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Reviewing the Practical Integration of the Web with Distance Education

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Abstract

In this discourse the traditional benefits of distance teaching and learning in higher education are revisited, with a particular emphasis on how the Internet and the World Wide Web (the 'Web') aids in further promoting these benefits and others, and suggests how the Web may thereby be integrated into such education. The relationship of the Internet and the Web is compared with proprietary methods, such as dedicated satellite links or private computer networks using commercial groupware such as First Class or Notes, thus supporting the moves being made towards integrating these methods into the Internet and Web. Existing distance activity on the Web is surveyed. As well as issues of evident poor Web page design, the need to reinforce pedagogical principles are raised even though the Web is shown to lend itself to student centred learning. Technical and copyright security obstacles are identified that at present fundamentally inhibit distance education programmes that are fully integrated with the Web. The technical obstacles essentially revolve around bandwidth, navigation, HTML and Java. Prolog, as well as user-friendly toolkits, offers potential solutions though not without further development. Given all these fundamental limitations, the discourse suggests a partial, or hybrid, integration of traditional distance teaching and learning with the Web in higher education. The discourse nonetheless anticipates that the obstacles will be resolved, and therefore recommends the adoption of a hybrid approach with the proviso that the distance education programme is principled so that it accommodates both the issues raised and can be updated towards a fully integrated programme as the obstacles are resolved.

Introduction

Within higher education, distance learning enables a wider sphere of our population to obtain an educational experience at a degree or diploma level. Studying through distance learning programmes allows the student to plan his or her study time around commitments at home or work, as well as an improved flexibility to indulge in leisure activities. The student can thus study at a time, place or pace to suit his or her lifestyle and, since the student is not physically required to attend university or college on specific days, the student can negotiate study leave with his or her employer or colleagues to take advantage of less busy periods at work.

Distance learning also enables the student to choose subjects at degree or diploma level for which the expertise cannot be provided effectively at that student's local university sector institution. Likewise the institution, unconstrained by geographical boundaries, can economically run courses due to a sufficiently widened student market.

As supported by major proponents of distance education, such as Parer and Henri (1993), Kember and Murphy (1994), and Rowntree (1994), distance learning's success is being successfully augmented by practical developments in computer technology,

particularly in multimedia and networking. These benefits are specifically demonstrated in the examples given by Reinhardt (1995).

Accordingly this discourse extends the initial work reported by Polovina (1995), which addressed the extent to which the World Wide Web, the multimedia-based facet of the global network of networks known as the Internet, benefits distance education. This discourse examines Polovina's work in greater detail, brings it up to date, and suggests how the Web, the shortened term for World Wide Web, might be integrated into distance education programmes.

The Use of the Internet in Distance Education

Unlike costly telephone conversations or dedicated satellite links, the widespread availability of the virtually no-cost Internet paves the way to allow more educational institutions to provide distance education at affordable costs for both the institution and the student. Halfhill (1996,page 70) states the following about users not connected to the Internet:

> "They're cut off from the convenience of email, isolated from the community of newsgroups, and excluded from what are fast becoming the world's largest and most accessible libraries of human knowledge. Soon, a computer that has no access to network resources will seem like a disembodied brain in a jar."

Kellogg and Viehland (1995) reason that the Internet is unlikely to be yet another instance of the latest hype in a long history of overblown expectations about the potential of technology to address educational challenges; they state that the Internet's infrastructure enables a real world of active participants, and it supports and engages us as human beings and global citizens.

Kellogg and Viehland's editorial also highlighted that as of January 1995 the Internet, the 'Information Superhighway', consisted of 4.8 million interconnected computers with untold millions of users potentially having access through networks attached to these hosts. As of July 1996 the figure for interconnected computers was 12.9 million. The latest figures can be obtained from the Web itself via the Uniform Resource Locator (URL) reference `http://www.nw.com` (For the sake of simplicity, future references to Web sources will ignore the `http://` part, thus `http://www.nw.com` would simply be referred to as `www.nw.com`).

Despite the fact that 'untold millions' still represents only a very small proportion of the world's population, Negroponte (1995a) echoes the widespread view that this proportion will increase significantly when he described the Internet as 'bigger than the invention of the printing press'. We can therefore expect that the Internet will feature significantly in any meaningful distance learning strategy.

The Web Factor

The Web, through its emphasis on the human-computer interface, is the major force that is driving this increase in the proportion of Internet users. The Web is also extending the Internet into a global means of multi-way communication in real time. Thus the established advantage of classroom style interactivity becomes present, unlike prevailing distance learning methods based on one-way media such as television, video, radio, audiocassette, or even multimedia compact disc (CD-ROM, CD-i).

Whalley (1995) underpins the inflexibility of CD-ROM and, by extension, CD-i in comparison to the Web. He found that course content could be rapidly updated, and that the student could work at his or own pace either individually or in a *distributed* group over the network, updating and reviewing on demand. The remote student can log in through a local Internet Service Provider (ISP), thus avoiding expensive long distance telephone calls. Indeed, given the increasing competition between the telephone companies in the UK, and cable companies, we can expect no charge at all for local calls as is already the norm in the USA.

