VISUALITY AND TACIT KNOWLEDGE:

The application of multiple intelligences theory to the design of user experience in interactive multimedia contexts

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Signed declaration

This thesis contains no material which has been accepted for award of any other degree or diploma, except where due reference is made in the text of the thesis. To the best of my knowledge, this thesis contains no material previously published or written by another person except where due reference is made in the text of the thesis.

Signed

Chi Huang
# Table of Contents:

1. Abstract
2. Acknowledgments
3. Preface
4. CD-ROM for PC
5. CD-ROM for Mac
6. List of Illustrations
7. List of Abbreviations

1. Introduction: From modernist rationalism to user-centred design
8. Human-centred Design: Beyond Usability
27. User-centred design from a multiple intelligences perspective
42. The application of multiple intelligences theory to interactive multimedia technology
64. Conclusion and future study

67. Notes
76. Bibliography
86. Appendix one
94. Appendix two
96. A list of publications produced by the candidate as a result of the project
Abstract

The major challenge for multimedia designers is to create user experiences that enrich the reception of content, designer’s traditional reliance on intuition not ensuring audience’s interest or understanding. The developing philosophy of user-centred design argues that designers should begin from an appreciation of their audience. In design there are various positions on how to achieve this, ranging from traditional market research through psychological, ethnographic, anthropological and sociological research to the direct involvement of users in the design process. This study draws on established knowledge about the cognitive processes, psychological motivations and preferences of user groups to advance a model for better-targeted and more effective design. In particular, it uses Howard Gardner’s multiple intelligences theory to extend design thinking. Where a specific audience is apparent multiple intelligences theory implies that (1) the interface should match user’s perceptual tools, cognitive styles and responses and (2) there is far greater scope than presently recognized to vary the design of the graphical user interface. The research explores how interactive multimedia can harness the ‘language of vision’ (Johannes Itten) for certain audiences, in this case Taiwanese drawing students aiming to enter tertiary art and design programs where high academic drawing skills are an important selection criterion. The high ‘visual intelligence’ of the target audience indicates their heightened capacity to process visual concepts and elements. The application of Gardner’s ideas is a speculative one, based on hypothesis and the formulation of an experimental graphical user interface environment built around predominantly visual cues. The designed outcome incorporates knowledge and understanding that is widely applicable to GUI design, challenging designers to develop multimedia products with innovative, imaginative design approaches that cater for the different needs and interests of users where the audience is a specific and identifiable one.
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Preface

This design research project is comprised of a written document and a design prototype presented on CD-ROM. The document considers the design of interactive multimedia products through an interdisciplinary theoretical framework. The design prototype explores the issues raised in the text through design practice. Please read the written document first and then view the CD-ROM.

The design prototype will need some hard disk space (approximately 300Mb) in order to view the program. For better performance, please copy the entire file onto your hard disk and then double click on the ‘start’ icon to begin the program. Although the prototype simulates a ‘complete’ commercial product not all of the indicated content is available. Please note that when rolling over a section of the interface links are only active if the cursor changes from an arrow to a finger icon. A content directory and translations of the Chinese audio guide are included in Appendix one to assist browsing the CD-ROM.
CD-ROM for PC
CD-ROM for Mac
List of Illustrations

12  Figure 1. Jakob Nielsen’s Website http://www.useit.com
13  Figure 2. Drawing sites that represent layers of images creatively yet effectively
20  Figure 3. Students practice drawing from the drawing practice section of the CD-ROM
21  Figure 4. Drawings produced by students using QuickTime VR during the evaluative testing
22  Figure 5. Drawings produced by students using QuickTime VR during the evaluative testing
23  Figure 6. Students using the CD-ROM
40  Figure 7. Abstract and complex interface design
45  Figure 8. The required standard of drawing
46  Figure 9. Examples of current drawing teaching VCDs
47  Figure 10. Two examples of text-based instructional Web sites for drawing
48  Figure 11. Two examples of image-based instructional Web sites for drawing
50  Figure 12. Local navigation system indicated by visual metaphor
51  Figure 13. Intuitive visual cues indicate the navigation process
52  Figure 14. Throughout the CD-ROM coloured balls link the same coloured pages
54  Figure 15. Work process with artists
55  Figure 16. The different subjects and levels of drawings presented in the ‘drawing demonstration’ section
56  Figure 17. The different subjects and levels of drawings presented in the ‘drawing demonstration’ section
57  Figure 18. The different subjects and levels of drawings presented in the ‘drawing demonstration’ section
Figure 19. The different subjects and levels of drawings presented in the 'drawing demonstration' section

