottleneck impended. The tape recorders of the 1950s and 1960s could only transmit and reproduce the acoustic traces of sounds without even distinguishing between fluent speech and pure noise. They resembled acoustic blackboards, except that—like the PCs of 'computer-assisted instruction'—they could contain much longer sequences of information, and could recapitulate a previous step with no trouble.

83. Repeating a whole sentence or conversation one hears on a tape does at least involve a more active use of the target language than just pressing a key. But the activity is still remote from real-life communication. The vastly exaggerated importance conferred on legibility and orthography in the blackboard and notebook era was now transferred to audibility and acoustic fidelity, as if clear and precise pronunciation were valid proof of deep knowledge of the language (cf. ¶ 55).

84. And again, the rote transfer of information has been restricted by sheer mechanics, this time of articulation rather than inscription. Articulation and pronunciation are not just the easiest aspects of language to regard as 'verbal behaviour' but also the most conducive for the drive of education to measure 'performance' in terms of 'correct' and 'incorrect'. The 'audio-lingual method' viewed the production of 'correct performance' as a mode of 'habit formation' modelled upon the pronunciation of fluent speakers. An unfortunate consequence has been the pressure upon teachers to be constantly 'correcting' the learners, even, or indeed especially, in the earliest stages of learning, when, in theory, the 'conditioning' of 'habits' is most vital. Yet the effort may be unwisely invested if the learners at that stage lack the ability to imitate the corrections they hear. Moreover, being 'corrected' tends to make the learners self-conscious, whereas, as I noted, normal articulation is not consciously manipulated (cf. ¶ 81).

85. So the demand for 'correct pronunciation' imposes an information bottleneck of a special kind. The technology of the language laboratory allows contact with a very small, closed set of recorded utterances, from which learners are expected to acquire competence in producing the very large and open set of fluent utterances in the target language. Yet the technology also tends to foster a slavish dependence upon the imitation of immediately accessible models, which is hardly likely to engender competence and confidence for unmodelled utterances. Besides, learners may be confused later on by listening to native speakers outside a classroom whose ordinary pronunciation is dramatically different from the resolutely standardised recordings of model speakers, especially where social or regional dialects are involved.

86. And imitation is in principle an unreliable method. The articulation of a foreign language is a complex act requiring a swift and precise interaction among numerous neural and muscular operations (e.g., tenseness, voicing, affrication) in co-ordination with the cognitive representation of an acoustic target (MacNeilage 1980). The language laboratory does not supply detailed information about these operations. It just presents their finished product in the articulation by native speakers, which carries a wealth of information non-native learners may fail to access. Learning proceeds inefficiently by trial and error, with errors being naturally generated by the prior set of habits from the native language.

87. No less complex —though less overtly so— are the operations of acoustic discrimination by a hearer of unfamiliar sounds. Again contending with a prior set of habits, learners who mispronounce the sounds of the foreign language can also mishear them. They obviously cannot command any advanced skills in acoustic discrimination for analysing the target performance. So they are almost forced to speak with an 'accent' that compromises by adopting or adapting some features of the target on top of their prior habits.

88. If the technology of the language laboratory imposes bottlenecks on information about pronunciation, it does so far more for 'grammar'. The complexity of grammar is of a fundamentally different kind from that of articulation, and is significantly more resistant to acquisition from imitation of a small set of samples. Outside the lab, learners are given information about 'grammar', yet grammar in communicative practice is a mode of knowledge. The information is focused on the needs of grammar-centred exercises in the lab, such as the 'pattern drill' which overtly treats grammar as a mode of observed behaviour. Such could hardly be more disparate from the use of grammar in real-life communication, so the frequent failure of learners to apply this practice during an actual conversation is only to be expected (cf. Met and Galloway 1992: 877).

89. Moreover, most samples represent what I propose to call *non-authentic language*, i.e., artificial constructions without any natural context (Beaugrande 2001a). Only authentic language manifests the delicate interactions between grammar and vocabulary that decide how fluent and idiomatic a speaker will sound. Children master the grammar of the native language through exposure to a huge set of authentic samples. How mastery can be achieved from exposure to a tiny set of non-authentic samples has never been explained; as far as I can see, the question has scarcely even been posed in earnest.

