Invited Paper

Intelligent decision support of design using advanced multi-media

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ABSTRACT

Emerging multi-media technologies enable design decision makers to inform themselves and their colleagues more effectively and appropriately than ever before about advances in science, social science, management and technology. This paper is in two parts. Part I discusses the exciting potentials of the multi-media hardware which enables technology transfer to take place in a highly interactive mode. In particular there is discussion of the comparative merits and performance of interactive videodisc, compact disc (CD-DA, CD ROM and CD ROM - XA and CDI) and Digital Video Interactive. Part II is more concerned with software issues of media design and, in particular, details a particular attempt to show how such systems could be used to improve busy design professionals' understanding of technical/social issues.

CONTEXT

According to the Management Group Board of the Institution of Civil Engineers (1) "control is the key word and management and control of time, cost and quality to meet objectives are the key issues" facing future engineering designers. For them the well informed designer is an innovative decision maker in control. This highlights the need for efficient management of all engineering design information. Such information management is becoming increasingly difficult as design methodologies and capital investment programmes themselves become more sophisticated and complex. Now just keeping up-to-date and properly informed, in a manner which does not overwhelm, has become a critical issue. Furthermore design decision makers now have to come up with humanly acceptable solutions, faster than ever before, which are, not only aesthetic sensitivity, but provide value for money. The need is clear - for ready and easy access to relevant and guaranteed information held in a comprehensive data base in a form which informs design decision makers - in the sense that such designers can give better form to their designs through enhanced knowledge.

Footnote: The author wishes to acknowledge members of DIRT who have made major contributions to the work described here and especially Drs Paul Newland and Chris Creed of Portsmouth University.
This is no longer a trivial task for, as Boardman (2) points out, most existing information technology tools have been "singularly unsuccessful in reducing or coping with complexity".

The national design information scenario is further complicated by the scale and fragmentation of much British industry which is responsible for carrying design solutions through to final products - for instance recent surveys indicate there are still over 150,000 general manufacturing small and medium enterprises (SMEs) and 170,000 private building or civil engineering contractors employing less than 7 people. Furthermore, to add to this complexity, design information itself can be portrayed in many different ways: as printed documents; photographs; on-line bibliographic surveys; Ordnance Surveys; videos; British Standards; spatial information in many forms; data sheets; product information and the like; it can also be held on microfilm or fiche; on videos; on 35mm slides; on hard disc; on optical disc; as software; in bubble memory or even be computer hardwired.

The present author believes interactive multi-media could work miracles in providing a cheap and robust single access information medium for designers, that is if the relevant set of comprehensive databases were developed. Interactive multi-media consultants exist to make the necessary databases and optically stored programmes which inform decision making and they now the technology available to develop appropriate systems. All that is needed now is the confidence and the resources from British industry to produce fully developed systems giving the right access to necessary information.

The paper now splits into two parts. Part I discusses hardware issues relating to multimedia. In particular it discusses the vexed problems of systems interfacing and data handling. It then details the potential of optical disc as a suitable medium for storing design information. Part II looks at the software design issues relating to multimedia and gives some concrete examples of successful systems developed by the author. It is important to get the design of the system matched to the needs of the information user if it is to stand any chance of proper communication.

PART I

APPROPRIATELY ACCESSING INFORMING MULTI-MEDIA

According to Aris (3), rigidity of human interfacing, or lack of user friendliness, is a key reason why much of British industry presently fails to capitalise on its general use of IT. Stability and familiarity of both the human-systems interfaces and the data-bank handling are key components of those information systems which satisfy human acceptability. These factors have therefore become the main design generators for the design of those effective interactive multi-media information systems so far developed. When designed well such systems appear "open", transparent or even semi-intelligent to users, almost recognising their needs and acting accordingly in a sort of dynamically 'bespoke' way.

