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Use-Representations**

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Rank Xerox Research Centre
Cambridge Laboratory
61 Regent Street
Cambridge CB2 1AB

Tel:+44 1223 341500
Fax:+44 1223 341510

DESIGN SPACE ANALYSIS AND USE-REPRESENTATIONS

Allan MacLean and Diane McKerlie¹

*Rank Xerox Research Centre
61 Regent Street
Cambridge CB2 1AB
England*

Tel: +44 223 341517

Fax: +44 223 341510

Email: maclea.euoparc@rx.xerox.com

*¹Current Address: CIS Department, University of Guelph,
Ontario, Canada, N1G 2W1*

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1 INTRODUCTION

Over the last few years we have been developing a perspective on design which emphasises the role and representation of design rationale (e.g. MacLean et al., 1989; MacLean et al., 1991b). We refer to the approach as Design Space Analysis (DSA). One of its key characteristics is that the output of design is conceived of as a design space rather than a single artifact. The approach therefore contrasts with the traditional conception of design which assumes that the eventual output is simply a specification or artifact. The final artifact, although embodying the designer's decisions, does not normally preserve any of the thinking and reasoning that went into its creation. We use a semi-formal notation (called QOC, for Questions, Options & Criteria) to represent the design space around an artifact being produced. This design space is an explicit representation of alternative design options and reasons for choosing among those options. The main concepts we use for the representation are Questions which highlight key issues in the design, Options which are effectively answers to the Questions and Criteria which are the reasons that argue for or against the possible Options.

DSA is a central part of a long term project in which we are addressing a wide range of issues in the software life cycle from early design through to maintenance and re-design. An important set of properties we are exploring relate to the support of group processes in design. Explicit documentation of the rationale involved in the design promises to be a useful aid for communication between members of the design team, between designers and users and between the current design team and future design teams who want to build on or re-use parts of the current design. In addition to the communicative function in group processes, the approach also shows promise for encouraging reflection on the current state of the design, leading to a better understanding and possible improvements. While it is difficult to be very analytic in the “heat” of the creative phases of designing, design projects are punctuated by reviews, reports and presentations. These are natural times for standing back and reflecting on the state of the design. DSA seems to be a useful framework to help structure such reflection—for example, justifying design decisions and considering other opportunities for exploration.

Most of our published work to date has focused on the properties of the approach and of the QOC notation, although some has begun to look at the way in which it relates to design practice. For example, we have used the QOC notation to describe the discussions of pairs of designers working on a simple design exercise (MacLean et al., 1990; MacLean et al., 1991b). The main output of this has been to demonstrate the parallels between the QOC concepts which are the basis of our approach and the concepts “naturally” used by designers. Our main conclusions were that, broadly speaking, over 90% of a design discussion could be directly related to QOC concepts, but also that there are a number of areas where an approach such as DSA might help to improve the effectiveness of the design process—for example, by encouraging an explicit emphasis on important issues and by helping organise, structure and index the progress of the design process. It should be emphasised here that we do not claim QOC to be the only design representation which is necessary—rather it is typically used in conjunction with other representations including physical ones such as sketches, notes and prototypes and conceptual ones such as requirements, lists of attributes, analogies and scenarios (MacLean et al., 1991a, 1993).

The aim of the present chapter is to describe in more detail ways in which a QOC representation builds on and relates to other design representations. We do this in the context of describing a twelve month project in which we explored user interface designs for future educational hypermedia systems. We take the scenario (or more generally, “use representation”) theme of the book as a focus and develop two threads. The first thread describes the generation and evolution of a set of Criteria which guide the design. In the present case, these Criteria are strongly grounded in a consideration of how the system will be used and they act as a reference to help guide the design process throughout its lifecycle.

The second thread considers the relationship between the QOC representation and use-oriented representations such as tasks, scenarios and story boards. The main theme of this thread is to illustrate the ways in which a QOC representation provides a mechanism to focus on and abstract from salient features of these other more concrete representations. The QOC representation therefore complements the other representations by summarising and generalising their key attributes.

2 THE DESIGN PROJECT

2.1 Process

The examples used here are drawn from a twelve month project in which we collaborated with the Open University using QOC to help design hypermedia interfaces for presenting course material (currently text books, course notes, and videos). The five-person design team is distributed across two geographical locations, about 60 miles apart. The design activities include individuals working on their own, the use of various forms of electronic communication, and face to face meetings of all or part of the project team. Many design related issues and ideas are informally recorded in personal and group notes and sketches, electronic mail messages, posted letters, and fax documents. From these various artifacts of the design process, one member of the design team has also had responsibility for producing a record of design issues and decisions using the QOC notation. Design spaces around approximately 200 QOC Questions were produced in either hand or computer drawn formats. They were used both as independent records of design reasoning, and to organise and index the variety of other design representations used in the project. More details of how QOC was used in this project can be found in McKerlie and MacLean (1993, 1994).

2.2 Aims

The goal of the project was to design a hypermedia interface to accompany Open University course material on Human-Computer Interaction. Some of the key requirements were to balance *guidance* using various pedagogic techniques with *flexibility* to accommodate various learning styles. The hypermedia learning environment was to emphasise the application of theoretical concepts in the real world. This implied support of learning by experience as one of the learning styles. Since the users would have wide and varied experiences, it was important to *minimise complexity* in the interface as well. These key requirements formed the starting point for developing the design Criteria to which we will return in the next section.

3 GENERATING AND DEVELOPING THE CRITERIA

We started the design process by considering the key requirements mentioned in section 2.2. We considered various user interface styles which might be appropriate and decided that a next step should be to determine suitable metaphors to guide the design. We also began to develop a more detailed set of Criteria to support the requirements (which are themselves basically high level Criteria). Initially this was done by brainstorming within the design group. Much of the discussion involved considering user tasks and casting these in terms of Criteria which the design would have to satisfy to support the tasks. For example, more specific concerns in the area of *supporting pedagogic guidance* would be helping the user to *retain, recognise and recall* the information presented and to support the *comprehension of the content*.