Due to the globally widespread nature of the Internet and the ease of using the Web, both the student and the tutor thus have effortless access to a wide range of information from which the relevant items can be selected. Moreover the student or group of students, like the tutor, can add their own 'Web pages' to the body of sources by publishing this content on the Web.

Such a 'democratic' environment enables the content providing students to be judged by their world wide peers, who may be eminent or novice, fellow students or not, as well as by the tutor. Indeed the students can respond to those commentaries by updating their Web content, posting to newsgroups or sending email. Consequently the tutor directs, from a distance, the student along deep rather than superficial surface learning as that student is encouraged along their own voyage of discovery on the Internet.

As also typified by Whalley, an allied benefit of the Web, in line with its Internet pedigree, is that distance learning is no longer computer platform dependent as a result. Hence the student can access the Web regardless of whether they are using, say, an Apple Macintosh, Microsoft Windows, or UNIX computer, and regardless of which platform the source of the Web content is provided upon. The user, such as the student, views Web pages using a Web browser application such as Netscape Navigator, all of which conform to platform independent standards.

Proprietary Approaches

There are, of course, proprietary multi-way real time methods, many of which pre-date the Web. Essentially these are video-conferencing, dedicated satellite links,

interactive television (ITV for short) or private computer networks using, say, SoftArc's First Class or Lotus Notes software. Such software is nowadays more commonly referred to as 'groupware'. The UK's Open University, whose students are distance taught for the bulk of their courses, extensively employ First Class in the remote teaching programmes.

All these approaches do not, however, have the widespread information sources and audiences that the more globally accessible Internet has to offer. Added to this limitation, these options usually involve the students having to log into a geographically restricted number of sites at consequently long distance telephone expense. Alternatively the students may have to travel to a regional classroom, so undermining the distance education concept.

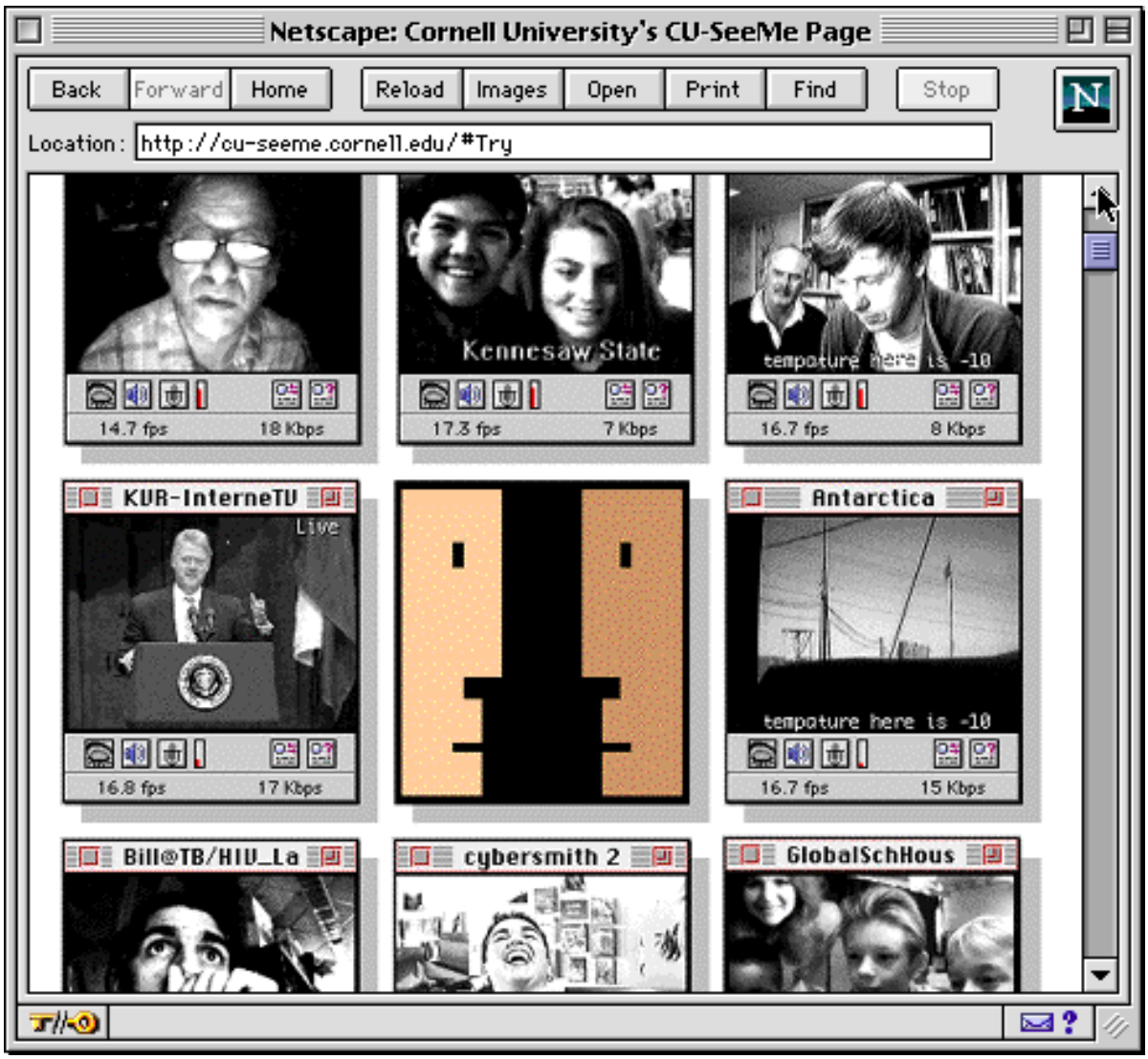

Figure 1: CU-SeeMe on the Web.