In this respect, since they suit designers modes of designing, WIMP interfaces (window-icon-mouse-pointer) and hypertext/hypercard based systems have become standard in most of the advanced multi-media information systems used by these decision-making professionals. This is because such tools,
techniques and instruments help the inexperienced user, while not hindering the expert. In particular, research by Apple Computers has shown that the mouse, a device for positioning a cursor on the feedback computer screen, is preferred as the information control mechanism by an increasing number of design professionals. Used in conjunction with HyperCard, which portrays data on the screen as a familiar index 'card', the mouse can be used to activate 'buttons' within each card linking it to other cards in a 'stack'. In effect a HyperCard system tries to emulate the free association characteristics of human thought and allows users to create, access and customise information held in digital form on the information system's hard disc. Its success in effective information handling is reflected in its wide and increasing use.

Such semi-intelligent knowledge based interfaces and data-handling systems are beginning to provide the sort of 'openness' all users now demand. In the past the HyperCard based system's major limitation related to the restricted nature of the computer databases open for recall. However, video adaptor cards and associated software - such as the Videologics' DVA 4000 and IBM's M-motion - open HyperCard access to mass storage of text, graphics, animation, stills, moving video, sound, music and numeric elements all held on optical disc. The video adaptor boards digitise the incoming signals, both analogue video and audio, so they can be used as information on the index 'card'. The boards also allow certain special effects so the user can superimpose graphics over video or stills, they can change the size or position of stills or video on the screen, they make a 'button' of a still and use it to call other cards, and they can simultaneously view several different video images. Both video adaptor boards will accept signals from the variety of sources, such as videodiscs, VCR's and compact disc, that could hold the massive databanks of information needed by our industry.

Organisation of and access to these massive databases has become the most fundamental concern of the information systems designers. Unlike a physical library where every book has a spatio-temporal location and competent individuals can easily build and retain a mental map of where required items are, the black box syndrome of an intangible mega optical storage unit can become an offensive Pandora's box. However, many of the new interfaces already mentioned access massive databases in a manner similar to the way professionals think about design and the making of products. For instance, point and click on a component of a product drawing and this 3-D object, held in a CAD system, becomes the search string which retrieves structural characteristics, manufactures' specifications and optional products, etc. In advanced systems such objects are automatically recorded and any updates (e.g. by dynamic links to manufacturers' source databases) are communicated to the designer by colour changes in the relevant components.

The above indicates we now have the right technology to **access or interface with appropriately informing massive databases**. The only remaining problem is the precise mechanism required to ensure cheap, reliable and high fidelity storage of a range of information sources. The next section concentrates its attention on one suitable medium, namely optical disc technology - a cost effective form of storage capable of mounting the full variety of database formats currently used by British design professionals.
All optical storage media allow fast, easy and reliable computer access to a range of high fidelity, but often unstructured, moving video, still images, graphics, audio sound or pages of text. Different systems allow cost effective storage of different types of information. The following sections describe the relative merits of the key optical media currently available to UK industry.

**Interactive Videodisc (IV)**

Imagine combining 15 hours of audio with over 55,000 still images or 37 minutes of moving video, all in vivid colour. For this is the extraordinary capacity of a single 30cm video disc. All available at random access within seconds or split seconds of demand, comparing favourably with the rate of retrieval from a purely computer-based archive, or material stored on conventional videotape. The videodisc can offer such enhanced retrieval because of the unique method by which video information is accessed. Information is stored in the form of tiny pits 'burnt' into concentric rings on a thin aluminium membrane held within the disc fabric and is retrieved by a well-defined low density laser beam trained onto the disc's reflective surface. A protective tough plastic coating on the disc surface, combined with the friction-free playback mechanism, provides a low maintenance robust system. Eventually this information is distributed to output devices such as a monitor. See Fig. 1 below for diagram of the system.

