New Media, New Practices: Experiences in Open Learning Course Design

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ABSTRACT
We explore some of the complex issues surrounding the design and use of multimedia and Internet-based learning resources in distance education courses. We do so by analysing our experiences designing a diverse array of learning media for a large scale, distance learning course in introductory computing. During the project, we had to significantly rethink the design and production of our learning resources as we *shifted from a paper-based teaching model to an interactive teaching model*. This shift entailed changes to our design products (to promote more effective media use by learners) and changes to our design practices (to foster consistent media use and design across a large and distributed team). Course designers and course students alike needed help in breaking out of paper-based models of learning to obtain maximum benefit from the interactive teaching model.

Keywords: Design, Distance Education, Educational Technology, Lifelong Learning, Multimedia

INTRODUCTION
Recently, there has been a realisation of the importance of lifelong learning to the envisioned knowledge-based economies of the next century [7]. With this realisation, there has been an explosion of interest in new forms of teaching and learning made possible by new technology – particularly on-line distance education and multimedia learning environments. These two areas are perceived as offering the potential to promote lifelong learning by supporting flexible learning, fostering learner control, and stimulating learner engagement. Given these perceptions, it is not surprising that many educational institutions, including our own, have started or announced plans to 'put their courses on-line' and make 'significant use of new media.'

In this paper, we unpack these phrases and explore some of the complex issues surrounding the design and use of 'new media' in large-scale distance education courses which consist of learning resources distributed across numerous media and technologies. Students work with a wide array of on-line tools: standard office productivity tools, various kinds of communication software, World Wide Web-based hypermedia, and specialised learning environments tailored to particular curricular needs. In this situation, it is a challenge for both course designers and learners to effectively manage the media-mix to achieve their educational objectives [4]. We focus on related *design and use* issues such as:

- Should we design for media redundancy or media complementarity?
- What forms of media integration are necessary or desirable?
- Can we transfer existing materials to new media or must we engage in substantial re-design?
- What new design and production practices may we need to adopt?

We examine these issues by critically analysing our experiences in designing and evaluating a large scale open learning course in introductory computing at The Open University in the UK. This course uses a wide range of technologies and media to deliver to students, in their homes, a full year's worth of learning activities in object-oriented programming, software design, and networked computing.

After describing our particular course and open learning setting, we examine our preliminary experiences with the initial course materials. Next, we show how developing an explicit interactive teaching model helped us understand and resolve the problems we encountered. We then reflect on the design and use issues outlined above and distil several lessons based on our experiences. Finally, we examine the consequences of these lessons for educators moving to technology-based teaching, and more broadly, designers of diverse media 'systems'.

SETTING: THE NEW COURSE
Since the late 1960's, The Open University (OU) has been providing mixed media, distance education courses combining printed texts, television, video, audio, and home-laboratory kits. Materials are centrally produced to an academically high standard, and presented in an open learning style that is accessible to people with no previous academic qualifications. After signing up for a

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course, students receive by post a course pack containing all necessary study materials. While materials are designed to support independent learning, students are not entirely on their own and are assigned to small tutor-groups of 20 students. They communicate with tutors and other students via telephone, e-mail, and computer conferencing, only occasionally meeting face-to-face.

The specific setting is the development of a new first-year undergraduate course called "Computing: An Object-oriented Approach." Such introductory courses often have between 3000 and 5000 students enrolled. This course is being developed in the Maths and Computing Faculty by a large, multi-disciplinary course team composed of about thirty academics, software developers, editors, graphic designers, and television producers. Our roles, as academics specialising in HCI and educational technology, were two-fold. First, we were responsible for evaluating the usefulness and usability of the new course resources under development. Second, we served as consultants to the team on media use. In the remainder of this section, we give an overview of the initial design goals and resources created for this course. A discussion of the pedagogical motivations can be found in [9].

