Logical pages: revolutionising the use of print for teaching?

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Abstract

“Edutainment” publishers have begun to deploy an alternative to traditional physical artefacts such as videos, books and cartridges, namely “logical pages”, stored electronically and able to be selected from, to provide content in various physical forms, including multimedia, and to extend content using hypermedia coding such as SGML, to create Memex-like documents that include structural, presentational, and semantic data. Educational texts can be created using the paradigm of logical pages, which is notionally equivalent to treating a course as if it were a database of learning resources. In the case of a study text, those notional databases can contain more study guidance and raw information than conventional educational texts. Each user can select differently from the notional database, and post-process the retrieved information. Thus, some users can choose to view, on screen, a teaching text whose content and layout are identical to a conventional text, then can print a single copy, “on demand”. Other users can select other page layouts or content, then transform their selection to suit their individual learning style and learning needs. This paper considers the implications of logical pages for teachers and learners. As yet, there is relatively little research into the educational uses of logical pages, so the paper extrapolates from the literature on reading and writing physical pages and hypertext.

The time before logical pages

Until the advent of the Open University in 1969-70, print-led teaching, at home, was seen as a poor substitute for lecture-based courses. The OU showed what could be done, by providing mixed media courses combining TV, radio and print. Its print material was written to an academically high standard, but was presented in an open-learning style that was both innovative and accessible to people with no previous educational qualifications. The drawback was the cost of preparing such courses. They required far more preparation than was usual for lecture courses, partly because much effort was spent in integrating the use made of each medium. The OU model of course production was capital-intensive. Drafts of course material were refined over a period of months or years, by a team of authors. Pages were then laid out by professional designers, who made decisions on a page-by-page basis about the most effective layout for each
double-page spread. It was very expensive to make changes to those set-out pages, and quite impractical to provide students with multiple versions of teaching texts, suitable for different learning styles or different learning needs. The whole process was labour-intensive and required mass production to be cost-effective. Luckily, economies of scale were possible, particularly in those subject areas with a slow rate of change, so that a course could be presented unchanged from one year to the next. With such courses, several years' stocks of course material could be produced in the first year for far less than the cost of printing new material each year. This cut the cost of courses considerably.

Since that time, the cost-basis of courses has changed dramatically, and so has the context of courses. There is a general trend in education towards individual exploration, cognitive apprenticeship, team learning and mentoring (Reinhardt, 1995), as part of a societal trend towards rapid change, individualisation and increased competition (Peters, 1994).

Regarding change, educational institutions now have many courses whose contents have to be created quickly, and which change from one presentation to the next; this is made possible, but neither easy nor cheap, by computer-based technologies such as desk-top publishing and on-demand printing.

Regarding individualisation, institutions also have increasing numbers of students who require some way to personalise the content and goals of their courses. Here, too, computer-based technologies play a part, eg, by providing students with copies of their texts on disk, in an editable form.

Finally, regarding competition, there has been a huge drop in the “entry cost” of the technologies required to create and deliver high-quality open learning. As a result, many institutions now offer open learning courses. Of late, such courses have to compete with “edutainment”, that is, education repackaged as entertainment which, some people feel, can lead to deeper learning than conventional education. Thus, “Research shows that what many students learn in higher education does not match the ideals of a deep approach to learning. Edutainment provides the potential to help reverse this. This format gives the opportunity for the creative engagement of the user with tools that facilitate the process of association and exploration, features critical to meaningful learning and the maintenance of the user's attention.” (Morgan and Sinclair, 1995).

The trends of rapid change and greater competition are made more evident by the increasing use of telecommunications to deliver courses, on demand, from suppliers who may be a continent away, and who may have lower costs.

Bearing these trends in mind, British Telecom’s research director, Peter Cochrane, is reported as saying in an address to a UK higher education seminar in 1994 that, ‘The technology that will take you all out [make universities redundant] is already here’ (Plant, 1995). There are certainly signs of the increasing accessibility of that technology to students, and the inaccessibility of that technology to colleges. For example, some students now own (slow) colour printers, which allow them to incorporate colour graphics in their writing, or to print out colour illustrations from CD-ROMs and books supplied electronically. By contrast, and ironically, today’s open learning texts make very little use of colour. This is because, as yet, there are no low-cost, high-speed, colour printers, suitable for the short runs associated with today’s low-
enrolment courses; traditional colour printing processes are economic only for the print runs of thousands that used to be associated with open learning courses.