3.1 Selecting a Metaphor

The decision of which metaphor to pursue was extremely difficult. Figure 1 is a QOC diagram which shows as Options a number of metaphors which were discussed and some of the specific Criteria which were considered relevant in helping to choose among them. It also shows a decision matrix which summarises the assessment of the Options against the Criteria. (Much of the QOC in this project was produced using paper and pencil. The hand drawn figure is taken directly from the original corpus).

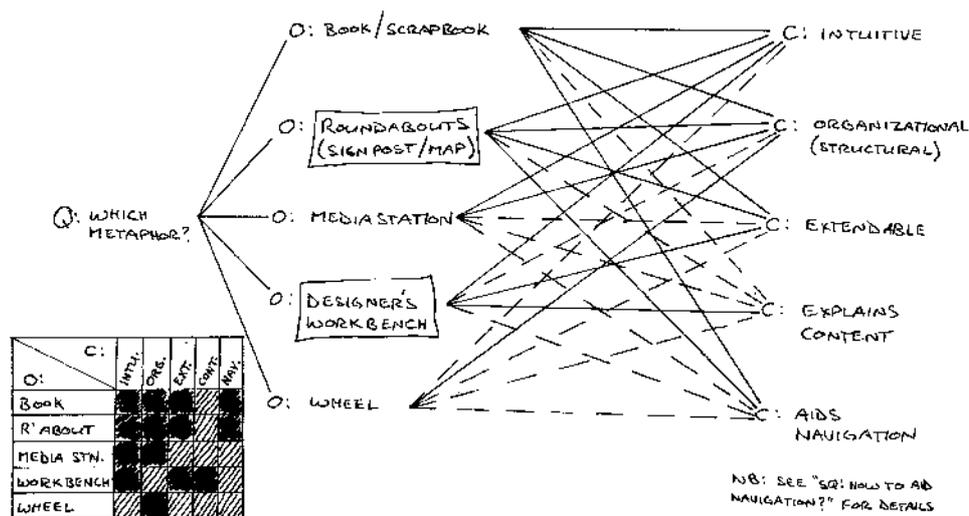


Figure 1: QOC diagram supporting the choice of “workroom” and “roundabout” metaphors. Solid lines between Options and Criteria (or solid boxes in the decision matrix) represent positive Assessments (i.e. the Criterion supports that Option) and dashed lines (or shaded boxes) represent negative Assessments.

Two of the Options were eventually decided to be worth exploring further (the boxed Options in Figure 1). The first was a sign-posting/map metaphor which we called “roundabouts”, (traffic circles for North Americans), and the second a metaphor focussing on the manipulation of objects, which we described as “workroom”.

The roundabouts idea is based on selecting routes which run through and connect the content material, making use of conventions normally associated with driving through roundabouts. The roundabouts therefore indicate choice points and the possible routes out of them the specific choices which are available. The emphasis is therefore on reflecting the structure and organisation of the material and supporting navigation through it in a fairly rigid way.

The workroom metaphor is based on manipulating objects (e.g. file drawers, equipment, etc.) in order to find information and derive feedback from actions and queries. The underlying concept therefore places emphasis on exploration and construction, in much the same way as a keen handyman might do in pursuing a home improvement project, making use of available materials and constructing something new out of them. However, in the present case the intent is to allow students to explore available information and manipulate it to help them discover relationships and learn new ideas.

The assessment links in Figure 1 of Options against Criteria reflect our positioning of the two metaphors. The roundabouts metaphor is structurally based; able to reflect the *organisation* of the course material. The workroom metaphor, in contrast, could be made to reflect the *content* of the course material (e.g. the interface designer's workroom and expertise).

Mirroring the content of course material in the metaphor was considered an important way to provide pedagogic guidance. For this reason the workroom metaphor became the favoured Option. However, the workroom (unlike the roundabouts) lacks an inherent *structure* and was therefore judged to be weak on its ability to provide *navigational* cues. This became the central challenge for developing the workroom metaphor and we concentrate on it in the examples used in the rest of this chapter. In fact, much of our design effort focussed on developing the workroom metaphor, paying particular attention to implications for navigation as more detailed design developed. In other words, Design Space Analysis was used to help explore issues around something which was recognised as a critical area of the design— we did not use it for every detail of the design space (see MacLean et al., 1991b for more discussion of this point).

3.2 Exploring Navigation

Let us now look in more detail at how the Criteria began to evolve. We noted that “navigation” was used as a Criterion in Figure 1. At this level of detail it reflects a fairly crude and general kind of task, but the level of description is adequate for gaining an initial understanding of the properties of the different metaphors being considered. However, it is important to note that the weakness identified on the workroom metaphor relative to navigation encouraged us to explore it in more depth to try to improve that solution. The navigation Criterion then became the basis of a Question which pushes on understanding what is relevant about navigation in rather more detail (Figure 2). This helped reveal a number of common devices for supporting navigation, such as maps, signposts, tables of contents, and association between objects. Perhaps more importantly it encouraged us to consider a more detailed set of navigation tasks (represented as the Criteria in Figure 2). Since this part of the design space explores navigation in a generic way, its results could potentially be applied to refine interfaces based on either the roundabout or workroom metaphors. An interesting insight made clear here is that maps and signposts satisfy different Criteria, with the implication that if used together they could satisfy all Criteria.