![Diagram of typical interactive video system configuration](image-url)

**Fig. 1 Typical Interactive Video System configuration**

Team the rapid reflexes of the videodisc player with the organising, calculating, text and graphic powers of the computer and you have interactive videodisc - a system that can respond instantaneously to the different needs of the user. All professional videodisc players are equipped with an RS232 serial communication port. This communication facility is the same as that provided on many personal computers to enable them to be used with printers, modem and so on. Basically it allows the information to be sent and received serially as a
'string' of data statements. Theoretically it is possible to use different makes of videodisc player on different computers and make them work satisfactorily. The most common way of achieving this is with a video interface/overlay card/board which plugs into a spare slot in any computer. EGA and VGA cards were the early ways of achieving, on the same screen, a combination of (digital) computer text and graphics with (analogue) video signal. However, as already mentioned, some interface/overlay boards now enable a great deal more than this and both the M-motion or DVA 4000 video adaptor cards have replaced the simpler ones as standard cards. They have done this because they offer many functions which originally had to be undertaken in expensive video editing suites.

Under computer control, the videodisc can take on many roles - simple database, trainer, educator, salesman or entertainer. Quite simply interactive videodisc has the ability to provide access to an almost exhaustive library of audio-visual information shown in dynamic and compelling ways, at the highest quality, without degradation in use. It has so far been used in British industry mainly to provide training programmes in the areas such as the design of safety critical systems, car maintenance, marketing, customer care and the like. It has been shown to reduce training costs from £250 per man day to less than £13 per man day, and this includes the cost of purchasing the original IV hardware. There are also a portfolio of videodiscs available for the general management training on topics ranging from 'assertiveness training', 'telephone answering skills', 'financial management' to 'customer care'.

Videodisc players can now cost less than £1,000, video adaptor card approximately the same and, for multiple copies, disc as little as £20. A weakness of this medium is its analogue form and the fact that it is tied to incompatible broadcast standards adopted by different countries. Thus videodiscs made to the PAL standard used in most of Europe are not compatible with ones made in North America in NTSC, or in France in SECAM. The next optical medium discussed does not have this drawback.

Compact Discs General (CD-DA, CD ROM, CDI and CD ROM - XA )
Compact disc technologies offer another compelling optical disc storage mechanism. These include CD-DA (Compact Disc Digital Audio) for high quality audio, CD ROM (Compact Disc Read Only Memory) for mass data storage, CDI (Compact Disc Interactive) for complete interactivity with pictures, text and data, and also CD ROM - XA (enhanced CD ROM) to enable storage and retrieval of standard images, graphics and sound as well as text. Like videodiscs, compact discs are based on the reflective optical disc. However, they are only 12cm in diameter and the data is stored on the disc in digital rather than analogue form. Fortunately, there is a common standard between all forms of CD, so such optical discs can be used anywhere throughout the world. Unfortunately, the problem with existing forms of CD is that it is impossible to store more than a very small amount of moving video on each disc. To produce high quality video images, data must be displayed on a screen at a rate of nearly 15 Mb per second. Such a video transfer rate is well beyond the reach of most low cost systems. As we shall see later some CD systems try to overcome this using compression and decompression devices.

CD-DA (Compact Disc Digital Audio) is the most familiar form of CD technology. It delivers up to 72 minutes of broadcast quality stereo audio on a relatively cheap and durable player. It is remotely produced in a factory environment to a physical format conforming to standards set out in the "Red Book". Interactive CD-DA players can cost as little as £200 and individual discs
CD ROM (Compact Disc Read Only Memory) have evolved out of CD-DA and have the same physical characteristics and specification, as laid down in the "Yellow Book". Unlike CD-DA, CD ROM store only large quantities of digital data - up to 600 megabytes - of various forms. Each disc can store the equivalent of up to 200,000 pages of text, enough storage to contain the information on all 18 volumes of the telephone directories of Switzerland. Like videodisc it is 'read only memory', being made in a factory environment. It can be easily interfaced with existing databases, on most computers, and is now being increasingly built in as a standard facility in the higher level PCs. Now, at a cost of less than £500, it is becoming the preferred storage technique for distributing mass software.

CDI (Compact Disc Interactive) simply extends CD-DA and CD ROM into a multimedia platform. It offers the same data or audio storage as its forbears, but can also handle up to 6000 high quality still images, 20 minutes of quarter screen broadcast video or 20 minutes of 42% screen VHS quality video. The technology is not yet sufficiently advanced to provide full screen full motion video. The higher levels of audio or video produce the best results but take up more disc space. The Phillips "Green Book" sets down a complete systems specification including how data is laid down on the disc, the disc content and the CDI player itself. Once again players will retail for around £500 in the UK. CDI is mainly intended as a consumer product.