Cochrane’s analysis assumes the existence of usable links between information providers (who include publishers as well as colleges) and the mass of consumers. Those links are becoming a reality, as a result of a convergence of computers and telecommunications, driven partly by major media publishers and entertainment groups. Some of those groups (eg, MicroSoft) are entering into partnerships with prominent institutions (eg, the National Gallery, the Smithsonian), as a means of transforming their books and audiovisual resources into edutainment. Such partnerships exist already for technical subjects such as computer networking, in which universities (eg, Sheffield) now run industry-certified professional and post-graduate courses, with curricula determined by leading vendors (eg, Novell).

Edutainment is generally expected to become a valid part of university-level education over the next decade. The enabling technologies proposed for widespread distribution of edutainment are:

- narrow-band and broad-band communications, for delivery of material to users, on-demand. Similar communication systems can be used to link an electronic campus, with links from students to tutors, other students, course documents and libraries.

- the “logical” page, which provides “the ability to deliver content in any form that the consumer wants” (Yunich, quoted in Batelle, 1995) and facilitates re-use and rapid assembly of content for new purposes.

The logical page
At one time, the dominant paradigm in word processing and desk top publishing was “WYSIWYG”


In a way, printed books are also an example of WYSIWYG, in the sense that books contain no explicit information, beyond what is apparent in the form of the words and layout of the pages. We can deduce structural relationships between elements in the book, by looking at its typography and its other access devices. However, it is only when the book is available in electronic form and the structural relationships are made explicit, that it becomes possible to process and analyse the content in ways not anticipated by the author. This is not just a philosophical point. For example, learners can gain much through a systematic comparison of the way in which a topic is discussed in several books. Learners have always been able to make such a comparison manually (ie, by making notes as they read). They can carry out the same comparison far faster and far more effectively if they have some computer assistance. This is recognised in edutainment products such as encyclopaedias and CD-based book collections.

Universities are often rather slow to adopt new technologies. Perhaps, therefore, it is understandable that university libraries are only now beginning to experiment with WYSIWYG, in the form of electronic images of pictures of pages from books. In those experiments, books are scanned on a document processing system, which saves each page as a WYSIWYG image, available for viewing on a student’s screen. The body of the text is not available electronically, although the document processing system carries
out some limited optical character recognition on each page. This OCR provides a few key words, which are sufficient to allow rapid access to a particular page image. If the student wishes to take a copy of part of a page (e.g., to include in an essay), this is possible through an electronic form of photocopying.

Many teachers and librarians consider that WYSIWYG images of books are sufficient. In my opinion, they should be considering providing access via telecommunications links to full, computer-searchable versions of books, plus reviews of those books. This can be done easily, as far as technology is concerned, by using the impending replacement for WYSIWYG, namely the logical pages paradigm:

What you see is NOT ALL YOU CAN GET.

There is as yet no generally agreed definition of a logical page, nor any agreed industry standard. My own working definition of a logical page is an electronically-stored page that contains more information than is seen by the user at any one time, and which can be rendered (made available to the user) in various physical forms (including WYSIWYG images of books, if they are needed). Conceptually, therefore, a “logical pages” document is closer to a database, from which selections are made according to the needs of the user.

- A small part of the information in that notional database is commercial, to allow for the exercise of publishers’ rights to charge for access to certain material and to help them to protect authors and other copyright holders against theft and reimburse them for legitimate use.

- Most of the information in the notional database is concerned with content. One analogy would be a World-Wide Web page, with links to many sources of related information. Another analogy would be the “full” versions of films now available on digital disk, which can include not only a full version of the commercial release of a film (or a “Director’s Cut” of the film), but also background material such as scripts, reviews and even “cutting room floor” material, left out of the final copy of the film.

- The remainder of the information is structural, so that relationships between elements of the document can be made explicit. This structural information is analogous to the use of Standard Generalised Markup Language, SGML, for mark-up of conventional texts. The kind of HyperText Mark-up Language that is most appropriate for logical pages is a topic under active research. Hendry (1995) sets out some possibilities, based upon a formalism called Entity-Relationship Modelling for Information Artefacts (ERMIA) (Green, 1991).

In passing, although I used film as an analogy, above, it is possible to apply the logical page paradigm to non-textual material, such as a videotape or a multimedia presentation, both of which can be characterised using ERMIA, as well as in terms of the (filmic) structure intended by their creators.

Here, I shall consider examples of textual documents only, and more specifically, examples in which the author had definite intentions in mind, in determining the structure of the document.