90. In order to achieve genuine learning and to compensate for the various informational bottlenecks, both the visual technology of the PC and the acoustic technology of language laboratory have implicitly depended on complex language processing by readers or listeners. Language demands a larger base of knowledge than does any other subject-matter. How to produce knowledge through conversion from the modest and measured doses of information, whether from textbooks, computers, or tapes is also among the most formidable challenges in modern education. So we should not be surprised if its success rates have consistently been disappointing.

## H. The advent of 'hypertechnology'

91. The foregoing sections might point to two conclusions. First, technology has always been present in one or another of the media to support the representation of information, with each medium implicating certain bottlenecks. Second, the later waves of more mechanised technologies like teaching machines, PCs, and language laboratories, have not removed the bottlenecks but have, on the contrary, implicated fresh bottlenecks, mainly due to the requirements of the machines that things should be represented in terms of 'codes' that are not processed the way humans process natural language (§ 34f).

92. Evidently, the introduction of technologies into education will not of itself necessarily bring about essential improvements if simply deployed to 'deliver' the same information with the same content and format as before (Lemke 1994; McKenzie 1994). Such a deployment may deliver bottlenecks too, and do little to bridge the pervasive gap between knowledge and information, or even to render the gap more perceptible.

93. A key question here would be whether the *technology itself* as distinct from the users of that technology can be properly said to *process knowledge* or even to *possess* it; or whether technology is in principle limited to information. This question is related to (though not identical with) the question of whether computers can



*understand natural language*, where a major problem might well be the division between information (which computers handle well) and knowledge (which they do not). I shall argue that technology can at least effectively support the communal production of knowledge and integration of the resources of cognition and information, provided some fundamentally new conceptions can be implemented in design and operation.

94. To make a fresh start in the new millennium, the term 'technology' might be withdrawn from educational planning for being overweighted by popular, historical, and institutional associations. A useful successor might be *hypertechnology*, though it does not appear in my data corpuses and only rarely on the Internet.<sup>1</sup> It can usefully link up with the term *hypertext*, which was coined by Nelson (1965) to describe 'an ongoing system of interconnecting documents'. The hypertext would provide access to the relations between any one text and the other texts to which it relates or refers. In turn, the term *hypermedia* 'expands the concept of hypertext to include other forms of digital information, e.g., graphic images, audio, video, and animation', and to 'present the material interactively' 'in response to the user's choices' (Ebersole 1997: 20; cf. Stebelman 1997).

95. Hypermedia offer a new potential for supporting the construction of elaborate configurations of knowledge and transcending the conventional bottlenecks in education I have described. Yet this potential may overload the user's processing capacities with a rising flood of multi-modal information and thereby create a 'hyper-bottleneck' (cf. Wright 1993). So hypertechnology should be designed and deployed to manage and channel itself in expressly cognitive modes (Turing, Hannemann, and Haake 1995; Ebersole 1997). Encouragingly, substantive research is under way relating 'hypertext' and 'hypermedia' to such concepts as 'cognition' (Shum 1990; Thuring, Hannemann, and Haake 1995; Rouet, Levonen, Dillon, and Spiro [eds.] 1996); 'cognitive processing' (Payne et al. 1993; Cho 1995); 'cognitive models' (Eklund 1995); 'cognitive mapping' (Beasley and Waugh 1995); 'knowledge construction' (Reed 1995); and 'knowledge representation' (Ayersman 1995). We can predict from such work that education will uncover new modes of 'cognitive flexibility' implicated in 'the nonlinear and multidimensional traversal of complex subject matter' (Spiro and Jehng 1990: 163).

96. Some authors have suggested that cognition itself is in some sense a hypermedium, or a complex of hypermedia, and as such differs from ordinary texts in being nonlinear and multidimensional (e.g. Nelson 1965). We might recall research in artificial intelligence and cognitive science proposing to model knowledge in terms of networks (e.g. A. Collins & Quillian 1969; Findler [ed.] 1979), including the knowledge underlying a text (Beaugrande 1980). Yet the examples and demonstrations were largely intuitive and considerably simplified

in comparison to actual cognition, particularly in isolating certain 'schema', 'frame' or 'script' from the rest of what a human presumably knows (Beaugrande 1982).