Initial Design Goals

Obviously, one set of design goals related to enabling students to meet the educational aims of the course – to develop a solid understanding of object-oriented design and programming, networked computing, and software design. However, the course team also wanted students to have more 'philosophical thoughts' and perceive both the software they used and the software they created as designed artifacts, necessarily embodying trade-off decisions between competing goals and objectives. Thus the course needed to be designed to encourage students to look at software artifacts from multiple perspectives, and to critically examine real world applications related to what they do in the course.

A second set of design goals was based on the OU charter of supporting 'open learning'; that is, allowing for and designing for students with diverse backgrounds who need to study in their own time and place. Students will have extremely diverse backgrounds in key areas such as previous experiences with academic study, programming, and computing in general. In terms of academic study, this may be some students' first experience with higher education. In terms of computing, some students will be using computers daily in the workplace, while others may be first-time users who bought their computer especially for this course. Thus, materials and tools must be designed to accommodate different levels of expertise and experiences with software and new media.

To support studying in their own place, learning resources must be designed to take into account the capacity, performance, and cost constraints of a student's typically moderate specification home computing kit (e.g., 8 megabytes of RAM) [4]. Also, students are unwilling to spend large amounts of time on-line with their modems given the price of telephone services in the UK (pay per minute for local calls). To support studying in their own time, materials need to be designed so that students can accurately estimate and plan the time needed for computer-based activities.

Initial Course Resources

By fall of 1995, the course team formulated the course goals and pedagogical approach and identified most of the resources (Table 1). The course would be structured around a printed text with accompanying practical work contained within Smalltalk LearningBooks (Figure 1) based on the notebook metaphor provided in the LearningWorks Environment™.

Table 1. Initial course resources.

Course Resources
Printed Texts
Smalltalk LearningBooks Programming Environment
Set Book: Parsons & Oja [6]
Eleven Television Programmes
Two Multimedia Titles – 'The Object Shop' and 'Grumble's Grommets'
Electronic Glossary
World Wide Web Site
Computer Conferencing
Email
Personal Productivity Tools

There would also be multimedia CD-ROMs, web activities, and television programmes. As with other OU courses, the printed text produced by the team would serve as the 'backbone', integrating the concepts covered by other resources and directing students to other resources. Additionally, the team constructed an initial web site which provided general course information and replicated some of the text materials in hypertext form.

PRELIMINARY EXPERIENCES

The team had produced draft texts and prototype LearningBooks for about the first third of the course and wanted feedback on their initial course design before proceeding further. So for the next six months, until April of 1996, we analysed our preliminary experiences with the new course. One strand of our activity consisted of detailed analyses of existing resources, whilst the other focused on empirical evaluations with users.

We brought together specialists from the course team in key design and production areas: educational technology, HCI, television, software development, graphic design, and text production to form a Media Group.

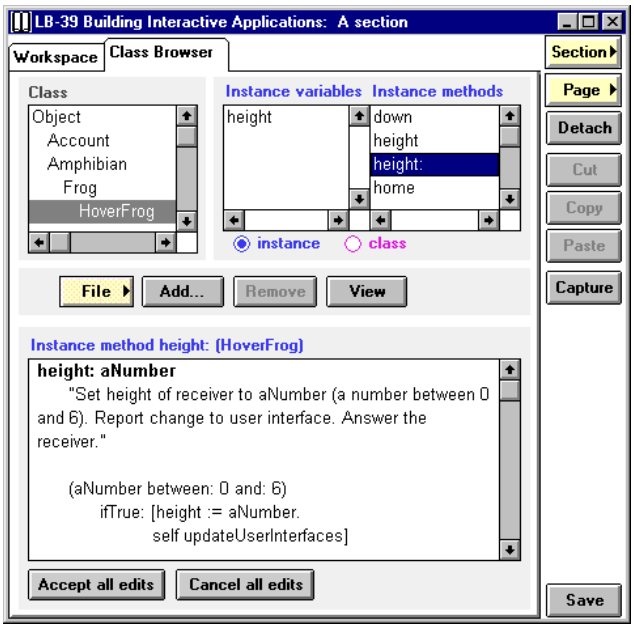

Figure 1. Notebook sections contain microworlds and programming tools, such as this Class Browser, that the team created for the course.