Recognising the benefits the Web can provide, the groupware vendors are now beginning to integrate their products with the Internet and the Web. Indeed, both

First Class and Notes material can now be transported across the Internet. Similarly Cornell University's CU-SeeMe (`cu-seeme.cornell.edu`), illustrated in **Figure 1**, is a low cost video- conferencing system that runs over the Internet.

With particular reference to Lotus Notes, Roberts (1996) illustrates the useful experiences that groupware can bring to the Web. Oy and Oy (`www.mroy.fi/doc/gware.htm`) maintain a groupware 'home page' from where developments in this area can be followed, and information about First Class and Notes can be found from `www.softarc.com` and `www.lotus.com` respectively. Microsoft Exchange, outlined by Gillmor (See Roberts, 1996, pages 70- 71) and a recent addition to the groupware market, is promised by its vendor to offer a tight integration with the Internet and the Web (Details of Microsoft Exchange can be obtained from `www.microsoft.com`).

Existing Distance Education Activity on the Web

Considering the pivotal expansion of Web users, its rich information arena, and the anticipated integration of proprietary groupware into the Web, it is not surprising that much distance learning activity already exists on the Web. Examples illustrating this include 'Cital' (`web.staffs.ac.uk/cital/distlearn.html`), 'Distance Learning Demonstration Projects' (`fiddle.ee.vt.edu/succeed/distance.html`), 'Learner Online' (`www.learner.org`), 'TeleEducation NB' (`cnet.unb.ca/lotw/`), and 'The Apple Virtual Campus: Distance Learning' (`www.info.apple.com/hed/distance.html`).

Some of the content given on the Web merely advertises that the institution in question offers a traditional distance learning programme alone, whereas some employ the Internet in other ways such as email-based courses. Others employ a variety of 'hybrid' approaches where courses consist of traditional distance education combined with elements on the Web or email.

Using the global search facilities of AltaVista (`www.altavista.digital.com`) or All4One (`all4one.com`), it emerges that true Web-based distance learning is currently at a nebulous stage. In some cases where the Web approach was being taken, it is evident that fundamental distance principles are not being addressed. As Parer and Henri (*op. cit.*), Kember and Murphy (*op. cit.*) and Rowntree (*op. cit.*) would exemplify, distance learning course design must be more than merely 'putting lecture notes on the Web'. Such an approach obviously lacks any distance learning framework, yet is embarrassingly common on the Web.

Experiences from Distance Education Using the Web

Sevast'yanenko (1994), via the Web, gives a candid account of a distance education programme in Belarus using satellite links and email. He highlights the archetypal need: students too geographically dispersed, the shortage of skilled specialists as

tutors, and the need for the students to receive the education. He also alludes to the lack of funds in the developing economy of his country. All in all therefore, this programme would clearly benefit from using the Web as a teaching and learning medium.

Feller (1995) describes how the prestigious Massachusetts Institute of Technology (MIT) in the USA is linking up with Asian Universities to deliver the Institute's Sloan School of Management's Master of Business Administration (MBA) as a distance learning programme using the Internet, including major use of email and the Web. Again the archetypal need is identified, including the avoiding of 'flying faculty half way around the world'.

Even given MIT's well known technological astuteness, including matters Web and Internet, Feller describes that the project revolves around a hybrid approach by primarily using satellite videoconferencing links rather than a full blown Web approach. This characterises the present nebulous state of Web-based distance education. It also highlights the potential difficulties that lesser Internet-technically endowed educational institutions, which in comparison to MIT would be the vast majority, face in promulgating distance education via the Web. Such obstacles are addressed later in this discourse.

Nonetheless these concerns are not deterring universities and colleges from planning degree and diploma courses by distance learning on the Internet and Web, thereby demonstrating the faith in these communications media. This is echoed by the author's own institution, South Bank University, London, UK. In the author's own department, the School of Computing, Information Systems and Mathematics, a Web-based distance learning Masters level unit on 'Perspectives in Mathematics Education' is currently under development in collaboration with Mid-Sweden University, Sweden.

The unit's students are based throughout Sweden, and the unit will run using email and the Web. Once again the vast disbursement of the students, and the lack of experienced local tutors have determined the distance learning need. Video-conferencing, perhaps in the form of the earlier mentioned CU-SeeMe is to be integrated into this structure. A visit to `www.scism.sbu.ac.uk/cme/` will reveal the initial details. Another Masters unit, the 'Strategic Management of Information Technology' is similarly being set up by the School for a world wide student audience. More subjects are so planned by the University's Distance Learning Centre.

Reinforcing Pedagogical Principles

Much attention has been paid to the design and presentation of Web pages, and quite rightly so too, as evidenced by the too-numerous examples of poor Web pages that can be seen on the Web. Clearly fundamental issues of human-computer interface (HCI) design are relevant to the medium of the Web, and it is encouraging

to see that Lemay (1996), like others, provides a proper coverage of the HCI aspects in her seminal text about Web page construction.