97. The linear and 'monodimensional' aspects of ordinary texts have probably been overestimated, also due to isolating the individual text. The cognitive representation of a text cannot be mainly linear beyond the 'shallow' stage of short-term memory (Beaugrande 1980; van Dijk and Kintsch 1983; Kintsch 1998). A topic concept forms a network of connections which expands and evolves each time the concept is expressed at any point within the sequence of words or sentences. The total representation of the 'textual world' could be visualised as an array of criss-crossing centripetal pathways of differing strengths and ranks (cf. Kintsch 1988).

98. One educational application of this research so far has been the 'cognitive maps' for helping learners to comprehend and organise the content of a text being read (e.g. Anderson and Huan 1989). The map is an informal visual representation of a rational way to block out topics and concepts. The question of whether or not it corresponds to the real or desired mental representation has not been answered, and may not be in the near future. The more relevant question is whether it proves useful to comprehension and to the construction of knowledge. Today, the notion of a 'map' is being reapplied for hypermedia (e.g. Barba 1993; Gaines and Shaw 1995).

99. Still less linear is *intertextuality*, a concept at the epicentre of 'post-modernism', a trend that anticipated the hypertext (McGann 1996). The processes of producing or receiving a text refer at least implicitly to many other texts which the same people have produced or received; this cross-reference is an essential precondition for an array of language to constitute a text at all, or to belong to a given text type, genre, or style (Beaugrande 1997). Any explicit training a person might have had in performing such processes can organise and elaborate the referrals, as can those occasions where a text responds to another text, e.g., by quoting it, answering it, or evaluating it.

100. Some text types or genres foreground their intertextuality, as when scientific or scholarly research papers or books refer abundantly to recognised sources (Lemke 1993). Indeed, the extent and range of these references may be interpreted as a measure of significance and validity, independently of the content. This factor points up the status of a science or field as a discourse community (Brown and Duguid 1995), with a strong bias toward published written discourse that has undergone favourable 'peer review' —itself a bottleneck with uncontrollable effects (Beaugrande 2001b). This bias is now being mollified by 'virtual publishing' on the Internet, but will persist as long as conventional hard-

copy publications count as the major evidence of professional achievement and recognition.

101. In a modified sense, a *library* is a site of intertextuality, insofar as it groups and arranges texts by a highly developed system (Lemke 1993). Yet resources like catalogues, abstracts, and citation indexes count as special 'meta-texts' that are not cohesive or coherent in normal modes, and are scanned only briefly and sporadically. As the library is being steadily digitised, it becomes a site of hypertextuality as well (McGann 1996); and its own in-house resources would be 'hyper-meta-texts'. The situation changes most significantly when the main texts are made available for electronic access. So far, the libraries implementing this technology have tended to reserve access for enrolled subscribers, but the trends to lift restrictions should eventually catch on here too (cf. ¶ 5)

102. Still, these precedents in intertextuality do not logically implicate hypertextuality. Without some compelling motive, few readers of a scientific research report actually run to the library to read the cited references. Now that technology offers us relatively effortless and immediate access from text to text, some novel considerations arise. Research reports are starting to replace their references with direct access to the source being referred to; and this possibility can significantly enhance the interest and relevance of citing references at all. The essentially monological status of the report can yield to a plurality of discourses and voices, and so heighten the solidarity and vitality of the research community.

103. But as far as I can see, the design of hypertexts does not yet take account of the distinction between information and knowledge. The ease, speed, and freedom of accessing information are obviously enhanced; but the construction of knowledge may well not be unless the technology is expressly designed to support it (cf. ¶ 92). The design should help to sustain both local and global coherence (Ebersole 1997). Increasing coherence can in turn 'facilitate the construction of semantic relations between information units' and 'minimise cognitive overhead', defined as 'the additional mental overhead required to create, name, and keep track of links' (Thuring, Hannemann, and Haake 1995: 61; Conklin 1986: 40).