Figure 20. Changing colours allow the user to visualize the drawing sequence

Figure 21. Animated drawing sequence

Figure 22. 360° QuickTime VR allows students to set up their own composition for drawing

Figure 23. The 'Web Gallery'

Figure 24. The red ball leads users to the 'Web Gallery'
**List of Abbreviations**

- **compact disc**  
  **CD**

- **compact disk-read only memory**  
  **CD-ROM**

- **graphical user interface**  
  **GUI**

- **human-computer interaction**  
  **HCI**

- **interactive multimedia**  
  **IMM**

- **intelligence quotient**  
  **IQ**

- **multiple intelligences theory**  
  **MI theory**

- **video compact disc**  
  **VCD**
Introduction: From modernist rationalism to user-centred design

The contemporary world is awash with information in the form of text, sound and image. Mostly, a small minority of people decides on the form of this material despite its mass audience, the designer’s role often restricted to the comparatively passive tasks of styling and formatting. Recipients may understand such communication, which means it will achieve its objective to sell, persuade or inform. However, when design is based on designer intuition the risk is that addressees will misinterpret or ignore the communication, there perhaps being only one chance to attract the attention of an audience in today’s flooded media sector, as shown by the collapse of the CD-ROM industry in the 1990s.1 Designers also regularly struggle against client’s preference for market-tested approaches, which promise to minimize the uncertainty of new products that succeed or fail on consumer preference. It is vital that designers have access to valid research models to convince clients of the importance of recognizing audience needs and interests. Yet, the emphasis on design as a service to business has meant the complexity of audiences in terms of cultural frames-of-reference and cognitive preferences is often neglected in design. The influence of modernism has also framed the work of the designer as principally one of translating information and ideas into rational visual communication rather than discovering the visual languages that appeal to audiences.

In embracing abstraction and geometry, modernist design believed in the universality of human experience and the importance of function, overlooking the need to consider viewer’s response to the designed message. During the 1970s and 1980s, however, increasing numbers of graphic designers began to question the received wisdom of modernist design, the disquiet growing to a peak in the 1990s in the form of the ‘legibility versus communication debate’. The anthology Looking Closer: Critical writings on graphic design, edited by Michael Bierut, William Drenttel, Steven Heller and D.K. Holland, summed up the dissent against modernism by sampling contemporary writing on design by designers, design educators and design critics.2 Throughout the book the modernist belief in the universal meaning of design elements was a primary target of criticism. From the modernist perspective the role of a rationalized design in aiding communication was seen as the core of professional activities, mimicking standards of anonymous objectivity from science. As a leading modernist, Gyorgy Kepes, for example, argued modernist designers worked ‘with simplicity of single-minded purpose, with an economy which is the logic of design, carefully avoiding all waste.’3 For Kepes, modernism sought transparency...
of meaning through the total correspondence of form and content. By contrast, Katherine McCoy’s essay ‘Rethinking Modernism, Revising Functionalism’ argued against modernism’s implicit belief that ‘clean’ and ‘simple’ were the highest design values. For McCoy, modernist designers were mistaken in associating the process of ‘sweeping away the clutter and confusion’ with a ‘professional rationality and objectivity that would define a new design’. She argued it was just as possible to view the modernist desire for cleanliness and grided layouts as little more than ‘housekeeping’.

The general agreement in Looking Closer was that the overarching concern for functional efficiency and clarity of meaning had led modernist designers to neglect the needs and preferences of individual audience members, as well as the possibility that there were numerous ways to get a message across. Tibor Kalman argued that far from ensuring utility and legibility modernism had seen ‘style’ become ‘a detachable attribute, a veneer rather than an expression of content’. For Lorrain Wild, modernist design was more interested in the production and distribution of designed artefacts than how they worked for users, the standardized values of mass production and mass communication perverting the basic idea of function and its original purpose in serving people’s needs. In many essays throughout the publication writers contrasted the modernist belief that designers could develop universal forms of communication—which would work in every case for every person—to the actual diversity of audiences in terms of identity, and social and cultural background. Milton Glaser disclosed that he for one had never been able to ‘simply subscribe to the idea that any one principle, such as simplicity or reductiveness, can be universally applied to every problem.’ The critique of modernism outlined in Looking Closer thus shifted the focus in design from issues of form to designer’s responsibility for the experience of audiences, stressing the importance of what things ‘mean’ to individual users over the designer’s skilful handling of the designed form as an expression of the client’s message.

