The Object Shop – Using CD-ROM Multimedia To Introduce Object Concepts

Mark Woodman[1], Andrew Law[2], Simon Holland[1] and Rob Griffiths[1]
[1]Computing Department/[2]BBC OU Production Centre,
The Open University
Walton Hall, Milton Keynes
England MK7 6AA

Email addresses: M.Woodman@open.ac.uk
AndrewL@oupc.bbc.co.uk, S.Holland@open.ac.uk, R.W.Griffiths@open.ac.uk

ABSTRACT

This paper describes key features of a new multimedia CD-ROM pack produced by television makers in collaboration with computer science educators – by the BBC for the Open University Computing Department. The pack, The Object Shop, forms an early component of an undergraduate course which introduces object-oriented computing and software development to students new to computing. Building on the results of empirical evaluation, The Object Shop has been designed to help students with no programming experience to understand core object programming concepts. Throughout the CD-ROM, video, animated graphics and an underlying object-oriented simulation of a virtual shopping environment provide an accessible introduction to the central ideas of object-oriented programming. The key power of the multimedia approach is that the student-user is able to gain a sound operational understanding of concepts before learning the details of programming code or syntax. Users can continually monitor their progress through a series of task-based, assessed exercises.

1 INTRODUCTION

The BBC has been working with the Open University (OU) for over twenty five years in producing audio-visual support for distance education degree level courses. For the last twenty years the BBC has primarily been concerned with the delivery of linear media. Some of this linear teaching material has been delivered in the form of broadcast programmes (radio or television). Transmission is an essential requirement to reach the full range of OU students and to provide open access to the public of at least some parts of university education. Some programmes will attract an audience of 350,000 people, and in total up to 3.5 million viewers see something of an BBC/OU programme each week in the UK. However, over 50% of the BBC contributions to OU courses is in the form of non-transmitted video or audio cassettes. It is recognized that the transmission media are

effective at inspiring or catalysing an interest in studying a particular subject, while tape-based media are well suited to providing more targeted support to individual students or groups already engaged in studying. However, both transmission and tape-based media form essential and integrated parts of courses.

BBC craft standards in video and graphic design are being applied to non-linear teaching and learning materials, specifically to multimedia on the Internet and on CD-ROM. Because Internet bandwidth and access are not adequate, currently most delivered multimedia products are CD-ROM-based. The OU's new introductory computing course, *Computing: An Object-oriented Approach* [1], is following this pattern. For this course the BBC is producing twelve new documentary TV programmes, one video cassette and three CD-ROM packages.

The paper is organised as follows. In Section 2 we outline issues concerning the various media the BBC and the Computing Department have been using to teach computing. Following that we concentrate on The Object Shop CD-ROM: in Section 3 we describe the primary aims for The Object Shop; in Section 4 we review the main features. In Section 5 we discuss some of the many teaching issues that have had to be addressed. Note that due to space limitations many features of the system cannot be detailed though some can be inferred in part from the screen shots provided.

2 EXPLOITING NON-LINEAR MEDIA

The aim of the TV programmes is to excite and broaden a student's knowledge with either:

- general documentaries on broad based subjects – e.g. Human–Computer Interaction, the History of Software, Computer Security;

- case studies in the U.S.A., Canada and Europe on the use of object-oriented and non-object applications in a variety of domains – e.g. in the arts, building design and construction, manufacturing, the financial sector.

These broadcast programmes are complemented by specific text-based teaching (on paper and via the Internet); they are also implicitly supplemented by teaching in other parts of the course. However, none of this material is designed to provide further illumination by repeated watching or to provide greater depth through

multiple study paths: it is linear and non-interactive.

The video material provides extensive location-based resources to help students with their understanding of object-oriented analysis and design. Although it is not interactive it is much more open to non-linear uses, inasmuch as it can be combined with its complementary text-based teaching in a variety of ways. So, for example, a student can study some ideas of object-oriented analysis before seeing them in action on the video or can watch them in action on the video first. Furthermore, student assignments which apply to the video can change its use from year to year.

By contrast, the multimedia CD-ROM packs provide a number of functions and are capable of being used in ways that their designers did not foresee; they are non-linear and highly interactive. The three packs associated with the course are as follows.