CD ROM - XA (enhanced CD ROM) extends the High Sierra specification of CD ROM to add interleaved audio and video. It will not add much to the cost of a conventional CD ROM drive, but will slightly extend certain features of CDI. It will include quarter screen motion video and graphics with simultaneous audio tracks. According to Bayard-White (4) 'CD ROM - XA achieves the bridge with CDI via two audio processors on the CD ROM drive interface card which compresses audio data. The XA standard also overcomes the problem of playing sound by interleaving blocks of audio data at regular intervals between blocks of text, image or programme data. This means that it is possible to synchronise a text display with any audio output - to see and hear them simultaneously - critical for example in developing foreign language learning programmes. Like CDI, XA offers different audio quality from mono speech to stereo sound and two audio channels. The physical form of CD ROM - XA is a plug-in adaptor card to a PC mainly aimed at the professional world. Aside from the conventional PC with VGA display and an ordinary CD ROM drive, the only hardware needed is the XA interface. The XA card has been specified to allow existing CD ROM software to run on XA hardware and CD ROM-XA software to run on CDI. As an intermediate technology XA lies just short of the more complex full motion video systems, although even this constraint may not remain as XA has been designed as a subset of other systems including digital video interactive'.

Digital Video Interactive (DVI)
Digital Video Interactive is similar to CDI but offers 72 minutes of full-screen full motion video, 20 minutes of motion video with 7 hours of voice over and 5,000 high resolution still, or 2 hours of quarter screen video with thousands of textures and 3D objects. It also offers 360 degree panorama views. It has been developed for the PC market and can make use of CD ROM, Hard disc or WORM storage. Bayard-White again, 'DVI is an evolving software based process. At its heart is Intel's 1750 chipset, the most powerful custom processor chipset yet developed for the PC. Perhaps most importantly, the chipset is programmable from software. In short, users will therefore not have to purchase new hardware with
Visualization and Intelligent Design

every new version of DVI. It provides compression and decompression of digital data (see above) on any IBM compatible computer, whatever the storage medium'

Many new applications are being developed for this extremely new optical retrieval mechanism. In comparison with Interactive Videodisc it still has a problem in coping with fast acting sequences especially with large colour changes. However, its flexibility, versatility and usability - it will be able to handle multiple video signals - give it an advantage over other optical media, including IV. Eventually, I expect the developers to overcome its existing fast data handling problems. So far there are few practical applications of this device in the UK and none in the construction industry.

The Benefits of Optical Storage
The benefits of optical storage for British industry are myriad. First and foremost they can store all forms of data and information, to a consistently high standard at any level of detail. The medium is extremely versatile and highly durable. The quality of audio-visual presentation from massive databases are always clear and cogent, to broadcast standard or any lower standard required. Presentations can appear personalised, or factual and can be presented at a convenient time and place, to meet a variety of needs. Images from the system are so good they grab attention and are very persuasive. Hardly surprising, therefore, that Poulter Communications have convinced over 2,500 manufacturers to sell their products by means of optical storage. Relatively speaking optical storage is also an extremely cost effective way of storing high quality images of many different sorts. In conjunction with the right computing technology, both control and interface hardware: they can act extremely patient, but remote and private, teachers; they can provide consistent messages for remote training in the use of standards and codes; they can provide remote help in an intensely human way; they can provide a realistic context for role playing simulations; they can provide a quality sales environment and many more benefits. Finally, they seem to motivate people to want to use them, what better reason for incorporating them into all new information systems.

Informing systems based around highly interactive, user-friendly multi-media databases can be an instrument for beneficial change, if design professionals are motivated to understand their true potential.