Good Web page design is, however, not enough in isolation. The nature of the subject domain itself affects its design and presentation on the Web medium; thus the domain is a key factor that cannot be ignored. In this discourse it is therefore the pedagogical issues in distance education via the Web that must also be addressed.

Lilley (1994), in his discussion about the evolution of distance learning on the Web, underpins the interactive advantages of the Web and recognised the area was still in its infancy. He particularly emphasises that the general principles of good distance learning design, such as engaging and enthusing the student, apply to Web pages too. Hence the established principles extensively detailed by Parer and Henri (*op. cit.*), Kember and Murphy (*op. cit.*) and Rowntree (*op. cit.*) on designing distance learning courses can be applied to those on the Web.

One illustration of this appropriateness can be gleaned from Price (1995), who presents a checklist of the criteria that nurses should consider when selecting a distance learning course. These criteria, given in the form of questions the nurse should ask, are:

- Will I be able to use this mode of study successfully?
- How can I be sure the materials are good quality?
- Does the material address my area of practice?
- Does the programme offer me support?
- What form does assessment take?
- What do I get for my money?

Price's checklist undoubtedly applies to potential learners outside the area of nursing as well; moreover the checklist is clearly relevant to Web-based distance learning courses too. Though many general principles may appear to be obvious, as Price's would suggest, their worth must not be under-emphasised as it is equally easy to fall into 'obvious' traps; remember the comment earlier about merely putting lecture notes on the Web?

The Web lends itself to the student-centred learning approach (SCL) as explained shortly. SCL is based on the work of Rogers (1951, page 389) who stated that "We cannot teach another person directly: we can only facilitate his learning". In this 'constructivist' view of education, the student is helped to explore his or her own fuzzy concepts and thereby 'construct' their own understanding. Constructivism, as opposed to rote 'behavioural' learning, is predominantly accepted among educationalists as being preferable. It also has significant support within the European Union (EU, 1994). Educationalists are therefore encouraging the student's independent learning which is enhanced by access to, and interaction with, the global information content that the Internet provides.

SCL is further facilitated by The Web, by virtue of its information being interrelated in one dynamic global Web-like structure thereby defining the term 'World Wide Web'. The student can navigate thorough the Web, using its signs and pathways to build up his or her knowledge as he or she progresses through his or her own global voyage of discovery. Indeed this structure was predicted by the key educationalists Schon (1971) and Ilich (1973). Ilich, in fact, coined the term 'learning webs' and believed these would obviate the need for students to be inside classrooms at all. Such evidence greatly supports the Web as a natural tool for distance education.

Avoiding Certain Traps

There are, however, certain scenarios that should be guarded against with SCL on the Web. Davies and Crowther (1995) highlight that a SCL approach does not absolve the lecturer from any involvement. Clearly the constructivist approach demands that the tutor facilitates rather than 'lectures'. Though this may seem to imply a *decreased* workload for the tutor, the prevailing educational climate directs towards an *increased* teaching load.

The tutor may, quite understandably, consequently use SCL as a vehicle to cut down the workload without realising the care or attention needed to providing sufficient facilitation for the student. Economic pressures on educational institutions are unlikely to help; some may see the Web as a means to cut costs further by reasoning that the Web 'eases' SCL. Such a perilous course of action could not benefit the institution, distance education or the Web.

Any responsible educational institution should also consider the needs of the visually impaired distance learner. Unlike text, which can be translated into Braille or speech-synthesised, graphical images do not convert easily enough into a form that can be interpreted by a blind student. This is a limitation of all multimedia; the Web is no exception. Nonetheless Web pages can be constructed so that there are text equivalents for images, and automatic translators exist on the Web that can convert text-based Web pages into a form readable by the visually impaired (e.g. `www.inf.ethz.ch/department/IS/ea/blinds/`). For those learners with hearing difficulties, text describing the nature of a sound can be included on a Web page.

Social aspects

Last, but by no means least, we must always be aware that learning is a social activity. Like any distance education programme, there is the danger of the isolated 'lonely' learner. As we have seen, the Web can provide the interactivity to mitigate this problem. Of course students actually attending a course widen their life experiences by forming new social relationships and participating in new social activities, though 'virtual' communities are now springing up as people form relationships and join in activities via the Internet.

Whatever the relative merits and demerits these social dimensions may have, designers of distance courses which employ the Web must remind themselves that their audience are still human beings with social needs. Accordingly Perkins and Newman (1995) address 'e-discourse' in education, highlighting the different social cues and candour that occur between real and virtual classrooms.

Obstacles to Web-based Distance Learning Courses

So far we have discussed the interactive, global information and pedagogical advantages of employing the Web in distance education, and that the established principles of distance learning design, amongst others, have a material part to play too. As alluded to earlier, there nonetheless remains certain key obstacles in adopting Web-based distance education. These are now addressed under the categories of a) the technical issues, and b) copyright security.