The Map CD-ROM: Because of the amount and complexity of materials and activities for a course on object-oriented and network computing – especially due to the mixture of paper and computer based materials – we have decided to go further than the normal paper 'study guide' to an interactive navigation tool, and provide an interactive 'map'. This provides the basis of a personal study manager. Much of the course is presented electronically and so the graphical, layered map will help students identify major course components, time scales, goals, assignments etc. So this tool will help students understand the breadth and depth of their course. It gives them an impression via the use of multimedia of:

- the broad content of the course

- key calendar events

- key tasks

The Net CD-ROM: This provides students with an opportunity to explore key features of networks and operating systems. Rich graphics combined with more complex underlying simulations will provide the opportunity for the user to design and build their own (small!) version of a network system. The task of building the network system is presented in several stages; at each stage the user is presented with specific goals and supported with associated technical and conceptual resources. The user is able to monitor their progress in design through question and answer sessions at each stage.

The Object Shop CD-ROM: This provides an introduction to the concepts underpinning object-oriented programming. The rest of this paper describes this third multimedia CD-ROM.

3   THE OBJECT SHOP – OVERALL AIM

By the end of the course all students should have gained a substantial introduction to most aspects of practical computing, including object-oriented software development and network computing. As well as a strong conceptual grasp of the field the students should also acquire skills in Smalltalk programming. However, an ability to program in a specific language is less important than an ability to develop feasible (object) models of software and to reason about them. We strongly believe that programming experience is an essential part of the course but learning about the concepts of object-oriented programming should not necessarily be dependent solely on practical programming exercises. Hence, a primary aim for The Object Shop is to develop and test student reasoning skills outside the programming context.

A related aim was to prepare students for object-oriented programming; one of the problems facing us as course designers was to find ways to involve students in thinking in an object-oriented manner from the start, even before significant practical programming experience had been gained. We have used a group of developmental testers who act as students during its development. Colleagues with specialist evaluative skills collected and analysed feedback from these guinea pig students that persuaded the development team of the need for students to interact with a system to concretise concepts before the minutiae of programming was addressed. Indeed it would be some weeks into the course before the students would again enough knowledge of syntax to explore interesting and challenging concepts in object-oriented thinking within the activity of programming. So providing additional means of conveying these ideas through practical activity was another aim of this CD-ROM pack.

The key concepts from object-oriented programming covered before students learn any significant amount of Smalltalk syntax. are: class, object, encapsulation, state, messages and methods, attributes, message/method arguments and replies, hierarchy and inheritance, and polymorphism.

Another aim was to provide a remedial facility for students who run into difficulties while programming. The Object Shop is a straightforward, game-like environment which can be used to explore ideas without struggling with aspects of the Smalltalk environment.

The final aim we outline here is to provide a rich scenario for later teaching of analysis and design. We have found that learning the detail of new scenarios is both time-consuming and unrewarding. The shop is both familiar from everyday experience and from use of the system itself. This has allowed us to include open-ended situations which we can explore in other parts of the course. For example, we omit to give the protocol or discuss the attributes of some objects in the system; we show the stock room object being used but leave out ant analysis of its behaviour and possible attributes.

In summary, we have set out to teach a general object-oriented computational model that does not conflict with Smalltalk or other object-oriented languages and to establish a conceptual model that will aid reasoning. The multi-modal (sound/pictures/text) presentation capabilities of multimedia were chosen to enhance the traditional text material to accomplish these aims.

Figure 1: Entrance To The Object Shop

message with an argument that moves them off the shelf into the microwave oven. and the oven can be sent a message to be turned on at a particular power setting. Both the message to move an article and the one to set an oven's power setting require arguments which are selected from a pull-down menu in a controller; this allows students to become familiar with the notion of arguments.

The controller includes a simulation of a TV (top of Figure 3) in which comments on the behaviour of objects is shown thereby exposing the concept of semantics. On upper floors a representation of message answers is given and an inspector on the attributes which make up the state of an object are also shown, thereby exposing the concepts of message answer, state, attributes and inspection. Thus, the controller is vital in making students familiar with ideas which can be difficult when encountered in a programming environment, no matter how careful that is constructed [2].