The group's task was to advise the larger course team: (1) how multimedia could be used to promote more active learning, (2) how to make use of the World Wide Web and (3) on the practicalities of producing resources given time and budget constraints. The Media Group conducted a series of resource analyses focusing on the contents of and relationships between the printed texts and LearningBooks, and between the printed texts and web resources. Our analyses highlighted potential use and production problems stemming from existing media redundancy and resource integration practices.

"Inscribed' into the structure of the printed texts was an implicit model of use which assumed that students were using the texts and their computer-based LearningBooks side-by-side in a highly interleaved fashion, reading a little, then programming a little. All the supporting context for the programming activities – problem statements, hints, solution approaches – were embedded in the print. Authors had been inconsistent in the granularity of their interleavings (with some authors going for larger 'chunks' before switching activities and others smaller). From a use perspective, we were concerned about forcing students to work in this interleaved fashion: it promoted dependence on textual materials, made it difficult for learners to estimate the time needed for computer-based activities, and was place-bound requiring students to read next to their computer. From a production standpoint, we were concerned at the tight, dependent coupling between the two media that arose from interleaving. This style of resource integration resulted in lots of media redundancy: the texts were filled with LearningBook-specific instructions and screen dumps. As the software evolved, the texts needed to be updated. This was problematic given the widely differing production time periods of the two media. (Texts often have to be ready a year in advance for printing and, due to costs, are rarely modified and reprinted.)

The team wanted advice on whether to render the printed text in hypertext form and make it available at the course web site. Again, there were concerns over production issues arising from this level of media redundancy, such as initial mark-up costs and maintaining consistency between the different media versions (print and web). More importantly, it wasn't clear if this approach provided any added value for learners or whether they would even make use of this type of resource.

In the same period, we conducted two forms of empirical evaluations on existing course materials: longitudinal surveys and open-ended interviews. The surveys looked at whether people were able to learn with the resources. Fourteen people, similar to the expected student population, were paid to act as students and 'take' the course using the preliminary materials. Each person was given the necessary computer hardware and software for the duration of the testing. As 'students' worked through each chapter in their homes, they filled in a questionnaire about the resources and the subject matter.

We also conducted open-ended, semi-structured interviews with eight of these testers. These interviews focused on trying to understand students' experiences working and learning with the computer-based resources. We asked them in detail about how they studied, how they organised their on-line work and study time, and their experiences using particular tools such as Smalltalk, email, and the web. Where possible, we asked students to show us their notes, filing system, diaries, etc. and explain them to us. Here, we will not consider these studies in detail but instead will focus on the findings that influenced our design (see [8] for more details).

Analyses of the survey data showed that overall things were going fairly well. About half of the students were able to do the practical programming activities and seemed to grasp the various object-oriented concepts with no significant problems. Unfortunately, other students were having difficulties, particularly those students with little prior experience with technology. Despite their initial enthusiasm, they were not making effective use of their computer-based course resources and instead were relying heavily on the paper-based materials. The interview data provided converging evidence and identified several areas of concern:

- Some students had little confidence in their ability to work and learn with the computer-based resources. Several had long-standing prior anxiety about computers and this was slow to change. Others had experienced setbacks, e.g., a difficult installation or 'web' session, that had shattered their confidence.
- Many students felt disoriented and had difficulty judging progress through electronic materials.

- Nearly all students were unclear about the role of the various resources in the course and how they should be using them to support their learning.
- While they could use resources to carry out specific activities, many had difficulties making connections between practical activities and larger conceptual issues. As a result, they tended to develop isolated, piecemeal views of their computer resources.
- Some students were relying heavily on reading texts. The interleaving approach led some to believe they could read about programming rather than actually doing it. Some reported difficulties using the texts side-by-side with the LearningBooks.
- Some students rarely visited the web site since the materials there were redundant to their printed text.