The Technical Issues

Bandwidth

Probably the best known problem with the Internet is that of noticeable access delays due to 'traffic jams on the information superhighway' i.e. insufficient bandwidth. This was an insignificant obstacle when the Internet merely transported text-based material in the form of emails, newsgroups or file transfers. Now that the Internet has been burdened with the rising popularity of the Web and its associated multimedia data, the bandwidth issue has been brought to the fore. This compromises the user's previously stated advantage of enjoying effortless access to the Web.

Halfhill (1996) explains the technical issues involved, revealing that solutions to the access speed problem will consist of much more than simply using better cables or modems. As an illustration of another difficulty, and to draw further on the highway analogy, improving the cables alone would build the motorway but leave the myriad of traffic lights along its route. Thus the means by which the cables interconnect, namely through 'routers' or 'gateways', needs to be improved.

Halfhill cites the inventor of the land-marking 'Ethernet' networking technology, Bob Metcalfe, who warned that a sudden rush of broadband users could crash the Internet. Nonetheless Halfhill evidences that the broadband issues will be resolved, perhaps in less than five years time. Meanwhile caution should be taken against including too much bandwidth-heavy content on the Web by distance course designers.

Access speed limitation became an acute problem in a study conducted by Ramsay, Barabesi and Preece (1996), and in an attempted distance learning course discussed by Inman, Saita and Harrison (1996). Both report on how CU-SeeMe, the earlier-

mentioned video-conferencing system that runs over the Internet, was too inadequate in its response times to be of any meaningful use. Inman et. al. describe the abandoning of CU-SeeMe as a result, and having to opt for 'QuickTime' motion video that was to be downloaded by the students instead. Apart from losing the real time interactivity as a consequence, there were significant delays in the downloading times, again because of bandwidth difficulties.

Navigation

Even considering the Web's advantageous structuring of data and information, and powerful search engines like AltaVista, the increasingly abundant amount of material that is becoming available via the Internet and the Web is making navigation through the Web itself very time consuming. Parallels can be seen elsewhere; a recent survey within commercial organisations found that respondents admitted spending an average of four hours a week hunting for basic business information (Computing 1995). Beales (1995) argues that users require a more structured approach than the Web in its present form.

Attempts are therefore being made to enhance the organisation and presentation of the material. Ping-Jer, Bih-Horng, Ming-Chih and Shyan-Ming (1996) discuss a system by which the students Web pages are synchronised to the tutor's Web page; thus the tutor provides navigation control. Realising the issues of constructivism in their approach they admit that (page 1212):

> "Therefore, if a master (e.g. an instructor) puts exceeding synchronous control over it's slaves (e.g. learners), the motivation and advantages of navigation control will defeated by compulsion."

Clearly, navigation must achieve a fine balance between controlling the student's explorations too severely and offering the student insufficient direction. Otherwise, in line with Friere's (1975) predictions, learning would end up merely pouring untargeted, or too narrow, information into the "empty vessel" of the student's mind. Heppell's technology-based studies in education similarly demonstrated a concern for the "passive victim" (Heppell 1994). We should therefore avoid turning the distance learner merely into 'couch potatoes' devoid of intellectual motivation.

HTML

Though editing environments such as Adobe PageMill (`www.adobe.com`) or Netscape Navigator Gold (`home.netscape.com`) nowadays exist to assist those wishing to produce Web pages, these environments nonetheless remain too inflexible. Thus an author wishing to produce Web pages not only needs adequate knowledge of the subject domain and be fully conversant with good distance learning design, that author must also understand the predominent language of the Web, namely Hyper-Text Mark-up Language (HTML).

Although Lemay (1996) and Graham (1996) elegantly teach the syntax and proper usage of HTML to construct Web pages, as do online sources such as Netskills (`www.netskills.ac.uk`), and that essentially HTML is not particularly difficult even for users with little computer literacy, the more advanced aspects of Web page construction can be very tricky. A sound knowledge of these advanced aspects nonetheless remains a requirement if an author wants to add interactive content to his or her Web pages.

An example is the use of 'forms' where the student would input answers to questions set by the tutor. Currently the adding of interactive content such as forms requires use of the computer operating systems such as UNIX or Windows NT, and intricate computer programming languages such as 'C' or 'Tcl', although 'Perl' and 'Java' are argued as being easy to learn. This is typified by Wall and Schwartz (1993) and Lemay and Perkins (1996) respectively. Deep and Holfelder (1996) discuss Perl's specific use for Web applications. 'JavaScript' is a language somewhat similar to Java, and is geared towards simpler applications. JavaScript is detailed by Danesh (1996).

Java

Java is generating a particularly high level of interest because programs written in Java take advantage of the 'client-server' architecture of networks. This means that the programs can be run locally as 'applets' on the user's, or client's, own computer. This is opposed to all the programs running purely on the Web item's source, or 'server', computer alone, thus potentially overloading it, with added delays as each interactive element has to battle along the bandwidth-limited Internet between the client and server.