Many essays in Looking Closer used social constructionist ideas of cultural reception to reject modernism’s belief in individual authorship and the universality of meaning, drawing on the poststructural position that it is audiences rather than senders of designed messages who shape meaning. According to Roland Barthes’s important 1968 essay ‘The Death of the Author’, writing—which later came to stand for any medium of cultural production—depends primarily on the reader’s response rather than the author’s intentions. The essay has a number of important implications for designers, arguing that an author is a bundle of influences created through society, history and language. For Barthes it was writing, itself a product of society, history and ideology, that makes an author and he argued that, ‘The writer can only imitate a gesture that is always anterior, never original. His only power is to mix writings … in such a way as never to rest
on any one of them." Barthes rejected the idea of a single, purposeful subject as the source of meaning, giving this role to language:

To give a text an Author [he wrote] is to impose a limit on that text, to furnish it with a final signified, to close the writing … refusing to assign a 'secret,' an ultimate meaning, to the text (and the world as text), liberates what may be called an anti-theological activity, an activity that is truly revolutionary since to refuse to fix meaning is, in the end, to refuse God and his hypostases—reason, science, law.

According to Barthes the author has no authority over a text, meaning being produced in the act of reading.

For poststructuralists like Barthes the subjectivity of the reader is likewise framed in social, historical and linguistic terms. Judith Butler, for example, contends that development in language and other symbolic forms of communication (signs, idioms and visual representations) is explained by the fact each is a social system in constant use, the modification of meaning over time being the product of random processes. Poststructuralism overturned established ideas about the reception of cultural texts. From the late 1960s a succession of writers challenged the ‘truth’ of culture, arguing for the collapse of the subject into subjection, essence into appearance, inside into outside, authenticity into inauthenticity, rationality into irrationality and signified into signifier, encouraging designers to engage in textual play rather than to seek fixed meanings. In exemplifying poststructuralism's impact on the understanding of how meaning was produced in design, Looking Closer approached the designed message as a decentred text in which the roles of sender and receiver were fluid and undetermined, especially by comparison to modernism's ethos of formal simplicity and strict adherence to the rationality of the grid, colour theory and anti-decoration.

**Rational design and learning about the user**

In one of the most forceful essays in Looking Closer, Phil Baines accused the Bauhaus of mistaking legibility for communication, arguing that the ‘legibility hypothesis presents information as facts rather than as experience.’ For Baines logic and linearity had value but satisfied only the rational side of the brain, highlighting the anthology's general theme that modernist ideas of rational design and functional efficiency ignored the human capacity for intuition and simultaneous perception. Stripped to formal essence, modernist design spoke to the intellect but failed to touch the inner qualities of the individual or stimulate the human senses or emotions. Where modernism saw design as a problem-solving process, Rudolph de Harak argued ‘successful’ design must strive to ‘communicate with the audiences for which the work is intended.’ In registering a fundamental shift in design thinking, the anthology's emphasis on
Introduction: From modernist rationalism to user-centred design

The social and cultural makeup of audiences challenged the idea of the designed message as a unitary text. The basis of such perspectives in poststructural inquiries into text and meaning offered alternative ways to see reception in design, suggesting new relationships between audiences, subjectivity, language and the designed form. In the wake of poststructuralism, representations and meanings were not simply there, waiting for interpretation. They were seen as dense, complex, erratic and contradictory while the role of the designer became one of making meaning from this intricacy by accepting the differences of one reading from another.