PART II

INTELLIGENT DESIGN DECISION SUPPORT - THE EDUCATIONAL SOFTWARE OF MULTI-MEDIA DESIGN

Context
As hinted at earlier the real design problem is usually to know what the real problem is, Rittel and Webber (6). In this respect the new informing technology can be conceived of as a tool which helps designers understand the nature of problems and provides a context to facilitate solutions which enhance the experiences of the individual. To this end the present author, and his colleagues in the Design Information Research Team, have been investigating the role of interactive media in the creation of appropriate experiential learning environments for use in the area of continuing professional design education. Early evidence
suggests such self motivating interactive learning technologies promotes confidence in the acquisition of useful skills and decision making knowledge.

**Repeatability and the Loss of Creativity - A Theory of Improved Communication**

Replication may be a high priority in maintaining the consistency of a manufactured product, but the present research questions such an approach when to task is to find the most effective way of purveying understanding to unique individuals. Unfortunately, learning by 'rote' all too often finds its way into professional education where it fails to influence designers. A good demonstration is a much better communicator for them since it makes explicit the decisions made in the course of the activity. Thus a good demonstration shows a learner what not to do as well as what to do. A skilled performance makes these same decisions invisible. This insight from Olson and Bruner (7) hints at two crucial factors my studies have found to be missing when inappropriate understanding results from traditional pedagogic training and 'rote' learning, as opposed to emotive experiential learning.

Much skilled professional performance, especially complex decision-making, has components of actor, stage and script and is essentially a set piece. As with acting, we believe introducing any form of training development for naive professional learners which simply instigates mere imitation of set pieces, has two fatal flaws with respect to the knowledge learned:

i. no account can be taken of either change on the stage (context) or in the script (content)

ii. no account can be taken of the individual's dignity and how their previous knowledge invokes a truly personal perspective (timing).

Let us maintain the theatrical analogy of learning contexts just a little longer hopefully to aid understanding. Imagine a naive actor (learner), who has simply 'rote' learned a script, being faced with one of those magical revolving stages whose sets she had not seen before. A ninety degree rotation of the stage would produce a totally new set, a novel situation with which our naive (learner) actor would at least feel uneasy. If the script no longer matched the setting what would they do, since their 'rote' learning would have left them without, either the confidence to create a new script for the novel set, or the experience to ad lib around this anomaly until the previous set returns. Imitation of the skilled performance leaves our (learner) actor bereft of truly useful tacit knowledge of how to act in the sort of 'wicked' contexts Rittel and Webber (4) that so often frequent, not only the stage, but especially the real world.

Furthermore, such imitation ignores the personal history of knowledge already held by our naive actor. For sure she may be naive with regard to the nature of the present information, but asking her to mimic without acknowledgement of her personal viewpoint dismisses a wealth of creative thinking. For, learning through imitation negates the development of adaptive ability necessary for real world decision-making of the professional and spurns the possibility for creative self-discovered knowledge. In the end knowledge has to be the acceptance of co-creative distinctions, not the rigid enforcement of another's views, if all individuals are to be given opportunity for creative action in response to novel circumstance.

Seeking to use multi-media technology to elliviate these flaws has been the goal of the remaining investigations reported here.
First Steps - Individuals and Their Learning

In particular the research presently reported first tackled the problem of individual preference for the assimilation of knowledge. Various studies including my own, Pepper (8), Thompson (9), Newland et al (10) had already looked at the approaches different individuals take in order to acquire knowledge - that is in order to act viably in their professional arena. The field of learning has been extensively investigated by Kolb (11) who summarised the various approaches open to an individual by a learning cycle, shown in Fig.2. Kolb's model portrays an ideal situation where the learner has immediate experience of the world, steps back to reflect on this feeling in context, thinks up an abstract model to explain the phenomenon, which is then tested by further active exploration. These doing actions cause the learner to re-sense the world and so begins a new learning cycle.

![Figure 2 Kolb Learning Cycle](image)

It might be thought that well balanced individuals would be those who follow this idealised learning circle. For this should give them a well balanced view of the world. However, Thompson's (9) work indicates that such a fully rounded view may be impossible and even counter productive to real world living, learning and especially complex problem decision-making. His view is based on the observation that in the real world people are not simply individuals learning by themselves, rather they are social animals in continual negotiation with each other as they learn. He, and now many others, have found that learning is clearly as much a socialisation process as a means of acquiring factual knowledge. Socialisation imposes severe constraints on learning, leading different people to learn in different or preferred ways. This itself eventually drives particularly professionals to adopt one of the four different and often incommensurable world views which we portray in summary below and in detail elsewhere Newland et al (10).