As with SGML documents, the relationships in a logical page can be manipulated by software to allow users to choose between printed or transformed versions of the
document. Printed versions retain their original layout, and can be mass produced or printed as single copies, “on demand”, by or for a student. Transformed versions have their layout and/or content altered, by or for a student, to suit other media or particular learning styles or learning needs. Both printed and transformed versions can be copied from, in an electronic form (eg, for quotations in essays, or for discussion in a computer conference).

The implications of logical pages for teachers, learners and educational institutions

Writing for the logical page
I shall consider the actual writing process later in this paper, in the context of writing by students. Here, I shall assume that teachers are competent writers, with two concerns:

- how to make a conventionally-written document, designed to be printed on paper (a hard copy version), into a version that can be studied from a screen and searched electronically (an electronic copy).
- how a conventionally-written document could be modified to suit the changing needs of a student, or the needs of a quite different user.

Considering the first of those concerns, the technology of logical pages is still too new for there to be commercial “logical” tools for authors. Ideally, authors would be able to use a new menu in their favourite word processor, which provides rhetorical mark-up, automatically. Here, automatic means that the program would infer the author’s original structuring intentions from the layout of the original document (here, assumed to be a printed document). It would then add its own mark-up instructions, to preserve those structuring intentions on another medium (say, a screen). Currently, automatic rhetorical mark-up of an existing document is not a reliable process, so authors would have to do much or even all of the mark-up by hand, using a conventional mark-up language such as SGML. This task becomes far easier if the document is being created, rather than being edited from an existing document. In the new document case, much or all of the mark-up can be added painlessly if the author creates the document using a program that imposes structure on a text, such as an outliner or More (Symantec Corporation) or Inspiration (Inspiration Software).

In the absence of rhetorical mark-up, it is likely that breakdowns will occur in writing intentions, if readers access the material using a different medium from the author. Hendry (1995) describes a number of examples of this. The examples all involve documents designed to be printed out (as hard copy). Each document is mis-formatted in significant ways when it is used without modification in an interactive computing system (ie, as electronic copy). He suggests that, pending the appearance of robust commercial “logical word processing” tools, or rhetorical mark-up systems, such documents will need to be written or revised using a new form of writing, multiform writing. This refers to “the activity of preparing a single source file that is to be deployed in several forms, including, for example, in print and in an interactive computing system”. Hendry goes on to suggest that, without such computer help, multiform writing will be much more complex than writing for a single audience. This is because,
“instead of attending to the properties of a single [presentational] form, writers must juggle the constraints of two output forms when making design and writing trade-offs. The likelihood that people will continue to use hard copy and electronic copy selectively, together with the need for organisations to strive for cost-effectiveness, necessitates this kind of writing.”

The need for multiform writing should reduce substantially, as commercial tools emerge for logical word processing. However, by analogy with the development and take-up of SGML, it may be a decade before there is widespread use of rhetorical mark-up in educational institutions (as distinct from commercial organisations, with a higher incentive to innovate and to exploit their intellectual property).

Turning now to my second concern, how might a conventionally-written document be modified to suit the changing needs of a student, or the needs of a quite different user? This can be done by filling the notional database associated with the logical page paradigm. Put more concretely, this means adding the three types of information mentioned above:

- **commercial information about copyrights**, etc.
- **explicit structural mark-up information**, required to generate layouts with any desired combination of structural elements, from headings to lists, tables, key terms, marginal notes and self-assessment questions. This is analogous to creating display templates in SGML, involving different sets of structural elements, via what are termed Document Type Descriptions (DTD). One display template would display the original content of pages in the conventionally-written document. A series of additional templates could be created for common needs such as Gaining an initial overview, or Revising, as well as group-specific needs such as layouts for older readers or visually-impaired readers (Hartley, 1994). As with SGML, it is reasonable to expect the development of a mark-up for pre-designed templates and DTDs. Those templates could hide or emphasise certain kinds of structural elements (and hence hide or emphasise certain kinds of information). They could also be part of an interface design (an on-screen page layout) which determines how a user can obtain access to information that is not being displayed in full or at all. That interface might be in the style of hypertext links or World Wide Web pages.

- **additional content information**, required to support the inquisitive student or the student who needs additional support. Each new content item would need to be characterised, either explicitly (using structural tagging) or implicitly (eg, by specifying a relationship between the new item and the information in the original page; see Parkes, 1995). Display templates could have content-specific and user-specific elements, which determine more precisely what information in the document is made available, to whom, and on what basis (eg, view only; view and copy; view and edit).