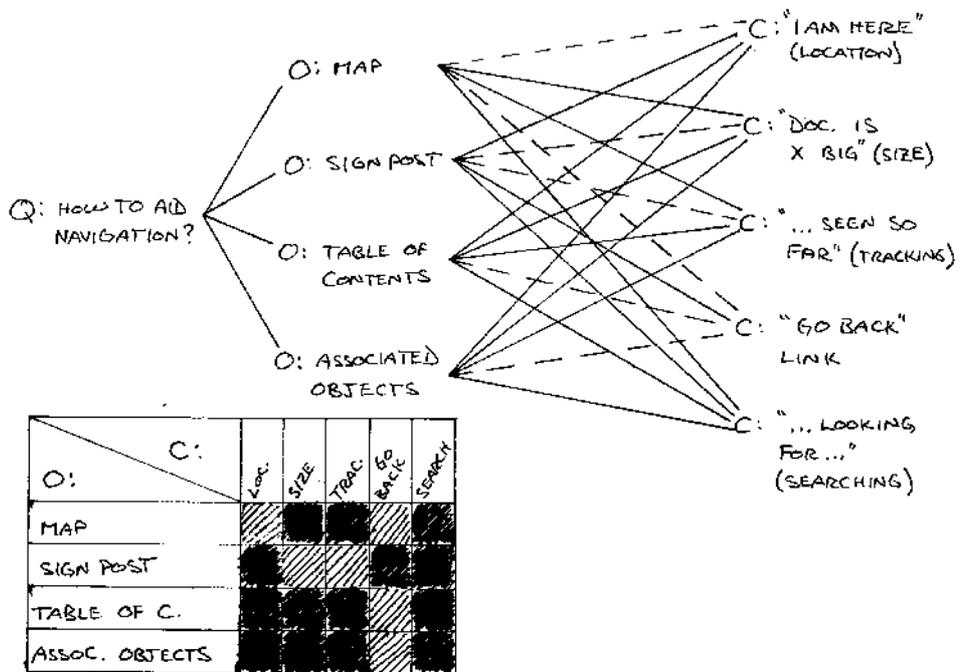


Figure 2: QOC diagram showing different navigation properties

3.3 Tasks and Criteria

It has already been noted that many of the Criteria we developed were derived from tasks the user would be expected to perform with the system. In this context, a working definition of what we mean by a task is that it reflects a discrete and relevant activity which the user must be able to perform. That activity is then reflected in the design reasoning by a QOC Criterion. The important point for now is that such tasks characterise a use-situation which in turn suggests Criteria to be included in the QOC design space. In a comprehensive representation of the design space, the task itself acts as part of the argumentation justifying the presence of the Criteria derived from it (see also MacLean et al. 1991b).

We should stress, however, the Criteria are not exclusively task based. For example, the Criterion of “intuitive” in Figure 1 is at least once removed from a task—it may be a means to a task based end, but that relationship is not made explicit here. More generally, one of our goals with Design Space Analysis is to support the integration of multiple perspectives within a design space (e.g. see Bellotti, 1993 which includes system-based Criteria). Task based Criteria are therefore only one perspective and the reader should not over-generalise from the examples given here.

In many ways these tasks are very similar to the kinds of tasks which Carroll and colleagues extract in the task artifact approach (e.g. Carroll and Rosson, 1992). However, Carroll and Rosson use a notion of “basic tasks” which attempts to define the level of abstraction at which tasks are characterised. We prefer the notion of “relevance” which tries to articulate the task (or Criterion) at the appropriate level for the kind of design deliberation being undertaken. For example, the Criterion of “navigation” was appropriate for discriminating among possible metaphors in Figure 1, but more specific navigation-based Criteria were necessary to evaluate the more detailed navigation aids represented in Figure 2.

It should be noted that a metaphor itself can be a kind of use representation as it relies on familiarity with a given domain to assist in the transfer to a new domain. So the roundabout metaphor carries with it use implications of following directions and the workroom metaphor implies assembling things. Metaphors as use representations will not be explored any further here, but more detail can be found in MacLean et al., (1991a).

- provide pedagogic guidance**
 - aid retention, recognition, & recall
 - aid comprehension of content
 - provide organisation and structure
 - emphasise content (rather than interaction)
 - extendible (i.e. in terms of metaphor)
- provide flexible learning**
 - support quick learning
 - support quality learning
- minimise interface complexity**
 - intuitive
 - aid navigation
 - “I am here” (location)
 - “the document is ... big” (size)
 - “this is what I've seen so far” (tracking)
 - “go back” link
 - “I am looking for...” (searching)

Figure 3: Initial Criteria developed in considering suitable metaphors and some of the navigational issues.

Keeping track of the evolving Criteria is a useful way to encourage coherence in the design by making sure that Criteria which were important early in the process do not get forgotten later on. The Criteria can be re-used and further refined throughout the still more detailed design explorations which occur later in the process. We find that a useful way to support

this is to maintain a list of Criteria throughout the design process. Figure 3 gives a summary of the relevant Criteria which were used up to the point just outlined in the process we are describing here. (We will continue to show how the list developed as more detailed design is described in the sections which follow).

4 USE REPRESENTATIONS AND QOC

A QOC network is only one of several design representations. Others include the lists of Criteria, sketches, story boards, screen shots, usage scenario descriptions, excerpts from documents which were important parts of the history of the development and of course textual descriptions. Multiple representations such as these are critical for providing adequate descriptions of the intended design. They have different properties which complement each other. Of particular interest in this chapter are the variety of representations which emphasise use of the system being developed. This section focusses on some of these use representations and explores how they relate to QOC, whether helping generate QOC elements, evaluate them, or simply provide a complementary representation.

4.1 Scenarios

In contrast to the discrete task representation, discussed in the previous section, which is reflected in a single Criterion, a scenario is a richer and more “dynamic” use representation. It represents the set of actions a user would have to engage in to carry out some activity. These actions may correspond to tasks in the previous section, or conversely a scenario may spell out how to carry out a single task in more detail. The precise relationships depend on the level of description required by the design problem being considered (cf. the navigation example in the previous section). The scenario may be represented in one of many ways—for example as a textual description, as a story board, or as a video. Because of the richness of a scenario representation, its relationship to a QOC design space is correspondingly more complex. That said, a pattern we will see in the relationship is that of the QOC providing a way of abstracting from the detail in the scenario and of highlighting its aspects which are salient for the design problem being addressed.