In order to cope with pressures of time and money, decision-makers will tend to stick to their preferred learning approach, their chosing of appropriate information and their corresponding action style while practising their profession. This gives them a secure basis from which to make decisions and they rarely change their approach to learning new ideas – it is not only too much effort, it also drains their confidence. In summary, it appears that all individuals have a predisposition to learn, then think about the world as they see it and finally act in
it, using one of four strategic action patterns, each is different, independent and recognisable. Powell (12) has called the types of learner-actors who portray these underlying traits Dynamics, Focussed, Rigorous and Contemplatives. Let us briefly discuss each of these in turn.

i. Dynamics have an approach to learning which is centred on doing and sensing. They are entrepreneurial and innovative, acting for the moment, sensing its potential and doing something about it immediately. It is the dramatic active events in the world which give them motivation and allow them to register understanding. To learn they must be personally involved and if this necessity is satisfied then they are eager for challenges and novelty. By being assertive and individual in their actions they can swiftly switch tack, being entrepreneurial and initiating centres of profit at one moment and, at the next, rapidly creating innovative designs. They seek acclaim for their work. Their risk–taking attitude makes them good copy for glossies and the professional, financial and management pages of national newspapers.

ii. The Focussed concentrate their attention on decisive action. They operate in the world with a down-to-earth approach which is above all practical. Their need to do can often lead them into being campaigners and expounders of alternative technologies and conservation policies. Their small is beautiful philosophy may make them reticent to try untested approaches. Instead these people stay with the safe, known approach.

iii. The Rigorous understand the world by creating abstract models of it. These models give the rigorous predictive power over the environment. Through assumed knowledge of the underlying patterns from nature these professionals have secured rules that guide them in all their decision making. They stand as the guardians of professional standards and aim to produce regularly competent solutions.

iv. Contemplatives with their emphasis on reflection, may feel no great urgency in real world decision making. Their reluctance emanates from a desire to create the all encompassing solution. To this end they will thoroughly analyse all the data which is at hand and then try to retrieve more in an effort to ensure every angle has been covered.

Appropriate Interaction and Tone

The preceding fourfold of strategic action patterns have guided DIRT's design and production of a number of information or learning systems which appear to have enabled more ready acquisition of useful professional knowledge. The effectiveness of these systems has been tested by practicing designers using them in their own offices. Therefore the underlying theory upon which the systems have been developed has been validated and other useful conclusions can be drawn which are detailed below.

DIRT's systems seem to work well because of the special ways in which they handle the interaction with the learner and through the tone of the information portrayed to the learner.

In the first respect particular emphasis in the developed systems has focused on designing an acceptable acquisition mechanism for the stored information. I have found that when an information system exactly matches a preferred style of learner engagement, or has the right "interactive sensitivity", it communicates particularly well. Thus, information presented to the appropriate "parish" of learning and in the right configuration stands a better chance of communicating than one that does not. For example the visual portrayal of a topic could be either: by a set of still photographs with text annotation; or via a film with an audio
commentary; or through self-paced questions and answers; or as audio/visual sequences etc. The mix and style of media presentations provided by any system like film, audio and text will facilitate different self-informing strategies (Jonassen (13), Salomon (14)). The diagram below indicates, in summary form, the sort of interactive sensitivity required by different design information users.