**Reading from the logical page**
The logical page paradigm does not require users to express a preference for a particular physical expression of the information stored in a logical form. However, according to Waterworth and Chignell (1991), some people prefer printed books (hard copy) for comprehensive reading (studying an unfamiliar topic or one that must be learned in depth), but prefer a screen-based version for information retrieval (typically, involving a limited amount of reading, and in which you know what kind of information will help).
Another desirable feature of a conventional book or course text is that it provides an explicitly authored linear structure, often with clear dependencies between units of material such as definitions and examples. This is absent or fragmented in most hypertext and hypermedia systems, with the result that learners may be unable to perceive or appreciate the author’s argument (Whalley, 1993). It is important to minimise this fragmentation of domain knowledge. This minimisation happens automatically in a logical page system, whenever use is made of its rhetorical mark-up information.

In principle, it would be possible to use rhetorical mark-up information to overcome common problems in printed teaching texts, such as the trade-off between minimising their length and making sections completely modular and self-contained, at the cost of some redundancy (duplication of information across sections).

In principle, again, it would be possible to use mark-up information to create a hypertext version of a “logical pages” document (e.g., O’Brian Holt and Howell, 1992). This would simultaneously minimise fragmentation of domain knowledge (in the way that a book does) and also serve the object of traditional hypertext, which is to:

“…represent a body of knowledge in a form that captures all the inherent interlinks in the information. Readers can then peruse the information, following the links of their choice… the duty of a good author is to cut links so that, to a beginner, the information appears to have a simple hierarchical structure - the backbone - with a few cross-reference links that cut across the hierarchy. Only more advanced readers need be presented with a full gamut of cross-reference links. This view holds, incidentally, independent of whether the material is presented on paper or via hypertext.” (Brown, 1989: 91)

Some problems encountered by learners who use hypertext and hypermedia are attributed to fragmentation of domain knowledge, but may arise from a poor choice of a way to represent the domain or topic of interest, or are problems of a general nature that may “manifest themselves in different ways that are sensitive to the representation being used” (Parkes, 1995).

Parkes points out that the usefulness of a given representation depends on the nature of the tasks being carried out (VanLehn, 1992), and/or the questions that the student is required to answer with (or from) that representation, as is to be expected if we consider the situational dependence of representations. Situational dependence is generally discussed in terms of the situated learning model, with its key components of apprenticeship, collaboration, reflection, coaching, multiple practice and articulation (e.g., Brown and DuGuïd, 1994; McLellan, 1994). As pointed out by Jonassen et al (1994), this leads to the insight that “the more important debate is not about the relative efficacy of instructional components as much as it is the role of [the] learner and the context of learning”. This is relevant to what the reader / learner directly apprehends (Gibson, 1979, 1987): “what we perceive when we look at objects are their affordances [ie, their properties taken with reference to the observer], not their qualities” (Gibson 1979, p. 134). According to Gibson, an affordance is “neither an objective property nor a subjective property; or it is both if you like. . . It is equally a fact of the environment and a fact of behaviour” (Ibid, p 129).
The logical pages paradigm gives readers a choice about at least the “affordances” part of their learning environment, and also may help to facilitate discovery learning, unlike many of today’s designs for instructional environments (Markle, 1992). This is important, because:

“The environment in which learning occurs affects the experiences of the learner and therefore defines the content of the knowledge constructed… Not only does media come into question from this perspective, but also the role of deterministic, interventionist instructional methods.” (Jonassen et al 1994: 31-32)

Concerning the usefulness of specific representations of content, Landauer (1991) reports that students who used a screen-based system, SuperBook, to find information, wrote better essays than students who used hard copy. The relevant factor in that performance difference, according to Landauer, was the fact that SuperBook highlights target search words, so students were encouraged to focus on key parts of a section. In SuperBook, users typically find what they want by first carrying out a full-text search; the results of the search, in terms of frequency of hits, are posted in the table of contents on a per section basis; the SuperBook software emphasises sections with high hit rates, and so helps users to choose relevant material.