The developers and designers of interactive multimedia (IMM) products who seek simplicity in graphical user interface (GUI) design should note these arguments for suggesting design’s potential to deliver content in more meaningful and diverse ways. The principle of user-centred outcomes is regularly claimed in texts about interaction design. As early as 1995, Kevin Mullet and Darrell Sano’s design primer Designing Visual Interfaces: Communication Oriented Techniques identified the primary purpose of design in the evolving field of GUI design as determining the approach best suited to the communication of particular tasks to specific users. Yet, the uniform character of much GUI design suggests not only that designers prioritize the client’s message and the positions of product developers and usability experts but that interaction design lacks developed ways to understand or accommodate user’s needs and preferences. This research agrees that the designer’s role extends well beyond the superficial appearance of content to determining the essential form of information, but it seeks to advance the approach to design beyond the understanding that meaning is arbitrary and unstable. The writers in Looking Closer speculated on the role of audiences in shaping meaning but left the nature of this process undefined. This research argues that to serve user’s needs designers must take active measures to understand exactly who they are designing for and how to reach them.

The challenge of user-centred design

As a leading authority on user-centered design, Donald Norman argues, ‘Design is really an act of communication, which means having a deep understanding of the person with whom the designer is communicating.’ This raises the basic problem of how to establish that understanding. In many cases learning about users is market research that abstractly defines audience wants and interests before the design process begins. Such research cannot provide insight into how users perceive or process information or what might constitute pleasurable or successful interaction. Since IMM products only come to life when users mentally process the content of which they are comprised, cognitive psychology offers valuable insight to interaction designers about users. This research argues that where it is possible to identify end-users as a distinct group or
range of groups, cognitive psychology—especially the theory of ‘multiple intelligences’—sheds light on the cognitive capacities and perceptual behaviour that lie at the basis of reception and interaction processes.

The research was developed from the following standpoints. The fundamental approach is a theoretical one, based on assumptions and hypotheses informed by cognitive psychology, principally multiple intelligences theory (MI theory), split brain theory, ideas of tacit knowledge and the discourse of user-centered design. The research methodology uses these theoretical frameworks to (1) establish a valid body of ideas and understandings about the nature of a specific user group and how to cater for their needs and (2) provide the basis for the design of an experimental, but ultimately commercializable IMM product. The target audience is Taiwanese students preparing for selection into tertiary art and design programs by extending their academic drawing skills. This audience is a self-selecting group with high-visual intelligence. The design prototype demonstrates the potential to orient GUI design to the particular cognitive needs and preferences of this group and by inference to other user groups where the audience is a specific and identifiable one.

Together, the written document and the experimental IMM product frame a thesis embodying the research aims, which seek to 1) expand of the understanding of what is possible in GUI design and 2) demonstrate that a commercializable IMM product can be based on advanced design thinking. The purpose of the research is to identify and exemplify the user-centered design strategies that might best connect with a particular audience, reversing the current situation where content is privileged over communication in much GUI design. The written document is an amalgamation of a broad range of knowledge and understanding beyond the general awareness of interaction and interface designers. While much of its content is synthetic, this knowledge provides a point of departure for new design thinking and articulates a number of advanced strategies in GUI design. The role of the design prototype is to validate and exemplify these hypotheses, providing an alternative model of GUI design for other designers. While the target audience for the designed prototype is a highly specific group with preference for visual thinking, the study challenges designers to be more adventurous in formulating interactive contexts to enhance user experience and communication—not just for those with advanced ability in interpreting visual meaning but for users with diverse cognitive preferences and abilities.

After the introduction the document is divided into three main sections plus a conclusion. Section two examines existing perspectives on user-centered design in IMM. It discusses the problems of usability testing and user research
and why such approaches cannot ensure effective communication or successful product development. It argues that usability principles might make products function in a basic sense but the current emphasis on simplicity and functional efficiency in interface design does not provide engaging user experiences. Section two argues that usability principles only consider specific dimensions of user's interaction with products and do not deliver the frameworks that designers need to develop compelling, useful and meaningful interface designs. Section two thus contends that there is a gap of knowledge and understanding in the field of interaction design, especially in appreciating the complexity of individual difference. In response, the research proposes aspects of cognitive psychology can provide designers with a deeper understanding of user needs and preferences in the development of the GUI and interaction processes.

Section three discusses multiple intelligences theory and its relevance to interaction and GUI design. It introduces Howard Gardener's theory of multiple intelligences, discussing its potential to augment current user research practices in respect of understanding user's specific perceptual behaviour and needs. Given the target audience for the design prototype, section three focuses on the nature of visual intelligence, drawing on a wide body of writing including MI theory, split brain theory, and studies in visual literacy and drawing pedagogy in the attempt to understand (1) the characteristic of visual intelligence, (2) how visually intelligent individuals process information, (3) why the current form of information is not suited to them, and (4) what might be preferable ways to design the GUI for such audiences. Section three also discusses the nature of drawing as tacit knowledge, that is, knowledge beyond or outside that which can be said or written, exploring the extra challenges this presents to the interaction designer. This section argues that enlightened practices in the field of drawing education, themselves informed by split brain and multiple intelligences theory, challenge interaction designers to become more informed about the cognitive strengths and preferences of target audiences.