There are two distinct roles for scenarios. One is in supporting the generation of design ideas, the other is in evaluating a proposed design. We will refer to these as “envisioner” and “evaluator” scenarios. This distinction places different constraints on the scenarios. For example, it is important to have systematic scenarios which are well grounded in the final use of the system for evaluation purposes, but this may be less critical for generative purposes where the scenario may simply serve a role of helping the designer to reason about the design and to help organise ideas coherently. Note that the approach taken by Kyng (this volume) effectively combines the evaluation and generation components in that it derives scenarios which describe an existing work situation and then uses these to help generate a system solution. There is clear value in such an approach for supporting the mapping between the old and new ways of working, but it also implies scenarios which are rather more detailed than some of the ones we consider here. Similarly, developing a systematic set of scenarios is a core part of the approach of Carroll and colleagues (Carroll and Rosson, 1992; Rosson and Carroll, 1995).

4.1.1 Envisioner Scenarios

We can illustrate an envisioner scenario being used to drive the design and contribute to the evolving design space from an example in which one of our team members prepared a written account of some of her design ideas. The document included descriptions of cause and effect as a “user” progressed through an assumed scenario. They also contained sketches of possible icons and sketches of ways of structuring the content information. Entries of designer's insights or “editorial notes” were also present in the descriptions. She sent this material to the other team members well in advance of the next meeting she was able to attend.

The following is a transcription of some text from the document which was distributed:

The open drawer can be enlarged ... and can cover the whole work bench if the user so wishes. Some icons have the same role where ever they appear (I am calling them generic context specific icons): the user clicks on the book and will get "introduction to the topic", for example.

Double-clicking on one of the other (topic specific) icons will open (i.e. lead the user into that area of information). So double clicking on the magnifying glass takes the user into the "Analytical Evaluation" section.

Clicking on "Task Analysis" causes a cascade of the three types of TA to be presented in the form of cascading menus. I am not sure how cascading menus are normally presented (staggered, I think). Anyway what has happened here is this: user selected TA, Macro, and will select Ethics (say) ... which will open a media window....

The first step in using QOC to explore the ideas in the document was to decompose it into issue, solution, and evaluation components. Representing this information as QOC provided a way of organising and evaluating the components of the proposed solution. This process of analysis helped the rest of the design team gain a better understanding of the specific design problems being tackled. Because the document described design ideas in terms of a usage environment (rather than explicit problems and solutions), the process of developing the design space involved inferring the appropriate Questions. This process is very similar to that followed by MacLean et al. (1991b) for representing design discussions. However, in this case we used the result as a "seed" to begin further exploration of the design space. It acted as a basis for critiquing and evolving the design solution—i.e. we directly used the QOC as a resource to gain further insights into the design problem and to lead us towards a more effective solution.

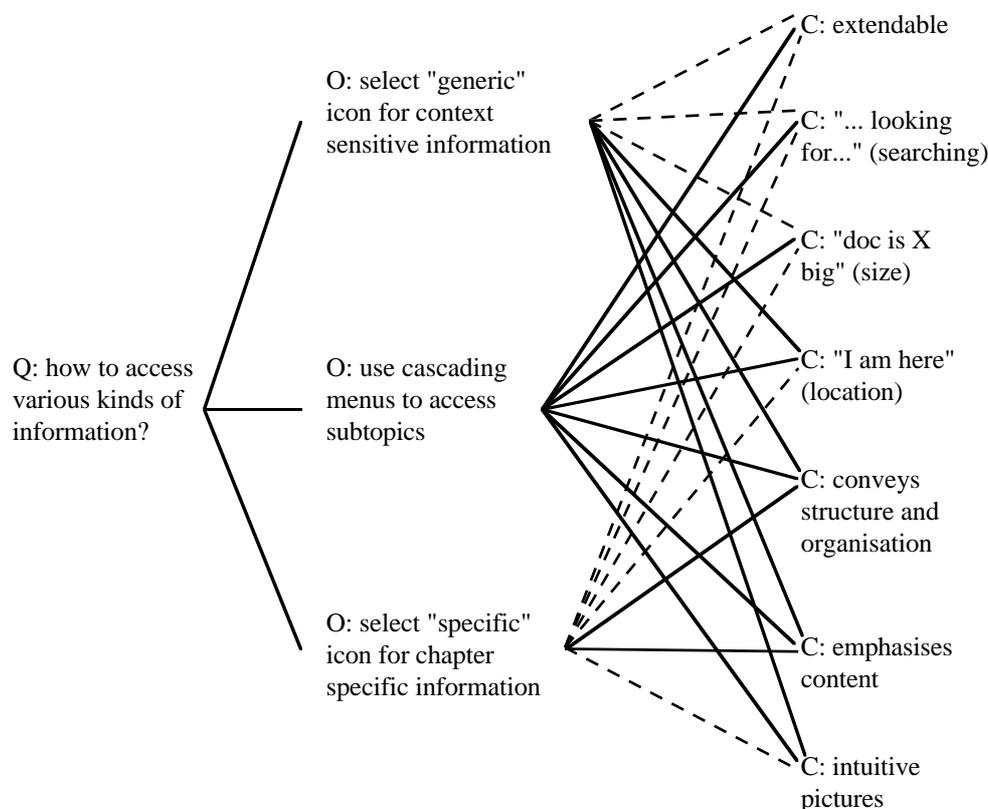


Figure 4: QOC diagram showing the analysis surrounding the use representation fragments from the scenario document.

The analysis showed that the fragments provide a common function: access to information. Figure 4 shows the QOC analysis which revealed that as three Options, they solve the same problem. This is an important insight for overall consistency. The Criteria in Figure 4 emphasise our interest in providing support for navigation. For example, *searching*, knowing your *location*, and knowing the *size and scope* of the document expressed our early ideas about the kind of navigation functions which were desirable. These Criteria are reused from those already listed in the Criteria hierarchy in Figure 3, but were not called on explicitly in the scenario descriptions.