Hendry (1995) conjectures that studying could become more strategic in a logical page system, because readers can see the roles that text elements are meant to play and the relations among text elements, and so make more informed decisions about what sections to read and in what order. This could solve perennial problems affecting hypertext users, to do with navigation, accessing information, integrating information into knowledge structures (via accretion, restructuring and tuning of a user’s schemas), synthesising information, cognitive overhead and hypertext processing strategies (Jonassen, 1992). One solution is to provide rhetorical structure information, which:

“informs readers of the dependencies between units of material, something that is crucial in electronic copy where the tactile affordances of a book do not exist… [Also, it] creates opportunities for readers to customise their views of documents. For instance, readers could… list all examples… and then pursue examples that seem relevant to their goals. These scenarios for flexible access are only possible if the rhetorical roles of the text elements are specified…” (Hendry, 1995: 90-91)

It seems plausible that, by being explicit about the rhetorical roles of elements in a document, it is possible to go further, and develop “logical page” views of documents that support all paradigmatic cases of information exploration. A number of these have been identified by Waterworth and Chignell (1991). The most pertinent are: navigational browsing, navigational querying, mediated browsing, and mediated querying. These are consistent with a more general model of information seeking, described in their paper, which encompasses six component activities: starting (eg., looking for key references to provide the right orientation to a search); chaining (following referential connection between material); browsing; differentiation (eg, identifying paths worth exploring, using criteria such as the status of an author or information source); monitoring (eg, highlighting changes to the document, since its last edition); extracting (eg, viewing the full version of a document being cited); and evaluating (eg, curtailing a search, or changing its direction, in response to the nature of the information discovered up to that point).
There is a considerable body of research on differences between the learning styles of users, (see Jonassen and Grabowski, 1993). That research is relevant both to printed texts and to hypermedia. By way of illustration, it was drawn upon in a recent study by Esichaikul et al. (1994), which suggests that rhetorically-unstructured hypermedia presents problems to people who are divergers on the Kolb model of experiential learning. Esichaikul et al. claim that this is because divergers are reflectors rather than experimenters, in terms of the Kolb model; their recommendation is to provide encouragement to divergers, to motivate them to explore the contents of the system.

Clearly, since users do differ in learning styles, it is desirable to offer them as much control as possible regarding the form and content of their material, whether it is delivered in print or on screen. In principle, material that is coded using SGML tagging can be printed out (or rendered on screen) in any desired fonts, type-sizes, line-lengths, margins, etc. As stated previously, this requires someone to create display templates, via Document Type Descriptions. Those templates correspond to Hendry’s (1995) proposed templates to support “scenarios for flexible access”. As suggested by Thomas Anderson, they can be extended so that...

“...perhaps students can opt to design their own specialised textbooks by choosing not only their preferred type-faces and type-sizes but also choosing between, for example, 1) inserted questions or not; 2) summaries listed before or after the chapter prose; 3) concept maps or outlines; 4) embedded or marginal headings; 5) headings written as statements or questions; 6) only specific chapters from the ones available. These choices would depend on the use that was to be made of the textbook. In other words, Anderson suggests that the future directions of textbook design may be more under the control of the readers rather than the authors. Research in textbook design may never answer the question “Which type-face/type-size/line-length is best?” for every individual occasion, but it may allow us to present readers of the future with an appropriate menu from which to choose.” (Anderson, quoted in Hartley, 1996, forthcoming)

This begs some important questions, concerning who creates the menus and who constructs the associated templates. I envisage the emergence of a limited range of “layout wizards”, within major word processing programs, to help users to design a textbook to suit their particular needs. Those wizards are likely to be of the type popularised by MicroSoft to assist with the layout of charts and tables. Ideally, they would take into account findings from research on learning styles, and would support special needs such as the needs of the visually handicapped.

Writing derived from the logical page by students
My interest here is in how students who are writing essays can make use of the information stored in a “logical pages” document. This involves consideration of technical issues (eg, compatibility of word processor file formats) and cognitive and social issues (eg, what determines the success of writers working individually or in groups, as they try to generate ideas, organise and draft them, annotate and revise their work, then proof-read it). It also requires consideration of values:
“In electronic or desk-top publishing the writer, copy-editor, typesetter, designer and proof-reader are often the same person. Achieving the exacting training desirable for expertise in each of these functions is daunting if not impossible. In such circumstances, the goal of gaining any of the three Olympic medal standards of publication recedes. It will be a challenge to those involved in books to take present publication values into the new environments.” (Dorner, 1992)

Dorner goes on to alert us to the dangers of taking for granted the ease with which we can store published information in a computer and retrieve it in small usable units, since other writers could manipulate them differently to give different conclusions:

“Why bother to put pieces of information into a coherent logical structure when one effect of this is to give users the trouble of picking them out again? Why not put the pieces of information — let us call them info-bricks — into the computer as they stand, clearly labelled according to an international standard? … Electronic stores of knowledge, unless used purely as masters from which conventional documents are produced on demand, are likely to accelerate the process of fragmentation. With less need or incentive to write books or articles, there is less motivation to think, and to structure thought, coherently and logically, or to develop an argument. The nature and concept of authorship and of creative writing are under challenge.” (Line, 1986)

From a cognitive perspective, the nature of creative writing, whether by a lone author or a group, is generally discussed in terms of processes in writing (eg, Galbraith, 1992; Rimmershaw, 1992; Hartley, 1993; Kraut et al, 1992).