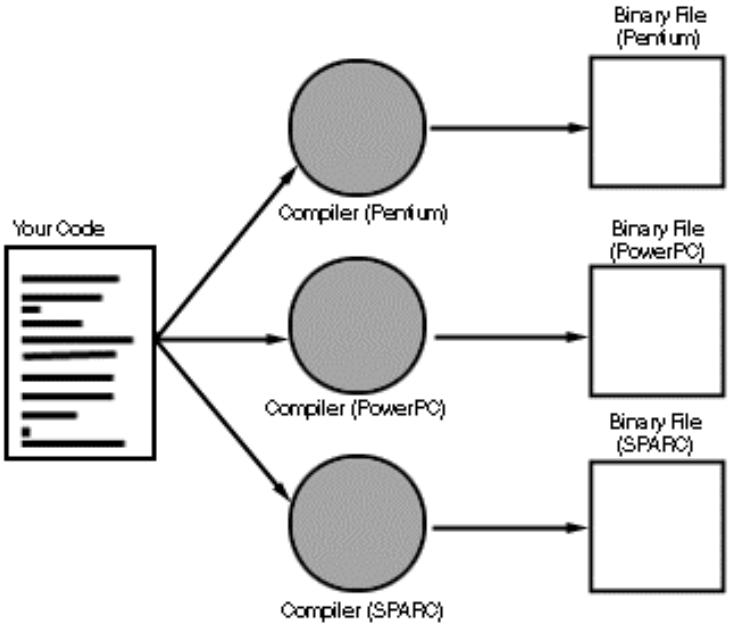

Figure 2: Traditional compiled programs (*Source:* Lemay and Perkins 1996, page 8).

Java also supports the earlier outlined advantages of being platform independent. This is because Java programs, unlike traditional programs which are compiled only to run on a single specific hardware platform as illustrated by **Figure 2**, can be compiled into an intermediate stage known as 'bytecode'. The bytecode is then interpreted by the Web browser according to the client's platform. **Figure 3** illustrates this process.

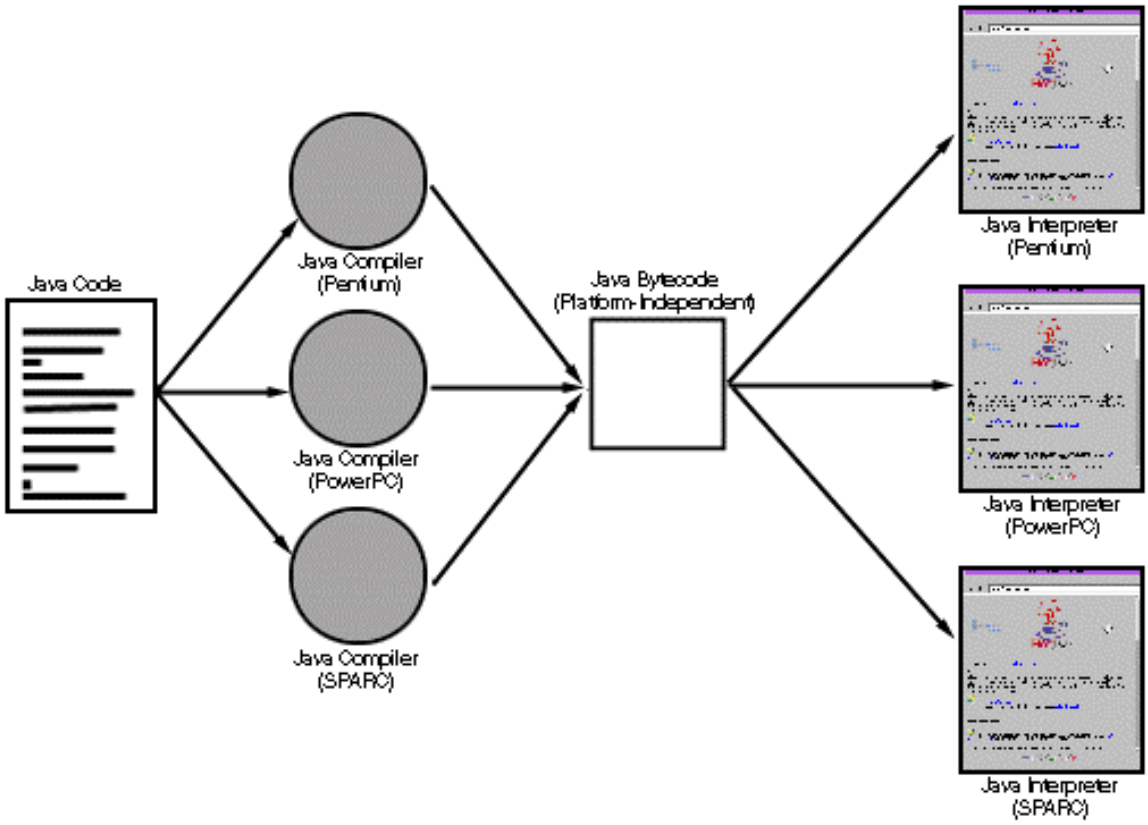

Figure 3: Java programs, (*Source:* Lemay and Perkins 1996, page 8).

Lemay and Perkins also discuss the benefits of Java being 'object-oriented', which they explain in detail. They highlight that (Lemay and Perkins 1996, page 9):

> "Working with a real object-oriented language and programming environment, however, enables you to take full advantage of object-oriented methodology and its capabilities for creating flexible, modular programs and reusing code."