We believed that many of the problems uncovered during these preliminary experiences were rooted in tacit paper-based models of teaching and learning which underlay the current design, and was promoted by interleaving. Lack of confidence with technology was also a contributing factor, reducing people's willingness to experiment with new ways of learning.

DEVELOPING AN INTERACTIVE TEACHING MODEL

Our evaluations indicated that *students* needed help breaking out of paper-based learning habits in order to capitalise upon the new resources. Specifically, learners needed: orientation support to feel more confident and in control of their learning process, bridging support to help relate specific activities to conceptual knowledge, and assistance fostering active learning habits. Basically, a framework was needed that defined a consistent task and support structure, encompassing both traditional and electronic media.

Conversely, the *course team* also needed help to break out of paper-based teaching and production practices. In paper-based courses, work practices are organised around a waterfall model of authoring: successive drafts of material are refined by academics over long periods of time and then handed over to editors and graphic designers to be produced. With computer resources, production is distributed and interdisciplinary, with parallel developments going on in different organisational areas by different media specialists. The course team needed a framework to guide both present and future course resource development. Such a framework should foster consistent production of materials across a large, distributed team and promote new models of working and divisions of labour across media specialists.

The tool the Media Group used to think about these inter-related use and production concerns was the development and refinement of an 'interactive teaching model.' This evolving model consisted of collections of representations, mock-ups, use scenarios, and prototypes that served as 'objects-to-think-with' as we considered possible new resource designs. We began by focusing on learners and their activities and developed models that helped make explicit:

- types and distributions of activities across resources,
- transitions between different resources in envisaged use situations, and
- where students may need support in adopting a new model of learning.

Changes to chapter structure

At the chapter level, we explored ways of moving the problem-solving contexts out of the text and into the LearningBooks to create a clearer distribution of activities across the resources. Figure 2 shows a set of mock-ups we created in April 1996 to demonstrate a new use scenario along these lines. We took an existing chapter and 'moved' problem framing and solution materials into separate LearningBook pages surrounding each programming problem. We added a special page at the front of each LearningBook called an 'agenda'. Similar to other systems [5, 10], we used the agenda to provide learners with 'support for practical action.' To support bridging between practical action and general concepts, we embedded hypertext links in the agenda, and other LearningBook pages, to concepts presented in an electronic glossary.

This particular redesign is based on the principle of media complementarity; i.e., that each resource should fulfil a unique function and support different activities. It addressed the production concerns due to integration by interleaving, and seemed to promote a more active learning style by reducing learner dependence on detailed instructions embedded in the text. For this scenario, the team was concerned with whether there were sufficient learner benefits to justify the re-working of existing texts and the extra programming effort required. They asked the Media Group to develop a working prototype of the model and test it with learners using the next chapter going out in May of 1996 for testing – Chapter 19. We did so, and conducted follow-up phone interviews with the testers. The response to the new chapter-level task structure was very positive. One student felt that the new approach "finally gave them a chance at success."

Developing the prototype involved changes to the LearningBook software and changes to the printed text. To function in a new role as a complementary resource, the printed text needed to be significantly rewritten. The editors and graphic designer undertook most of the restructuring and re-writing of both media. The HCI and educational technology specialists looked at how the problem context needed to be modified as it moved from printed text to software. The software developer modified the LearningBook software to support the addition of the new hypertext pages by editors.