Thus, Hayes and Flower (1980) consider three main processes, which Hartley (1993) describes thus:

“planning (generating the content, organising it, setting up goals and procedures); translating (the physical act of expressing the content of the planning); reviewing (evaluating what has been written or planned). Reviewing often (but not invariably) leads to revision at both global and molecular levels. Hayes and Flower are at pains to point out that (a) writing is a hierarchically-organised, goal-directed, problem-solving process and (b) although it consists of the three main processes described above, these processes do not occur in any fixed order.” (Hartley, 1993: 23)

Programs of sorts exist to support each of the processes (see Hartley, 1993), although computer-aided writing is still in its infancy, especially as regards planning and organising. Bearing this in mind, students can still gain some benefit from using a “logical pages” document, in the sense that it is particularly easy for them to extract the information stored in such a document.

Suppose, then, that a student has extracted a significant amount of such information, in preparation for writing an essay. This may well be sufficient to satisfy most of the need for “generating the content”, which is the first part of Hayes and Flower’s planning process, above. However, sheer quantity of information is not enough. How can we help the student to organise the information and set up goals, let alone successfully negotiate the processes of translating and reviewing? To put this another way, how can we help the student to avoid treating the extracted information as “info-bricks” (Line, 1986), and hence assembling them without thought, in an unstructured, incoherent or illogical way?

Two possibilities suggest themselves immediately:
It is possible to emphasise the original author’s rhetorical structure, so that it is perceived more readily by the student. One way in which this can be done is by creating the equivalent of an “Information Mapping” view of the original document, or of the information selected from that document (Horn, 1982).

The extraction process itself can be designed to convert some or all of the original rhetorical structure into a form that can be used in an outliner or word processor (Kember, 1992). The student can then build upon that “expert” structure, in accordance with the notions of apprenticeship, reflection and articulation, contained in the situated learning model alluded to earlier.

Concluding remarks
Will logical pages truly revolutionise the use of print for teaching, to return to the title of this paper? I believe that they will, over the coming decades. Logical pages provide a way to secure the future of printed pages in education, even when publishing “…is no longer a river in its own right, but is just a current in the digital ocean. Once we drop the idea of discretely bound and sold sheaves of glossily processed wood pulp from the model, what do we have left? Anything useful? From the reader’s point of view, it’s useful in much the same way that a paper magazine is: it’s a concentration of the sort of stuff she’s interested in, in a form that’s easy to locate, with the added advantage that it will be able to point seamlessly at all kinds of related material in a way that a paper magazine cannot.” (Adams, 1995)

In this relatively short paper, I have set out a partial agenda for strategists in educational institutions. For example, it seems clear that they should take seriously the growing shift of power, from traditional providers of education, to publishers and media organisations. Similarly, they should investigate, as a matter of urgency, the kinds of technological “edge” that derive from the use of “logical pages” by publishers, who are achieving faster and deeper exploitation of their existing material, and faster and deeper exploitation of material provided by their collaborators, some of whom include universities.

I have also set out an agenda for researchers in a number of disciplines, straddled by educational technology, from the social sciences to computer science and information technology.

Even so, I have hardly touched upon issues that could become of crucial importance to traditional providers of education, such as the claim by Plant (1995) that digital developments of the kind I have outlined are challenging the education system itself, by challenging various assumptions. These include assumptions about “the mediating role of the teacher and the efficacy of specialisation… [assumptions that] the goals of education are always known in advance, and that the best route to those goals is a well-planned curriculum… [and that an educational institution’s] ability to control access to knowledge and information is no longer guaranteed. It can no longer dictate the means and ends of education.”

Even if this is true, I am convinced that people will need help for the foreseeable future in making sense of that knowledge and information, and so making it their own. Reading and writing will be key elements in this. As educationalists, we have a
powerful tool to develop reading and writing for the future, in the form of the paradigm of logical pages.

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