Having established that GUI design is currently skewed toward efficiency and the performance of technology rather than the affective aspects of interaction and the orientation of information to user preferences, section four examines how the flexibility and media-rich character of IMM technology can be used for (1) the delivery of tacit drawing knowledge and (2) the individual cognitive capacities of its target audience, using visual message to create more engaging user experiences and more effective communication. The document also contains two appendixes containing material relevant to the project. Appendix one includes a content directory and translations of the Chinese audio guide to assist browsing the CD-ROM. Appendix two is the results of survey with the target audience, taken after using the CD-ROM. The role of the CD-ROM
is a dual one, serving as (1) a concrete expression of a program of research into immersive interactive environments that promotes reception in the ‘right brain’ mode and (2) the basis of a commercial product.
The great challenge facing contemporary interaction designers is how to create products that accommodate the needs, interests and preferences of the different users that make up today’s mass audiences. The history of consumer products reveals that over time new products evolve into complex product ranges in an effort to capture the broadest range of market segments. When new products are invented function is dominant, the market driving the development and rapid obsolescence of new technology to stimulate and fulfil consumer demand. In later stages of a product’s life, however, products become highly differentiated, their features, price and styling targeted to specific ‘niche’ markets. In this process design becomes increasingly concerned with aesthetic aspects and end-user factors such as lifestyle and identity.

This pattern is starting to be reflected in the evolution of IMM products. The first wave of CD-ROMs in the 1980s targeted a general audience by emphasizing unparalleled access to information in a period in which new media and interactive technologies flooded the market with a wide range of information products that promised to transform information delivery. Early CD-ROMs were largely built on an inherent belief in the value of interactivity and the superiority of multiple information formats combined in the one package. However, in the rush to get products on every possible topic to the market Nathan Shedroff argues most early CD-ROMs provided little more than exotic experiences, failing to effectively communicate information. Likewise, for Richard Buchanan some new media products were ‘highly effective’ but a significant number failed to meet the ‘expectations’ of users. With few practical standpoints on which to judge one product from another, individual products failed to attract purchasers and the market collapsed.

While the judgments of the market place can not be seen as absolute measures of successful interaction design, the power of individual consumers in a broad field of product choices reveals some important lessons about people’s engagement with IMM products. The failure of IMM products in the market place contests the idea that consumption and engagement with products are passive states of being and challenges the naive belief in the intrinsic value of new technology. It also suggests the scope for design researchers to address shortcomings in design strategies for the development of IMM product where these can be attributed to gaps in knowledge and understanding about users. Industrial design has led the way in recognizing that designed objects
incorporate emotional values and generate highly personal responses that shape the processes of making value and meaning for users while driving consumer choices. In recent decades, leading manufacturers and product designers have rethought the nature of products to see desirability, pleasurable interactions and emotional resonances as critical to commercial success. Companies like Apple, Nike, Philips and Sony have proved the commercial value of designing all aspects of the interaction between customers and their brand to create a total product experience, thereby increasing product appeal, customer satisfaction and brand loyalty.

Behind this process is the need to ensure that products elicit desirable values, emotions and experiences for consumers. This is a realization developers of IMM products have not yet fully appreciated. Similarly, the emphasis on functional efficiency in fields like usability and Human-Computer Interaction (HCI) has not yet embraced the affective dimensions of interactive products. The process of IMM product development presents many hurdles to achieving enhanced outcomes for users. Designers often have little power in influencing the nature of products by comparison to clients and programmers. They also have limited information on which to argue for the importance of innovative visual communication strategies. Typically, the literature on users in IMM design is borrowed from HCI. The HCI community provides the designers with guidelines based on empirical findings from user studies. These are presented in the form of lavish handbooks on interface design in the belief that such material will allow designers to make design decisions that meet user requirements. Yet providing primary specifications for structuring tasks like navigation within the GUI cannot ensure that individual products provide users with the quality of interaction that makes multimedia products engaging, meaningful, useful and empowering.