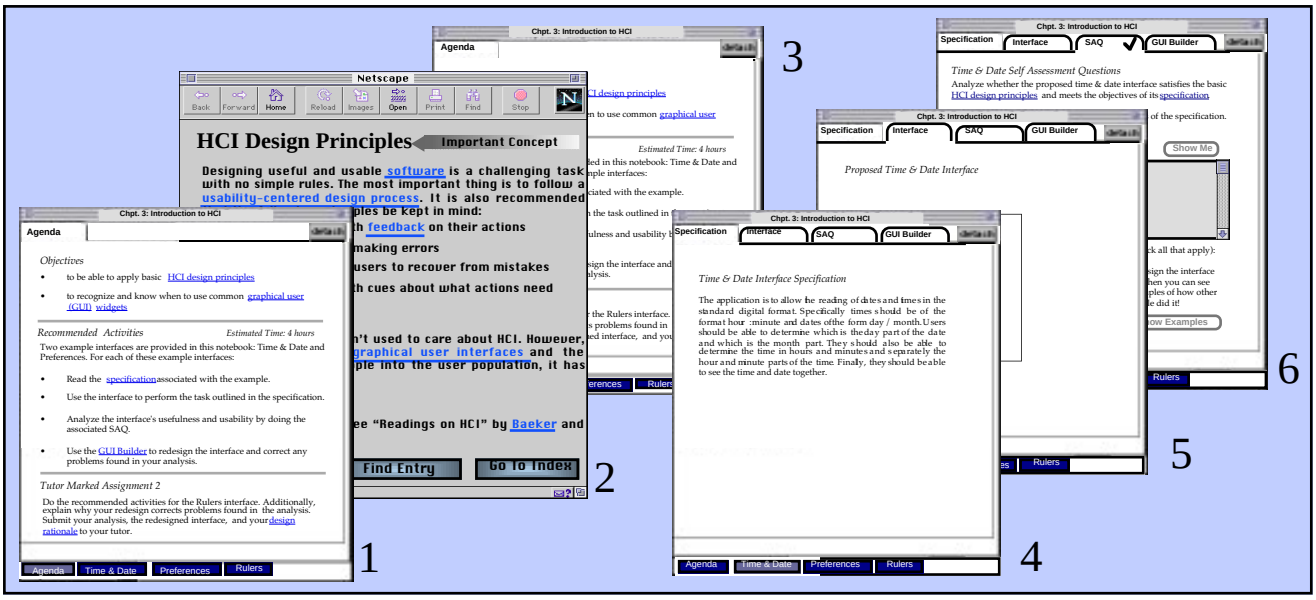

Figure 2. Mock-ups in a use scenario showing how the learner moves between the different resources during a programming session.

Since all the various Media Group specialists had contributed to developing the prototype, we were able to collectively analyse our experiences and produce authoring guidelines and ideas on new divisions of labour to promote the consistent production of the new resource structure. For example, the authoring guidelines offered advice on how to write the problem context pages in the LearningBooks to promote more active learning. Changes to the division of labour included recommendations for editors to become involved much earlier during production and assist academics in producing the hypertext pages. As time progressed, this part of the model was progressively refined by the larger course team as they produced more chapters.

Changes to course structure

At the course-level, we used architecture diagrams to help us analyse different resource configurations (Figure 3). These diagrams helped us see the amount and types of integration being built into the course as we analysed various production and use concerns. Figure 3 shows the current course configuration. The Course Map and the web-based Study Calendar integrate, either by reference (dotted lines) or by computational links (solid lines), all the course resources. When other resources change, these need to be updated. There are computational links between the LearningBooks and hypertext Glossary, and between the CD-ROMs and Glossary supporting smoother work flows between these resources. Now, the integration between the printed text and the LearningBooks is primarily through conceptual linking using common examples or problem domains. For instance, to help students bridge between a conceptual treatment of inheritance (an object-oriented concept) in the texts and activities where they create their own inheritance network, resources rely on a similar ecosystem inheritance example.

The web serves as a digital library for materials not available elsewhere, such as time-sensitive information and updates for all resource types. This use of the web as an periodic delivery mechanism is consistent with the design goal of limiting the time student's must spend on-line due to high telephone costs. The only form of media redundancy left in the course is the Glossary which is replicated in both the printed text and in hypertext. Many students would not bother to use an electronic glossary while reading the printed texts.

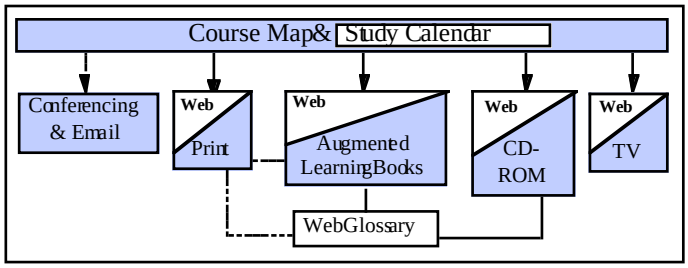

Figure 3. Course architecture diagram showing resource integration and web complementarity.