Within the complete written account of the use scenarios, the above fragments were treated as distinctly separate. However, the QOC extracted from the scenario abstracts away from the details with which the scenario was articulated and characterises them in terms of classes of solution (generic icons, specific icons and cascading menus). This is what gave us the insight that all of these were solutions to a single issue of information access. This had not been clear to the designer when she developed the scenario, but is revealed by the form of the resulting QOC. Also, note how the scenarios are described in very concrete terms in the original description (e.g. “so double clicking on the magnifying glass takes the user into the ‘Analytical Evaluation’ section”). The description at the detailed level is clearly not complete, but neither are the abstractions drawn out clearly in the scenario articulation. Summarising via QOC appears to help encourage the abstractions to be drawn out and emphasised.

Another thing to beware of in this kind of situation is that there may not be a strong commitment to the concrete instantiations used in articulating the scenario, but this is not clear from the descriptions given. For example, the detailed suggestions in this scenario are not necessarily picked up in more detailed exploration of the same issues, however, the more abstract ideas are. We would argue that QOC helps to identify and emphasise the relevant abstractions and helps avoid getting prematurely side-tracked by the detail. This is similar to an example described in MacLean et al. (1991b) where designers are observed revisiting an issue of how many pre-set cash amounts should be offered by a bank Automated Teller Machine. It was striking that each time it was revisited different possible alternatives were discussed, but there was no feeling that the issues were changing drastically. The essence of the issue seemed to be whether there were many or few amounts available—the precise number could be decided later. However, this was not at all clear from the surface level of the protocol, or from the sketches produced. Since such concrete representations *require* detail to make them real, the designer is forced into providing a place holder whether or not there is yet a commitment to use it as a solution to be used in the final design.

4.1.2 Evaluator Scenarios

Evaluator scenarios also involve envisaging what it would be like to use the artifact being designed. However, where envisioner scenarios can do their job even if they are relatively vague, open-ended or even inconsistent, the role of evaluator scenarios is to demonstrate the coherence of the proposed solution relative to its context of use and so the scenario must be more clearly and carefully grounded in the details of the actual or proposed system. From the QOC perspective, such a representation shows how the set of current design decisions (i.e. preferred Options) fit together within a context of use. If the evaluation is successful, the representation of the steps in the walkthrough act as a “holistic” justification for the set of Options over which it is applied (i.e. a broader scope than an individual Criterion can typically provide). Alternatively, the walkthrough may show up flaws in a possible solution. MacLean et al (1991b) describe how in visualising the steps required to use a new bank ATM, the designers might reach the point where the customer wants to select another service, only to realise that the proposed interface neither displays the services available nor provide a means of reaching them. This highlights two things both expressible in QOC: it suggests additional Options to resolve the problem, and a new Criterion of ensuring that relevant facilities are accessible. We did not pursue scenario based evaluation in any depth in the

hypermedia interface design project, although informal examples emerged in critiquing design suggestions such as those described in the previous section.

The scenario based approach described by Carey and Rusli (1995) is similar in some respects to this way of using scenarios since both rely on comparing performance with a system to descriptions of its use. However, it differs in that Carey and Rusli (1995) emphasise the scenario as a description of how the system is *actually* used, whereas we are placing more emphasis here on describing how the system *should be* or is *expected to be* used.

Although it is convenient to discuss envisions and evaluator scenarios separately to draw out the distinctions between them, it is perhaps more realistic to regard them as points on a dimension. For example, the developing QOC design space described in this chapter gradually became more detailed as the design progressed and the corresponding use representations also included more detail and were used in ways which gradually included a greater and greater evaluation component. This is similar in some ways to the description provided by Rosson and Carroll (1995) for using scenarios to bridge from specification to implementation, which also involves drawing more and more out of the scenario in terms of its implications for system details as the design progresses.

4.2 Graphical Representations

The scenarios discussed so far have primarily been represented with textual descriptions (although there were some sketches in the example described in section 4.1.1). However, graphical representations played an important role in the project. Many of these graphics have “use representation” components of the scenario kind (i.e. they all have a broad scope and explicitly address the sequencing of actions for using the proposed solution).

4.2.1 Sketch from Design Meeting

Figure 5 shows an image from a white board sketch produced during a design meeting which we preserved for our design documentation by using a video frame grabber. It illustrates various components of a workroom interface. The aspect of the design picked up in the QOC diagram in Figure 6 focuses on the provision of navigation cues, and in particular cues which help orient the user to the contents of a folder opened from within the filing cabinet. The basic argument is that the use of animation to show selection feedback and the origin of information is preferable to simply producing a list of labels with the contents of the folder. For example, the filing cabinet drawer would slide open in response to a user selection of the drawer; a file in the drawer would “float” up and reveal its contents on the “white board” in response to a user selection of the file; and as a video played on the white board, it would “launch” link buttons at appropriate stages in the video. In addition, this solution is claimed to satisfy other Criteria such as engagement. In this case, the sketch is not a screen shot but illustrates a number of components of a proposed interface and also illustrates some of its behaviour over time to support the animation.

The sketch in Figure 5 describes a further evolution in the workroom design than that described in the above use scenario (section 4.1.1). It suggests the use of animation to cue users about interface responses to various user selections. As the QOC in Figure 6 suggests, animation is one Option for addressing the issue of how to provide navigational cues. It is successful because it answers “*where am I?*”, “*how did I get here?*”, and “*where can I get to?*”. Because animation is able to show the effect of a user action, it can satisfy more of the Criteria for navigation than the other Option (labels) can. It is also within the spirit of the workroom metaphor (cf. cascading menus which are foreign to workrooms). Note also, that as the ideas for the workroom evolved, QOC analyses were revisited and revised.