104. In particular, the linked sources and references should exercise the function of enriching the discussion at appropriate points rather than such functions as intoning shibboleths, saluting prestigious colleagues, or invoking powerful figures, all of which have been common enough in research reports. The user or reader who has followed a hyperlink should be able to return to the main text without a break or disorientation. These requirements would call for some framing of the linked source, presumably by commentary given before the opening and after the ending. Such framing would be helpful for any further links leading out from the source.

105. For hypertexts to support knowledge, some incisive shifts are evidently pending in text design. The conventional 'introduction' or 'abstract' at the start of text is general and unfocussed, without regard for where the reader might be coming from. The 'conclusion' is mainly directed to the text itself, without regard for where the reader might be going next. Either these initial and final text segments should be redesigned by the author, or adjusted by the 'linker', or some balance of both, e.g., the author might provide a range of link sets to accommodate anticipated link types.

106. The hypertext also holds the potential to become its own intertext; i.e., to be a different text for various purposes. The main text could be a frame or scaffold with distinctively sorted links for respective audiences who differ in terms of their interests, fields, or degrees of specialisation. The labours performed in working out such a design should encourage the author to appreciate how much of the central content of the field can be better communicated in plain language than in the 'stylistic norms' illustrated above (¶ 38, 43). The same effect could be predicted for specialist readers who, perhaps surreptitiously, click over to the non-specialist versions for more reliable support in building up their knowledge.

107. A special aid for text design in writing can be derived from a promising mode of hypertext created by interfacing a word processor with a *concordancer*. The writer considering the use of a word or phrase can call up and inspect a set of authentic examples from a corpus. For example, I was wondering whether this mode of 'mode of hypertext' might be called 'propitious', 'auspicious', or 'promising'. Data from my several corpora displayed the first two choices used in old-fashioned discourse and only for (often ritual or historic) circumstances rather than objects or resources, whilst only the third appeared in discourses of technology and so was chosen:

circumstances were propitious to the designs of a usurper.  
when the hour was be propitious, Valentinian showed himself from a lofty tribunal;  
Darkness is propitious to cruelty, but it is likewise favourable to calumny and fiction

The northern climates are less propitious to the education of the silkworm;  
his predecessors had always remitted, in some auspicious circumstance of their reign,  
the public tribute  
under Rome's auspicious influence the fiercest barbarians were united by an equal  
government

Medals were struck with the customary vows for a long and auspicious reign;  
moderate, stable growth provides a more auspicious environment for adjustment  
than boom and bust.

using a mixed fidelity simulation approach appears to be promising

When a technical area is identified as promising, more extensive research will usually be required

However, the idea of materials being available on the web was recognized as promising

these methods seem like a promising framework for alternative tests which can reduce misspecification

Such data are helpful even when writers have some intuitive notion of usages, but far more so when, as is true of many non-natives, they do not.

108. The most effective and encompassing cognitive uses of hypertechnology in education could be achieved in a '*constructionist environment* where the children take charge of how they reflect on the educational opportunities they have had'; they can 'use the affordances of new media to make learning an active process' (Bobrow 1998). 'In constructivist approaches', 'learning is regarded as the formation of mental models or "constructs" of understanding by the learner' who 'actively builds knowledge based on previous understanding by dynamically interacting with the learning media'; so 'the learning medium must create the situation where the learner has the freedom to exercise judgement about what is to be learned and at what pace' (Eklund 1996). The role of 'constructivist teachers' is to 'nurture their students' natural curiosity'; 'encourage and accept student autonomy and initiative'; 'use raw data and primary sources, along with manipulative, interactive, and physical materials'; and 'encourage student inquiry by asking thoughtful, open-ended questions and encouraging students to ask questions of each other' (Brooks and Brooks 1993: 103-107).