Table 2 shows the final functions associated with the media as a result of this process of re-design and refinement. The materials are both complementary and overlapping, with each resource playing an important role in the overall course. While some media may support overlapping objectives, each does so in a different way. These different ways include supporting different learning styles (i.e., experiential versus reflective cognition) or providing a different perspective on the same material (e.g., the printed texts take a theoretical look at networks whereas when using 'Grumble's Grommets', students design a network using today's existing technologies).

Table 2. Course resources and their different functions.

Course Resources	Function in Course
Printed Texts	Provides the conceptual and theoretical learning materials in the course; designed to give the students a 'good read' without requiring being on-line.
Smalltalk LearningBooks	Provides the practical materials supporting learning-by-doing activities related to programming, object-oriented concepts, and software design.
Parsons & Oja	Provides much practical information on computer hardware, software, and networked computing and relates many general ideas in these areas and to existing real-world applications.
Eleven Television Programmes	Contextualises students' activities to real-world problems and applications. Programmes feature interviews with designers, users, and clients.
Multimedia Titles	Provides two experiential, learning-by-doing environments in object-oriented concepts (Object Shop) and networked computing (Grumbles Grommets).
Electronic Glossary	Supports linking of terms and ideas into larger concepts and, by integration with the Smalltalk environment, linking of practical actions with concepts.
World Wide Web Site	Serves as the course library containing complementary course materials and materials of a timely nature, new updates to course resources, and pointers to further background materials.
Computer Conferencing	Supports general communication among participants and the necessary discourse between group members during collaborative group working.
Email	Supports student - tutor communication and electronic assignment submission.
Course Map and Study Calendar	Helps clarify the role of resources in the course, integrates resources, promotes more effective media use by linking academic objectives with practical action, fosters learner confidence with new media.
Productivity Tools	Word processors and drawing tools are used for written and design work.

Our interactive teaching model helped us reflect on what models of learning we may be building into the resources and where students may need support in adopting a new model. The redesign of the LearningBooks created a new model of learning at the chapter-level and the agenda pages made the new model explicit. However, our evaluations uncovered broader course-level learner problems concerning lack of orientation and clarity about the overall role of different learning resources in the course, which appeared to have a negative impact on learner confidence and motivation. We explored ways to address these issues through the creation of an Interactive Course Map. Our design goal was to create a multimedia map with 'welcome tour' that students could use in the early part of the course to get a feel for how to work and study using the course resources. We developed several prototypes exploring different styles of representation and eventually refined and tested the prototype shown in Figures 4 and 5.

The colours and fonts were chosen to match those used in the course's printed text and web site. Thus, resources have a familiar and consistent look, regardless of the media. The Map (Figure 4) is composed of three main areas: a course content area (right-hand pane), a course resources area (left-hand pane), and a tour area (video window, top left). The course resources area provides students with an overview of how a particular resource will be used in the course and global advice about how to study with the resource for this particular course.

The course content area supports orientation by laying the structure of the course bare and reflects the block structure of the course. Pressing the Block 1 button at the top level (shown in Figure 4) brings up the two panes shown in Figure 5. Each block area is structured into two panes – the Block Overview pane (right-hand side) and the Weekly Resource pane (lower left). The Block Overview pane shows how each study week is composed of one or more chapters. Clicking on any chapter title will bring up a third level pane containing a chapter description which focuses on learning goals and high-level tasks. The left side of the Resources pane shows what tools and resources are used to achieve the learning goals or complete that week's tasks. Making connections between learning objectives and resource activities is supported by the interplay between these two panes.