Despite all these benefits, using Java directly to develop sufficiently flexible distance education content remains questionable. Java still exposes its 1960s 'third generation' computer programming pedigree, as indeed does Perl, particularly the 'imperative' programming style. This style demands that the developer has to focus on the prevalent 'von Neumann' architecture of the computer itself and how it processes

data, rather than model the logical interrelationships of the subject domain itself. The dominance of von Neumann computers, named after the person who designed the architecture on which they are based, should not be underestimated; this design includes all the popular computers in use today such as the IBM Compatible PC, Apple Macintosh and UNIX machines.

As imperative programs are closely tied to the design of these computers, they can be executed efficiently. Nonetheless, as suggested by Wilson and Clark's seminal text on comparative programming languages, the imperative paradigm may not be the most appropriate computational model for the subject domain (Wilson and Clark 1993). With the dynamic subjects of study that are a feature of higher education, there is a danger that this shortcoming could prove to be fundamental. Given the added difficulties with the student being remotely located from the tutor, a distance learning subject's content modelled with an imperative mentality runs the risk of turning into an educationally and economically expensive disaster.

An associated consequence of the imperative paradigm's close alignment to the computer is that a sound computing knowledge is required *as well as* expertise of the problem domain. Thus claims about Java, or Perl, being easy to learn can also be questioned. As any glance into the leading material, such as Lemay and Perkins (*op. cit.*) on Java and Wall and Schwartz (*op. cit.*) on Perl, will in fact reveal, applying these languages in meaningful ways can be seen to be very difficult without specialist computer programming knowledge. Hence the overwhelming majority of subject domain experts will not, quite understandably, be able to use these languages anyway.

These issues might be resolved by dividing the duties between, say, the subject domain expert and the computer software engineer. Thus the latter's expertise can be called upon, including not falling into the imperative trap. We have to consider, though, that such a strategy has a significant cost, namely real time interactivity due to the domain expert being delayed, perhaps by many months, as the software engineer amends the materials to reflect developments in the subject being distance studied. With dynamic subjects of study, keeping up may be impossible as a result, thus the Web approach becomes little more than established distance learning approaches. Clearly there is a need for major advances to be made in this area.

Prolog

Recognising the limitations arising from the von Neumann architecture of computer hardware, computer scientists have sought to find a logical paradigm that does indeed model the domain problem at hand rather than pacify the computer. This effort has lead to the development of *logic programming* languages, of which 'Prolog', short for *Pro*gramming in *Log*ic, as its major culmination.

Strong arguments in favour for the use of Prolog accordingly are given by Bratko (1990), Callear (1994) and Sterling and Shapiro (1994). An added feature of the Prolog computer programming language is that it can run on von Neumann computers. Prolog interpreters or compilers 'convert' the modelled domain knowledge into the imperative form, but do so in a principled way that avoids the dangers outlined earlier.

Given that Prolog has been around for some time, we must wonder why it is not as popular as it should be. Essentially the reasons are historical, but have managed to persist nonetheless. Early versions of Prolog were inefficient and therefore very slow, essentially because of the inherent difficulty of converting the Prolog code into von Neumann executable form, thus illustrating the order of magnitude between logic and imperative programming. Since then, however, much work has been conducted resulting in the efficient implementation of Prolog, even on prevailing computers, through the use of 'optimising' compilers. LPA Prolog is such an example; there is even an object-oriented version of this software called Prolog++ (`www.lpa.co.uk`).

Also, because of the large established base of imperative programs and expertise, an instinctive reluctance to change has prevailed due to the fear of 'trying something that is unknown'. Indeed this a pattern that is reflected throughout computing's history. Examples include the predominant QWERTY keyboard layout, despite the fact that it had been *deliberately* designed to be inefficient thus preventing early mechanical typewriters from becoming jammed due to too-rapid key pressing. The efficiency argument itself does seem to matter little, since certain modern popular computer languages such as Visual Basic, though imperative in nature, are renowned to be very slow.

Given the need for expressive models of the subject domain, it therefore could be that Prolog's 'time has come'. Certainly Prolog, because of its problem-based logic focus, allows the more rapid development and deployment of distance education courseware, possibly including the end-user writing his or her own code. Even if many tutors still felt unable to program in Prolog directly, the software engineer could produce revised material more quickly for these tutors, as the engineer would not have to go through the careful process of matching it to the imperative paradigm.

Where the tutor, or student for that matter, produces the code directly there does remain the issue of software engineering; he or she would still need to be taught the appropriate principles of software engineering thus preventing the tutor from producing badly written and difficult to update code. This overhead would be mitigated if a Computer-Aided Software Engineering (CASE) tool was developed that could be effectively embedded into the Prolog programming environment.

In addition, the latest Prolog compilers do not enjoy the distributed client-server advantages of Java as explained earlier. The author is, however, investigating

possibilities in this area in conjunction with LPA, the vendors of LPA Prolog. One desirable outcome would be a compiler that automatically converts Prolog code into Java bytecode, thus immediately benefiting from Java's advantages without its limitations.

Toolkits

Developments are also beginning to emerge whereby the tutor, or student, can employ a user-friendly package to build distance learning content on the Web. With these 'toolkits' the requirements for programming and, to some extent, software engineering skills become unnecessary. An example is Web-CT (Goldberg, Salari and Swoboda 1996). Another is W3LP (`www.comp.it.brighton.ac.uk/w3lessonware/`). **Figure 4** illustrates the 'Path Editor' component of Web-CT. There is also a 'Glossary Editor' and a 'Reference Editor' amongst other features.