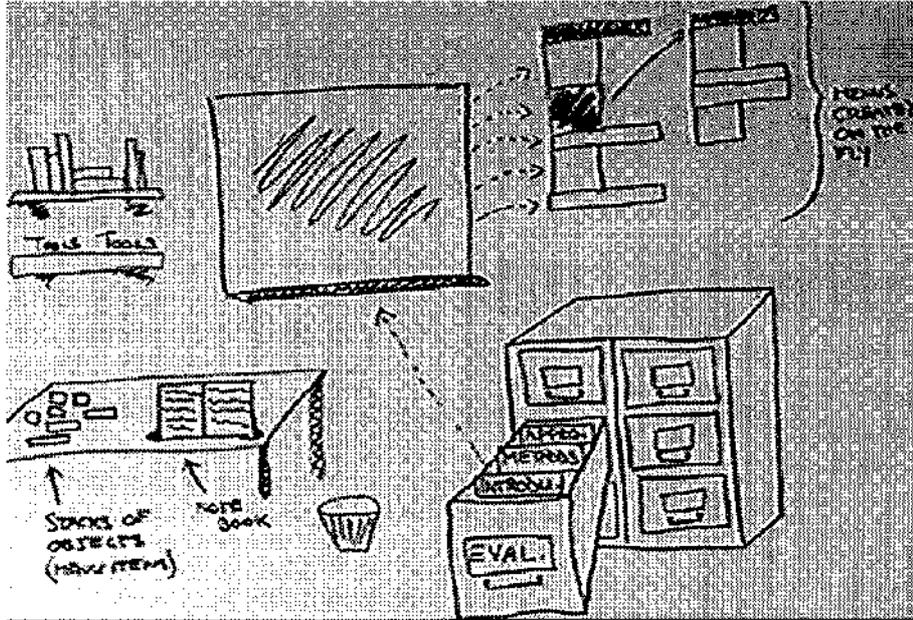


Figure 5: Digitised white board sketch describing the workroom design

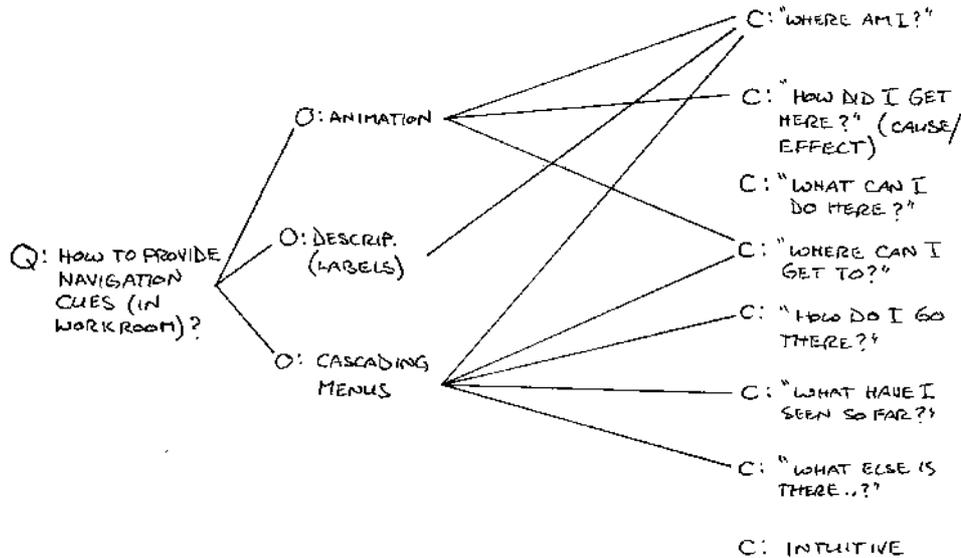


Figure 6: QOC diagram showing the analysis behind the workroom design in Figure 5—only positive Assessments are shown in assessing Options against Criteria.

Figure 6 is really a refinement of the earlier analysis represented by Figure 4. A stronger emphasis on navigation support is represented by Figure 6, however. For example, the Question in Figure 6 is phrased to emphasise the navigation problem. Further, many of the Criteria from Figure 4 have been carried over to Figure 6, but the navigation Criteria take a new perspective. They reflect a set of “questions to answer for successful navigation” from Fischer & Mandl (1990) and McKerlie & Preece (1992).

provide pedagogic guidance
 aid retention, recognition, & recall
 aid comprehension of content
 provide organisation and structure
 emphasise content (rather than interaction)
 extendible (i.e. in terms of metaphor)

provide flexible learning

minimise interface complexity
 intuitive
 aid navigation
where am I?
how did I get here?
what can I do here?
where can I get to?
how do I go there?
what have I seen so far?
what else is there to see?

avoid ambiguity
familiar
visible

provide engagement
integrate media

Figure 7: Revised and updated list of Criteria

Our list of Criteria was updated at this stage, as shown in Figure 7, (additions we have just discussed in italics) to reflect this refinement of navigation Criteria. (Note that some categories have been collapsed for brevity here). Two further general design goals became important in discussions parallel to those presented here. We felt it was important to *provide engagement* for the user to make using the hypermedia fun as well as educational. We also decided that in making use of multiple media we needed to make sure we addressed concerns of *integrating media* appropriately. These two are included in the list as they are important for motivating some of the examples we use here, although they are not the central concerns we address in this chapter.

4.2.2 Story Board

As a different kind of example, Figure 8 shows a story board which was produced to explore the design in still more detail. Each picture in the story board is a potential screen shot and the use representation is produced by the changes occurring in the transitions between the pictures. The sequence of pictures and short text descriptions captured use scenarios whose functionality and appearance closely resembled the resulting prototype. For example, Figure 8 describes the sequence of steps which demonstrates how users would navigate their way to a particular piece of information. Again, this is a refinement of the previous thinking described above and shows more detail of one specific user selection (of a file drawer). This issue is explored in the corresponding QOC diagram (Figure 9): “*how to present the contents of the drawers?*”. In this case the Options considered in the QOC are the *row of labels* (similar to one of the Options in the previous example), *cascading menus* (from the example described in section 4.1.1) and *accordion files*. The accordion files are a solution derived from consideration of the trade-off between sticking strictly to the metaphor (and producing a solution which would be poor on legibility of the result) or breaking away from the metaphor back to the computer domain (cascading menus). Figure 9 describes the benefits of accordion files as: *visibility* (writing can be large enough), *familiarity* (in terms of metaphor or pop-up style menus), and *extendible* (any number of files can be accommodated).