<table>
<thead>
<tr>
<th>Dynamic Messages:</th>
<th>Focussed Messages:</th>
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<tbody>
<tr>
<td>Based on a simple throw away model</td>
<td>Based on nature/nurture embedded model</td>
</tr>
<tr>
<td>Excite - What's in it for Me?</td>
<td>Motivate - Why should We do this?</td>
</tr>
<tr>
<td>Allow for self-discovery</td>
<td>Give confidence</td>
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<tr>
<td>Give context to share with someone else</td>
<td>Affirm the positive and Guide away from the Negative</td>
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</tbody>
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<tr>
<th>Rigorous Messages:</th>
<th>Contemplative Messages:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Based on an authoritative rule based model</td>
<td>Based on all pervasive model</td>
</tr>
<tr>
<td>Pre-test - Confirm present knowledge</td>
<td>Remote Sensing</td>
</tr>
<tr>
<td>Teach - Import new Paradigm</td>
<td>Broaden Awareness</td>
</tr>
<tr>
<td>Post-test - Evaluate Competence</td>
<td>Allow for Reflection</td>
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<th>Informed by:</th>
<th>Informed by:</th>
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<tr>
<td>Simulation</td>
<td>Examples</td>
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<tr>
<td>Surrogate experience</td>
<td>Step-by-step detail</td>
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<tr>
<td>Face-to-face discussion</td>
<td>Practise based Case Studies</td>
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### Each Quadrant's View of the Interactive Sensitivity Typology

#### Dynamic Sensitivity
- Watch

#### Focussed Sensitivity
- Dynamic Sensitivity
- Focussed Sensitivity

#### Rigorous Sensitivity
- Reflective Learning

#### Contemplative Sensitivity
- Reflection

### Summary of Messages Preferred by different Designer Learners

Concentration on better presentation of information alone, contrary to previous research, has been shown to be insufficient to remove the barriers to communication if the underlying interactive sensitivity is inappropriate.

While interactive sensitivity forms the basis for good communication, of equal importance is the need to get the tone of knowledge in the system right as a means of achieving resonance between any individual and the imagery, learning, interpersonal interaction preference, philosophical basis and social assumptions they naturally seek. I have coined the term "semiotic credibility" to define this...
important matching of content characteristics with a learners belief structures and culture. Identical information portrayed by a system can be semiotically credible to some learners while being semiotically incredible to others. The latter group find information transfer much more difficult than the former even if the information is presented with the appropriate interactive sensitivity.

"Interactive sensitivity" and "semiotic credibility" work together in a complementary way so as to improve technology and information transfer, and help to promote deep learning in information systems users. Finally the following descriptions indicate the general characteristics of media presentation, tone and interaction relevant for each strategic action patterns.

**Dynamic.** The tone of information needed for a Dynamic individual centres around the notion of 'information transfusion'. In terms of portraying a particular topic, a sense of transfusion is only invoked when a topic is made tangible. Therefore, for these individuals, any topic of information transfer should draw heavily on personal experiences or shared experience events leaving them to weave a description of the topic into their own viewpoint. Dynamics portray their knowledge through their actions, and to be of a matching tone, an information source needs to be similarly active. I have found one useful mode of interaction for Dynamics is setting up a framework of challenges. Such challenges can give a near real life quality to involvement with an information source thereby demanding spur-of-the-moment acquisition of knowledge.

**The Focussed.** Those who choose to inform themselves by a Focussed strategy seek information that has a 'tone of transposition'. For this individual there should be provision for practical knowledge both at a general and specific level. For knowledge to be acceptable to these individuals it should be capable of grabbing their attention and being naturally incorporated or transposed into their own normal professional processes. The Focussed engage with the environment in order to understand why processes are as they are and their's is essentially a small is beautiful philosophy which demands information with a clear cut, down-to-earth quality. These individuals would appreciate an interaction which makes it possible to readily interrupt the documentary style case studies when detailed questions are raised. Such interrupts would give the Focussed opportunity to: review the material presented; enquire about the general usefulness of the topics covered for their present concerns; select particular points in the material for which greater detail could be requested.

**The Rigorous.** These attain viability through the principle of 'transcribing' codes into practise. Individuals who find this strategy appropriate are those who seek information which reinforces the validity of the rules they already use to guide their action. Such rules are recognised as emanating from authorities. In a similar fashion information which is seen to have been generated by these authorities will also be given credence as well. Therefore, they would be assured by information whose tone implies it is a code or standard practice. Procedural information would also be welcomed for its strength in providing straightforward, economical solutions.