The Map operates on a principle of 'self-disclosure' [2] – two guided tours are available, in which a member of the course team (whose head appears in the video pane, top left) talks students through different aspects of the course structure or resources, whilst simultaneously the map illustrates what is being said. The General Course Tour outlines *all* the course resources and students are advised to watch this at the start of the course, before they do anything else. There is also a Block 1 Tour which introduces learners to the multiple media structure of chapters; i.e., printed text, LearningBooks, and web pages.

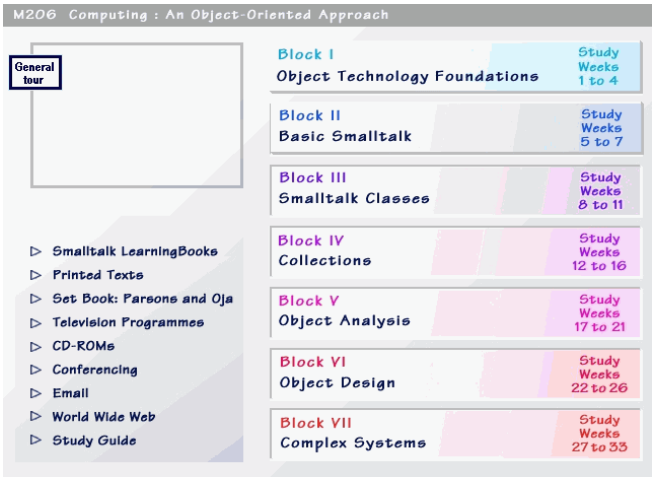

Figure 4. Top level view of the Course Map

We have completed formative testing of the map using six volunteers. To summarise our results, all participants were very enthusiastic and positive about the overall look and feel of the map, and had very few problems navigating, easily finding the things we set them to look for. All six participants described the tours as 'helpful' in the following specific ways: for taking them through the structure of the course phase by phase, for introducing the media and for showing them how to use the map itself. All participants said they would probably listen to all, or parts, of the tours several times. As a result of using the Map (with tours), 5 out of 6 participants were able to clearly articulate the structure of the course and the rather complex structure that 'chapters' might have (e.g. printed text, electronic learning books, web pages and television programmes). Additionally, everyone was able to articulate the general role of major resources in the course; i.e., that conferencing was for communicating with other students and tutors, while the web was a resource area for getting updates to course materials. We regard this as a measure of success. A full-fledged Course Map based on this prototype is currently being developed.

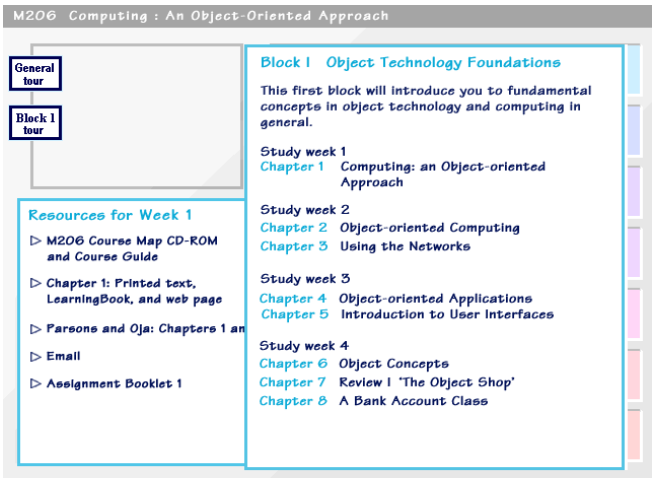

Figure 5. Course content area in the map visible after selecting 'Block 1' in Figure 4.

REFLECTIONS

In the Introduction, we articulated several issues surrounding the design and use of 'new media' in large-scale distance education courses. Here, we reflect on how we resolved these issues in our project and generalise some lessons based on our experiences.

Lesson 1: Design for media complementarity. Media redundancy (replicating the same materials in different media) did not help our learners or our production process. Many learners will not bother to access digital resources that are in more readily available paper form. Replicating materials can be a production nightmare; changes to content in one media will necessitate changes across all media to preserve consistency (a problem Green describes as viscosity [3]). We designed for complementarity based on learner activities and the media's time-base for modifications. Thus, we concentrated all materials supporting programming activities in the LearningBooks and used the course's web site as a digital library containing materials that change from year-to-year.