DEVELOPMENT OF INITIAL OBSERVATIONS

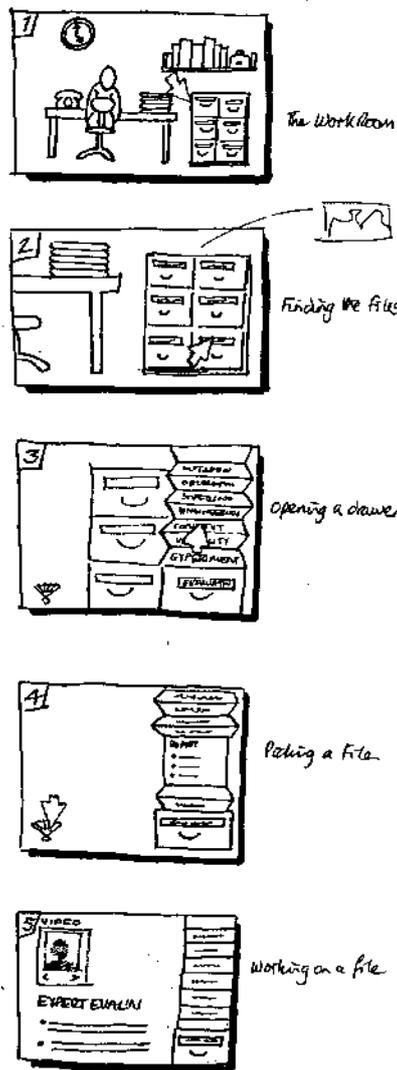


Figure 8: a story board describing a refinement of the file cabinet functionality.

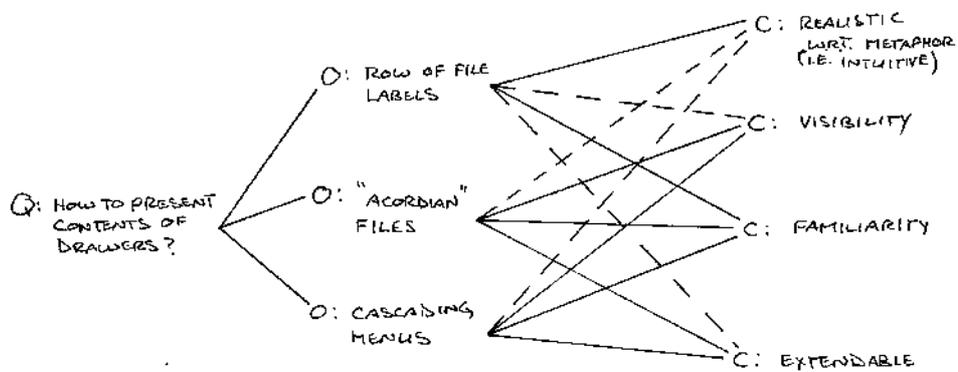


Figure 9 : QOC diagram showing the analysis of the file cabinet design in Figure 8.

4.2.3 Screen Prototypes

Finally, prototypes were built to envision design ideas as well as to demonstrate functionality and usability. The prototypes were often presented to support scenarios which represented a typical use session. Figure 10 is a screen shot from one of these prototypes showing the level of detail used to represent the design idea. Many of the ideas presented earlier are incorporated into this design.