**Contemplatives.** My research shows that those who choose to adopt a Contemplative strategy are interested in a broad spectrum of information. For them a comprehensive montage is necessary to adequately support their desire to accumulate a mass of knowledge which is sufficient to allow them to transcend a unifying principle. These individuals are given confidence through having access to a wide range of primary information sources. In essence these individuals are
seeking the means to undertake an integrative analysis of a topic and a welcomed information source would need to divulge uncensored data and incorporate guidelines to unify the known facts.

DEMONSTRABLE ENVIRONMENTS

In developing the above systems I have investigated the range of multi-media information technology mentioned earlier. Each has the potential to facilitate educational environments which allow response on a bespoke basis to at least four different types of user. In this section I briefly describe two of the systems DIRT has already developed on multi-media information systems using the aforementioned theory.

The first of such system presents information on energy conscious design from four perspectives and aims at engaging individuals of any strategic action pattern preference (Newland et al., 5). This is accomplished by use of interactive videodisc a medium which allows a pictorial base of film and stills to be instantly sequenced and re-sequenced by the learner. The context from which such visual imagery is presented can be easily manipulated, extended by multi-track audio, integrated with text and combined with an overlay of computer generated graphics.

More recently DIRT’s learning/information system has been enhanced using Apple Macintosh series II computers themselves extended by the addition of transputers and real-time video digitising boards. These hardware improvements have enabled us to make more responsive educational environments to support specific strategic action patterns. The following more detailed description concerns a second educational environment developed using this refined system.

A Case Study of QUALITY: My Definition - Architectural Video Package

The Problem. In order to gain an understanding of different peoples strategies for attaining quality in design, it is important for those managing a design project to have a clear, reciprocal awareness of what each active participant involved in the design process means by quality. At present quality is a noun looking for appropriate adjectives. In the round table design discussions normally associated with most early phases of designing each participant of a design team, and even the client, can bring their own particular and idiosyncratic view of quality to bear. In many cases they will not be sure themselves what they mean by quality. The project manager should have a clear understanding of that quality before the notion of quality simply becomes a catch all noun to represent many facets and contradictions that can be left undefined.

The Solution. Through the use of a MacIIx equipped with a video digitising board and CD-ROM/ videodisc storage sources a one screen mouse controlled environment was created giving the learner access to a montage of information on designed artefacts portraying very different aspects of quality. This provided a changing array of menus gives access to the views, thoughts and expressions on quality from architects, engineers, and product and fashion designers using nine key artefacts as a suit of common parlance. Filmic vignettes of impressions of quality and a database of Design Council award products were also open to interaction. The design professional using the system was asked to agree, or otherwise, with a series of views portrayed on quality. These judgements were
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continuously stored by the systems as participants negotiate their own perception of quality. This is summarised for them when they have explored sufficient of the quality information package. Designers and clients can therefore explore what each means by the term quality giving the opportunity to explore perspectives and hopefully gain reciprocity. The information environment can also act as database of raw information appropriate for a more Contemplative individual.

The Effectiveness. Students within Portsmouth University's Environmental Studies Faculty together with industrialists, managers and designers have found their use of the package illuminating and rewarding. All find they are familiar with at least one of the key artefacts and the range of comments accessible for each artefact is often surprising and an inducement to constructive discussion with colleagues when they have finished using the system. They leave with a clearer understanding of their own perception of quality and many comment that the experience encourages them to seek out the opinions of others on this concept. We have also seen that participants become more aware of the nature of language and the creation of definitions as a social construct. The design process itself then benefits from this heightened understanding that negotiation of as many viewpoints as possible to achieve an agreed design objective(s) is a fundamental basis for quality design.

CONCLUSION

I believe an edge in competitiveness is achievable if individuals can forge their understanding in experience rather than having it formatted as training. Use of DIRT's multi-media informing systems seems to aid understanding which in turn improves decision making skills in design professionals: their capacity for immediately understanding the systemic nature of a problem and in knowing the right course of actions to take when faced with novel situations is undoubtedly enhanced.

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