Figure 3: The 'Path Editor' component of Web-CT
(*Source:* Goldberg, Salari and Swoboda 1996, page 1223).

Experience has shown that the price paid for the simplicity and usability of a toolkit is a loss of expressiveness and flexibility, though future toolkits might somehow overcome this dichotomy. The limitation is typified by Davies and Crowther (*op. cit.*) in the established yet highly related context of Computer Aided Learning (CAL) and multimedia packages (page 6):

> "Many CAL and multimedia packages have an in-built student assessment facility. ... . The use of such assessment in multimedia packages has serious limitations from a learning effectiveness perspective, as such packages can only test objectively. In other words, they are only suited to yes/no or right/wrong questions and numerical problems with only one possible correct answer. It is hard to imagine how Bloom's analysis, synthesis and evaluation objectives can be achieved through such objective tests."

There may, however, be scope to provide toolkit-based distance education on the Web that is sufficiently expressive. For instance a spreadsheet component could be incorporated to examine financial and statistical methods for instance. The course could revolve around the students simply downloading and uploading spreadsheet files. These files could then be opened and worked upon in a locally-installed spreadsheet software application or 'add-in' package. Ambach, Perrone and Repenning (1995) discuss such an approach using 'Agentsheets' as the local application.

Copyright Security

One of the primary limitations on using the Web amongst the distance learning community is the danger of copyright infringement. Of particular concern is the situation whereby one institution puts much time and effort into produce a distance learning course publicly on the Web only to have another institution frustrate that effort by easily copying that course, or unregistered students accessing the material, thus losing vital income for the legitimate course provider.

This ease of access may even cause a legitimate institution to violate copyright unintentionally, thus creating another avenue of concern. The legal system has yet to catch up with the increasingly universal use of the Internet; this is further complicated by the national boundaries within which legislation would tend to apply. This problem should not present a lasting difficulty insofar that international intellectual property rights agreements already exist for printed material and computer software.

Copyright infringement can also be prevented by secure Web documents, where its access is restricted only to those entitled to see the item by means of passwords, secure links, encryption that governments will allow, or 'digital' signatures. These

measures would also help to ensure that students undergoing assessment were actually carrying out the work themselves.

An insert in an article by Udell (1996, page 72) and Flohr (1996), between them, elucidate on all these methods and related issues. As they reveal, significant results are currently being made in this area, given that commercial development of the Internet is hindered by, for instance, the inability of the Web to allow the user to pass his or her credit card details securely over the network. Flohr, in fact, details the possibilities in the context of electronic money, though his commentary clearly applies to securing against copyright infringement too.

Concluding Remarks

Given the proper design of Web pages and the reinforcement of pedagogical principles, there are significant advantages that the Internet and the Web can offer to distance learning in higher education. This discourse has nonetheless revealed that there remain a number of fundamental limitations, primarily of a technical nature, that preclude fully integrated Web-based distance education. Despite these hurdles we can still expect that many of these hurdles will possibly be overcome within the next five years, mainly as part of the large-scale general development of the Internet and the Web.

Meanwhile, given the significant advantages that the Web offers currently, one possibility for the higher educational institution is to adopt a hybrid approach. In this set-up the core material could be physically dispersed in the traditional way, such as printed copy. The Web or email, as appropriate, could then be employed for the more straightforward aspects of certain tasks involving the course participants' interactions, individual communications, problem solving exercises and assessments.

The hybrid approach would enable the institution to progress through a gentler process towards gaining familiarity with the Web as an educational resource. It would also essentially obviate the copyright security issues arising from any unauthorised Internet access by a rogue institution or an unregistered student, as the course would make no sense without the key material. Clearly the hybrid approach would particularly suit open learning as in this case, accepting one of its differentiations from distance learning as given by Parer and Henri (*op. cit.*), the student and institution physically meet from time to time anyway.

Though less than the interactive global information arena ideal of the Internet and the Web, a well thought out hybrid strategy would immediately suffice yet can be adapted as each remaining obstacle is steadily eradicated. Once adequate security becomes established on the Web for instance, key course content could begin to travel along the Internet.

A major step along this progression would also arise from the investigation and widespread development of an expressive and natural software development environment as suggested by a CASE-enhanced client-server based Prolog, or software toolkits. These would enable the tutor or student to focus around their own intricate subject domain knowledge unconstrained by irrelevant and potentially misleading computational overheads such as Java itself. Thus more intricate subject knowledge would, at last, be set free to build upon the inherently dynamic global media of the Web.

This discourse therefore recommends the adoption of a hybrid approach with the proviso that the distance education programme is principled so that it accommodates both the issues raised, and can be updated as the obstacles are resolved. There is, after all, enough evidence to suggest that we should not lose sight of distance teaching and learning programmes that are fully integrated with the Web, or its derivatives, in higher education. Indeed, like so many technological developments in education, "We should not be seduced by the novelty nor must we let the opportunities they present pass us by" (Newble and Cannon 1991).

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