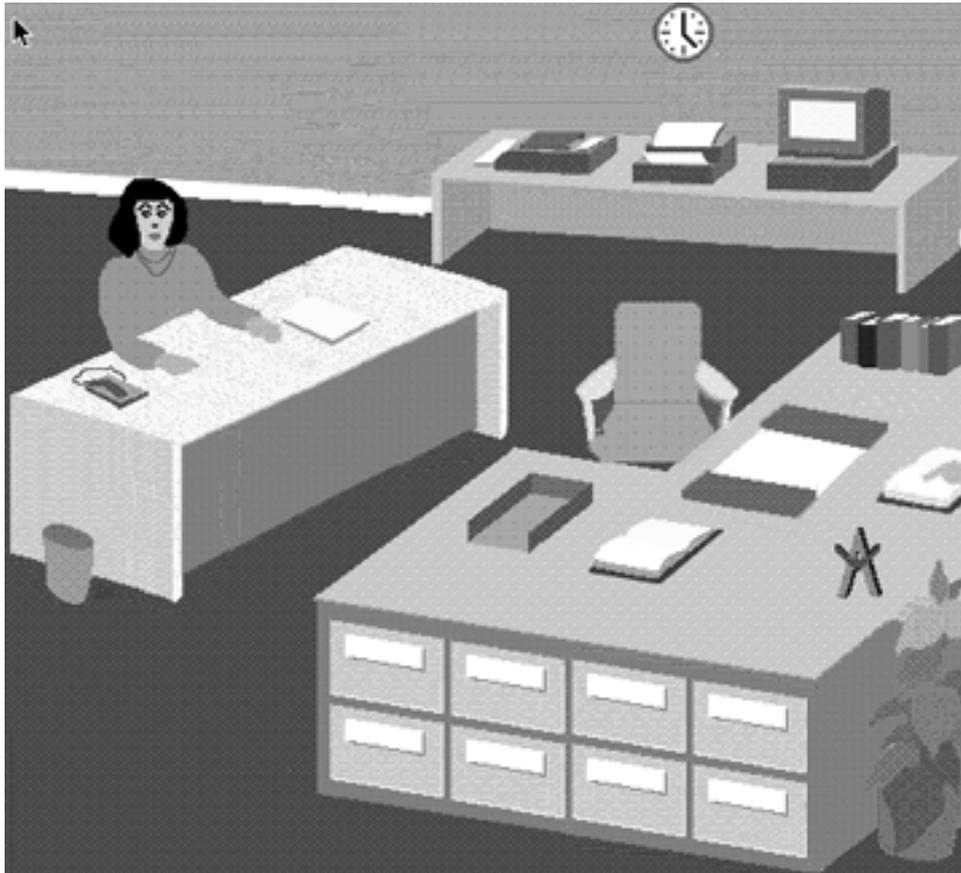


Figure 10: Screen shot from a version of the workroom prototype

4.3 The Criterion List

A major thread in this chapter is the development of an increasingly refined set of Criteria which start from the requirements of supporting both guided and exploratory learning and encouraging the grounding of concepts in practical application. As the emerging designs were described at increasing levels of detail, the appropriate characterisation of the Criteria also becomes more detailed, in part reflecting the increasing emphasis on navigation which emerged as a Criterion to be tracked to try to improve the weaknesses of the workroom metaphor.

- provide pedagogic guidance**
 - aid retention, recognition, & recall
 - aid comprehension of content
 - provide direction
 - provide organisation and structure
 - emphasise content (rather than interaction)
 - extendible (i.e. in terms of metaphor)
- provide flexible learning**
 - user control
 - support various learning styles
 - learn by experience
 - learn by example
 - support quick learning
 - support quality learning
- minimise interface complexity**
 - intuitive
 - aid navigation
 - where am I?
 - how did I get here?
 - what can I do here?
 - where can I get to?
 - how do I go there?
 - what have I seen so far?
 - what else is there to see?
 - avoid ambiguity
 - familiar
 - visible
 - minimal actions
- provide engagement**
 - create interest
 - animation
 - show application to real world
- integrate media**
 - variety
 - appropriate media for content
 - redundancy

Figure 11: Complete list of Criteria which evolved as the part of the design described here progressed. Initial requirements and other high level design goals are shown in bold.

The final list of Criteria developed throughout this process is given in Figure 11. It is represented as a hierarchical list, in which the level of Criteria in the hierarchy is roughly correlated with the level of detail in the design to which they are applied. This is similar to the notion of Bridging and General Criteria introduced in MacLean et al., 1991b and the Criterion trees described by Shum (1991). However in this case we illustrate the development of the Criteria alongside the progress of the design rather than as a more retrospectively produced structure in our earlier work.

5 DISCUSSION

The basic philosophy behind the Design Space Analysis approach emphasises maintaining a focus on the design space and the reasons for making choices within it (MacLean et al., 1991b). The QOC notation provides a way of representing the space, and the main focus in its creation is the gathering, organisation and development of design information (see MacLean et al., 1993). As such, there is no intrinsic emphasis on usability issues *per se*. Nevertheless, one of our aims is to encourage usability to be emphasised without making it the *only* focus to which attention should be given (e.g. see Bellotti, 1993). To this end it is

important to demonstrate the ways in which use representations and QOC design space representations can inform and complement one another.

Complementarity is especially important. The QOC representation is not supposed to be a stand-alone representation. Rather, it summarises the structure of a design space in ways which linear text, diagrams of possible solutions or even prototypes cannot. The terse wording within the various elements in a QOC diagram is seldom comprehensible on its own. It generally requires further detail or familiarity with the content to be fully understood. The value of the notation is to show alternative design possibilities, how they relate to each other and what determines their suitability, in a form which allows these relationships to be examined simultaneously. Compare this to representations such as scenarios of the type discussed in this paper. These show more clearly how the components of possible solutions fit together in a context of use, but do not highlight the differences between possible solutions, far less any reasons for these differences. A similar argument applies to the role which sketches and other kinds of graphical representations play. For example, not only does the sketch in Figures 6 represent the issues which were drawn out in the QOC diagrams, it also represent a rich set of other kinds of design information which sets it in context and indeed which may even represent specific design commitments (but remember the caveat mentioned earlier about concrete design suggestions sometimes being place holders for more abstract entities). In general, if we consider the relationship between QOC and these other forms of design representation, QOC represents local optionality; use representations (or at least scenarios) represent coherence across time in terms of the use of the system; and many graphic representations emphasise coherence across space in term of how various possible components of the design fit together.

In contrast to some of the approaches in this book which aim to produce systematic use representations as a major input to design (e.g. Rosson and Carroll, 1995; Kyng, 1995); Muller et al., 1995, Jacobson, 1995), our approach gives use representations a rather less central role and relies on QOC representations to coordinate much of the design content. When tasks are viewed as Criteria, our approach relies on the designer to provide the argumentation to justify the extent to which the task under consideration is satisfied by the possible Options identified. The relatively informal scenarios we cite illustrate an acknowledgement that designers generally find it easier to work in concrete than abstract terms. In many ways, these are closer to the kinds of things which Erickson (this volume) cites as “design artifacts”. However, QOC also provides a mechanism to help produce abstractions from the scenarios, for example, by encouraging the generation of Questions to encompass several possible solutions. That is not to say we do not believe in more formal or systematic approaches - quite the reverse. For example in the European Esprit funded Amodeus project we are exploring ways in which various approaches to user and system modelling can benefit design, and the role which Design Space Analysis can provide to help achieve these goals (e.g. see MacLean et al., 1991c). Similarly, other chapters in this volume provide us with insights which promise more effective use of systematic use representations (e.g. Johnson, 1995). Nevertheless, we would not want to subscribe to a view of design which *only* focuses on well defined systematic representations. Rather, our goal is to work with a representation to which designers can relate their partially defined and fluid ideas which emerge from design discussion, but at the same time to which more systematic principles and perspectives can also be related.

In summary, there are a variety of ways in which we have found use representations to be of value within the Design Space Analysis framework. Conversely, we have found the framework useful to help us draw out distinctions in the content and design roles of the different use-representations we employed in the project described here.

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