Part of the oven's protocol is to cook whatever it contains. Sending an oven a message to cook its contents results in it sending to the contained object the message to heat itself. All objects that have a 'heat yourself' message in their protocol, will accept the message and change their state. For many objects (e.g. popcorn) this will enhance their value; for others it will diminish their value or destroy them (e.g. ice cream or a plant). The objects which can be placed in a microwave but which do not have 'heat yourself' in their protocol, such as some durable articles like metal cutlery, will cause an exception – with a consequent undesirable effect on the microwave oven! Activities such as these bring out important ideas to do with message protocols, polymorphism, behaviour and exceptions.

An article can be moved to a basket and the contents of the basket can be 'brought' to a till for their total value to be calculated and for the goods to be paid for with the usual sort of credit card transaction which checks if there is enough credit in the user's account. However, to expose state dependant behaviour we allow the user to haggle over the price of goods if an article's 'health' (see Figure 3) is not 100%, maybe because it has passed its 'sell-by' date.

4   EXPOSING OBJECT CONCEPTS

The Object Shop presents itself to the user in an immersive virtual reality style (it was developed in Director 4 with graphics from 3D Studio). The user is given the task of passing through four floors of the shop and buying the component articles required for a particular event. Figure 1 shows the narrator pointing out the various floors and other generally useful facilities.

The event is a three course dinner and so food, items to enhance the atmosphere, and durable goods such as plates, and cups are all available for purchase. Purchases are made using credit cards, where credits must be earned in a game-like way by attempting self assessment questions available in the system. The shop is populated with computational objects, not just those which can be bought. The student can interact with many directly but some (e.g. the stock room) can only be sent messages by directly manipulated objects (e.g. the till.).

Each floor contains objects such as tills, credit cards, a calendar, saleable articles of different classes, and container objects such as baskets and a microwave oven.; see Figure 2. A student can directly interact with each visible object in the usual WIMP style via pop-up user interface 'controller'. One of these is shown in situ in Figure 2 and presented in detail in Figure 3; it is labelled dog_002 to represent the notion of object identity. If the user clicks on an object, its controller becomes available. Controllers vary in the detail they offer, according to the difficulty of the concepts, i.e. according to which floor of the shop the user is on. On the lower floors the controller simply allows the user to act upon the object; the message protocol for the class is shown, divided into those messages that can be sent directly from the controller and those that only other objects can send. So, for instance, articles on the shop shelves can be sent a

5   TEACHING ISSUES

It is expected that students will come to the system with a wide range of experience and expertise. The Object Shop domain was finally chosen from a long list of

Figure 2: Floor 2 Articles In The Object Shop

the controller's panes provide increasing amounts of information. First concerning the object's main methods (shown as English language descriptions) and attributes (attributes and values shown in English). By the fourth floor the user can inspect the object's class. Also additional tools become available as the user moves up through the floors. A dictionary on Floor Two shows a list of all the objects known to the system on that floor (but not necessarily seen as graphical representations by the user), and on Floor Three a tracer provides descriptions of the main message passing events (and attribute changes) that take place following any user actions (many of which would not be obvious from simple observation of the objects' surface behaviour).

On entering each floor users are shown an introductory generic animation. The commentary for these introductory animations introduce some of the basic terminology to be illustrated by the behaviour of the shop's objects. On leaving the floor users can view a review animation. Whilst the introductory animation is presented in a generic, abstract format, the review animation points to particular events or phenomena on this floor which illustrate key concepts.

Self-assessment questions are associated with each floor and answers and explanations provided. The latter often involve members of the academic team

The task of obtaining and heating items for a three course dinner cannot be completed without buying objects from each floor. However, not only do users have to visit each floor, they are not given enough credit to buy all the articles required for the task. So on each floor they have three activities which will provide them with more credit.