109. In secondary education, one model project along these lines is 'Pueblo', a virtual village:

Pueblo is a text-based simulated environment that is a home for some 1500 people building a learning community together at Longview Elementary School, an inner city K-8 school in Phoenix, Arizona. [...] Pueblo is a dynamic on-line space that has reached out through the Internet to include families of the students, local college students, senior citizens, and people with severe disabilities who are physically confined to nursing homes. [...] The children [...] use their ability to build their own on-line games to work with the knowledge that they are learning in school. They build worlds that reflect the books they have been reading (Bobrow 1998).

110. In tertiary education, a 'comprehensive alternative paradigm' has been proposed by Lemke (1993):

1. *Components*. The basic learning environment for education should have three relatively independent, but loosely integrated components:

- *individual multimedia workstation interfaces* to global information resources and intelligent learning assistants, both human and computational, with some stable and some ad hoc networked communication groups for interaction and collaboration;

- *learning centers* for face-to-face individual and group interaction with peers, older and younger students, and specialist teachers and counsellors, where skills can be learned through use of specialized materials and equipment;

- *familiarisation visits*, and shorter and longer term *placements in real-world settings* to observe and participate in economic, technical, artistic, and recreational activities with adults.

2. *Integration*. The components of the learning environment should be coupled in multiple ways:

- Visits and placements should be prepared for by *individual computer-assisted learning* (ICAL); experiences during placements should give rise to interests and needs to know which are pursued by ICAL, and by peer and group discussions on-line and face-to-face.

- *Learning of specialized skills* in learning centres should be contextualized by theoretical knowledge and information gathered by ICAL, and by visits and placements in which the social contexts of use of these skills can be experienced.

- Explorations in the *cyberworld of global information access* should give rise to interests and needs to experience and discuss, which can be pursued on-line, at learning centers, and through visits and placements.

3. *Evaluation*

- Participants in such learning programs should periodically offer the results of their work for evaluation by a variety of criteria established by a variety of interested third parties.

- This work should be primarily in the form of multimedia presentations (hyperdocuments), including video records of their performance of technical skills and their participation in collaborative work and discussions in learning centre and placement environments.

- To the contents of this cumulative portfolio may be added evaluations and recommendations by others, at the discretion of the participant. The contents of the portfolio is at all times to be the private property of the participant and under his or her total and sole control.

Lemke's 'paradigm' resolutely addresses most of the problems I have aired respecting technology in education. Instead of fitting the learner to a primitive machine with sparse, closed, and mechanical tasks, it fits the hypertechnology to the learner with rich, open, and creative tasks. Instead of deskilling, the outcome

is reskilling, so that learners are empowered to interact with current but also future levels of hypertechnology.

### I. Back to the future

111. I have argued from multiple perspectives—social, economic, psychological, historical, and technological—that the most promising role of technology in education is to support the integrated, communal construction of knowledge rather than merely the episodic, competitive transmission of information. Only in this way can the several severe bottlenecks inherent in the educational process be effectively transcended.

112. In parallel, we must transform education to reconcile theory with practice if we are indeed committed to an enterprise of 'imparting or acquiring general knowledge and of developing the powers of reason or judgement' (§ 17). Education urgently needs to be recentred around discourse as an interactive process of knowledge construction, including explicit strategies for extracting knowledge from information, such as the 'critical rewriting' of discourses of information (§ 43, 60, 63). The 'educated person' is one who is skilled in this process, not one who has a large store of information withheld from the others. Such a person might achieve Gramsci's (1991 [1930]: 9) vision of a 'new stratum of intellectuals' through 'a critical elaboration of the intellectual activity that exists in everyone at a certain degree of development':

each man [...] is a 'philosopher', an artist, a man of taste, he participates in a particular conception of the world, has a sustained line of moral conduct, and therefore contributes to sustain a conception of the world or to modify it, that is, to bring into being new modes of thought.

### Notes

<sup>1</sup>. 'Searching 'hypertechnology' with AltaVista on the Internet in January 2000, I found just 54 websites, nearly all of them for businesses or games. By contrast, 'hypertext' returned 466,500 websites, and 'hypermedia' 97,920. These differences in frequency reflect the respective life spans of the terms in common usage.

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