Lesson 2: Resource integration is important for learners, but how you do it affects your ability to evolve resources independently. Integration refers to the coupling between different resources. Referential integration (e.g., showing a picture or description of one resource inside another) greatly complicates the production process. In the original 'interleaving' approach, the referential integration between the LearningBooks and the printed text meant we could not evolve the software without re-writing the texts. Now, the integration is primarily through conceptual linking using common examples or problem domains. We also confined integration into specific components such as the Course Map and Study Calendar. This serves mainly to isolate the locus of possible viscosity effects; thus, rather than having to adjust several resources, efforts can be focused on keeping the Map and Calendar up-to-date.

Lesson 3: Be aware of models of working and learning you may be inscribing into the resources. As more educators move their teaching materials on-line, there is a likelihood that tacitly held models of teaching and learning refined for traditional media (e.g., paper- or lecture-based) will be inscribed into resources. We found it useful to explicitly articulate and reflect on what new model of learning we were trying to create and to analyse the resources we were producing from this perspective.

Lesson 4: Be prepared to rethink, restructure, and redesign your learning resources. If you design for complementarity and avoid referential integration (a common practice in paper-based teaching), you will need to restructure your learning resources. If you are trying to promote a new model of working and learning, you will inevitably need to rethink and redesign as well.

Lesson 5: New models of working and learning require new practices, from both course designers and learners. Our learner evaluations and production analysis activities

helped us to understand current practices. The interactive teaching model helped us reflect on future use and production scenarios. The challenge is how to transform current practices in order to these future scenarios? In our case, the academics, editors, software developers, and graphic designers used the mock-ups and authoring guidelines to help rethink the division of labour within the production community.

Fostering new learning practices is always a difficult task. In our case, it is even trickier given our distance education setting: we will never meet learners face-to-face and their learning situation is distant and uninspectable. We attempted to foster new practices through resource redesign (e.g., the LearningBooks) and study support tools (e.g., the Course Map). While initial tests were promising, success remains to be validated during actual course presentation. However, we can – and do – confidently assert that many students will always need help!

Lesson 6: A Media Group can be helpful, but form the group early in the course design process. The most important function of the Media Group was to help the course team engage in self-reflection about their design products and practices. To do so, we undertook a variety of evaluation and analysis activities, looking at both use and production issues. We used these activities to provide a starting point for further rethinking and redesign by the team themselves. In the vein of participatory design [3], our key contributions were to construct representations, mock-ups, and prototypes that served to ground their redesign process and to help them reflect on how their practices might need to change.

While these lessons arose out of our very specific experiences, we feel they are applicable to other situations. Educators considering moving existing materials to new media forms, whether in traditional classroom or distance education settings, could benefit by thinking about resource complementarity, integration, and how to promote new learning practices. At the organisational level, educational institutions considering how to promote new practices could consider the Media Group option. Yokam et. al. ([11] in [1]) discuss how teachers learn new practices in special 'classrooms of tomorrow' but have difficulties transferring their new skills back to their own classrooms. The Media Group option side-steps the transfer problem by making the teacher's own context the locus of the re-thinking activity. Finally, our lessons are relevant to the publishing community, who are also creating products (educational and otherwise) using multiple media; i.e., combinations of books, CD-ROMS, and web-based resources. Our experiences indicate that the current trend towards media redundancy is problematic from both production and use perspectives.

In summary, we have described and analysed our experiences creating a new large-scale, media-rich distance learning course. These experiences opened our eyes to the shortcomings of previously implicit practices; a lifetime of practices honed for paper-based courses didn't transfer well to new media for either learners or designers. The new media required new practices, and we used our 'full battery' of HCI techniques to understand the changes that needed to be made. We do not claim that either our design process or the resulting course resources are without flaws, or even that we carried out all our own lessons faithfully and consistently. But we will certainly use these lessons as a starting point in our future course designs.

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