The object hierarchy for the shop had to be sufficiently rich to allow us to introduce the concepts outlined in Section 3. Consequently there was considerable work to be done to come up with a story of sufficient complexity to match reality and to expose the concepts but simple enough for the detail to be fully understood by students. Part of the hierarchy is given below:

    Article
        Non-durable
        Alive
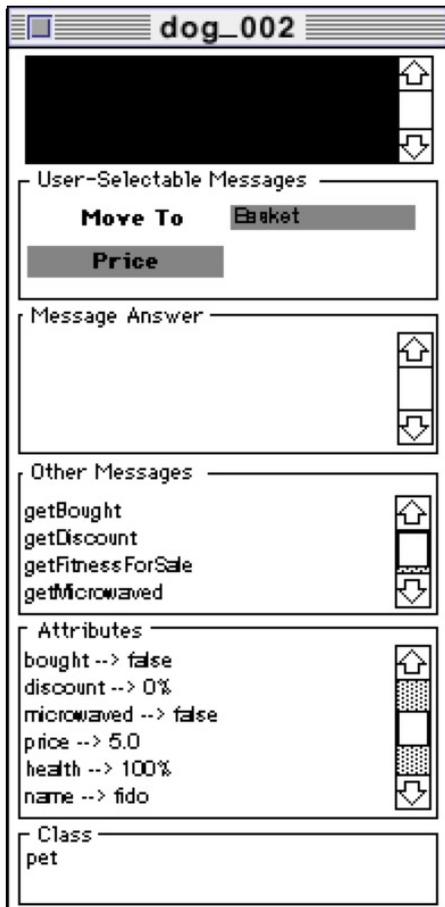   **Pets**
                Parrot
                Dog
        Plants

candidates as one which would not demand an unnecessary 'knowledge overhead'. The task of shopping and bringing together (from a range of options) the items for a three course meal should be within the grasp of all possible students. Some illustrative domains (aircraft control, vehicle ignition systems, air conditioning systems) required significant background knowledge of the domain in order for the user to interact in any significant manner. The designers also had to keep in mind whether the illustrative domain would appeal to all age ranges and both genders (or at least not alienate any one group).

As designers of the system we were acutely aware that many users are left with a variety of questions when using educational multimedia systems; namely 'Where am I?' and 'Why am I doing this?'. With regards to the issue of 'where': The Object Shop has a fairly simple structure (a series of floors) and the metaphor of a real shop with a lift to move from floor to floor designed to aid users in their navigation through the system. With regards to the 'why': users of The Object Shop are left with many open-ended choices about which (if any) floors they will visit and in which order. However, The Object Shop should not be regarded as a purely open-ended exploratori-um – the user is not left unguided or unsupported. On entering the shop users are advised about the help system, about the task, how to complete it and how best to make their way through the shop (although they can chose any route).

The background simulation running behind the virtual reality style graphics has been constructed as close to an object-oriented view of a virtual shop as was possible in Director 4. The implementation code is never shown to the user. However, the controller for the objects becomes ever more explicit as the user moves up through the floors. On the first floor only simple control of the various objects is available. As the user moves up floors

Figure 3: A Dog Object Controller

Cactus
Crocus
Perishable
    Popcorn
    Microwave chips
    BLT
    Carton of milk
    Apple
    Orange
    Banana
    Strawberry
    Ice cream
Durable
  Can cook
    Plate (not metal)
    Cup (not metal)
    Read to microwave coffee drink
  Cannot cook
    Metal spoon
    Metal knife
    Metal fork
    Can of fizzy drink
    Can of baked beans
Container
  Shelf
  Basket
  Microwave
  Stockroom

6 CONCLUSION

We have described the use of CD-ROM multimedia from a TV programme makers stance and explained how it fits with linear broadcast media in an introductory computing course. A major part of the course's syllabus is object technology and the functionality and pedagogic design of The Object Shop system has been outlined. The Object Shop allows students to explore interactively many concepts needed for object-oriented programming, design and analysis.

The system is currently in field test before final refinements are made in the autumn of 1996. The final refinements will be influenced by the media quality standards of a broadcasting organisation. Final revisions will also take into consideration user feedback on the efficacy of the approach and the effectiveness of its relationship with the rest of the course.

Although The Object Shop was written for a course in the distance mode, we believe it will be immediately useful in a conventional situation where student-centred learning techniques are employed.

References
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