The ethos of putting users at the centre of the design process and associated methods of user research are at an immature stage of development in IMM design and often conflict with the view of IMM as a medium and a set of technologies that commercial and corporate interests can exploit for profit. In developing the GUI there are two primary approaches; (1) the designerly ideal of using graphic elements to make information accessible and visually compelling and (2) the engineering ideal of focusing on usability to solve a communication problem. Rigid usability principles echo modernist efforts to establish fundamental aesthetic laws of the designed form. Conversely, the option of providing differently styled interfaces or a choice of functional options is not a solution if it only reflects the commercial imperative of product differentiation. At present technologies, design strategies, products and consumers in the field of IMM are mostly shaped by commercial forces and the beliefs that frame them. This research contends that communication practices, media literacies and design
possibilities demand closer consideration for IMM to develop as a humanized medium of information and communication.

The rate of innovation in information delivery systems and global communications networks suggests that the technology that will be used at the end of any future decade has not yet been invented. Rather than accepting current thinking on the nature of human computer interaction designers need to play a part in envisaging new ways of allying design to rapidly evolving technologies and the workings of the human mind or, as is currently the case, have the perspectives of others imposed on them. The application of ‘user-centred design’ principles is one way to explore the needs, purposes and preferences of audiences in their use of IMM products, as well as the semiotic and cognitive resources they bring to them, in order to arrive at creative and innovative ways of designing the GUI.

Simplicity and user experience

The term ‘user-centred design’ was first proposed by Donald Norman’s research laboratory at the University of California, San Diego, in the 1980s and became popular in the fields of computer systems and industrial design after the publication of Norman and Stephen Draper’s 1986 book *User centred System Design: New Perspectives on Human-Computer Interaction.*27 The goals of user-centred design are varied but basically aim to provide easy-to-use, desirable products and user interfaces that match people’s actual needs and patterns of use. Recently the idea of user-centered design has developed into a broad ethic among design scholars and some designers in industry, dedicated to respecting the experiences and preferences of end-users.

The goal of user-centred design is to humanize products and technology by putting the user at the heart of the design process. For example, Philippe Truillet and Régis Privat write that:

user-centered design is an approach that can help in [the] process of conception of more usable systems, because the design is a process that starts with users and their needs rather than with technology, especially when trying to “design for all”. It requires designers to be able to evaluate physical devices, communication and action modalities to see how users employ them in their activities. It also requires [designers] to evaluate usability, effectiveness, efficiency and user’s satisfaction.28

This is a complex set of goals and in many instances efficiency of use wins out over exploring how people prefer to use products, especially from the perspective of the more affective aspects of design such as perceptions of value, meaning and quality of experience. Many interaction designers, for example, tackle the goal of meeting user requirements by making the appearance of the GUI as simple as possible, a strategy codified by Jakob Nielsen who argues that the way to create
As a pioneer in the field of usability, Nielsen has set strict frameworks for page layout, including typographic specifications and the size and number of images. Nielsen disregards the aesthetic and affective dimensions of design, proposing that, ‘A general principle for all user interface design is to go through all of your design elements and remove them one at a time. If the design works as well without a certain design element, kill it.’ Nielsen put the issue of usability and usability testing on the map for web designers. While CD-ROMs and web sites have some different characteristics the interaction design principles are essentially the same, the preference for CD-ROMs over a web platform being the ability to deliver larger amounts of media rich content. The far greater number and reach of web sites means that the web dominates the discussion of usability and design principles for interaction design, beginning with Nielsen’s book *Designing Web Usability: The Practice of Simplicity*, of which there are over a quarter of a million copies in print, and editions in eleven languages, including Chinese and Russian.

Nielsen’s aim in writing is to ensure usability through the delivery of a simplified GUI, which he argues will ‘increase users’ quality of life by eliminating a lot of frustration and the feeling of inadequacy that follows every time you are stumped by a computer.’ This statement, however, seems a little off the mark when you consider Nielsen’s own web site. **Fig. 1** Renowned for his dislike of graphics, Useit is visually unappealing and oriented to those adept at processing text-based information. Nielsen defends his site by arguing, ‘I am not a visual designer, so my graphics would look crummy anyway. Since this website is created by myself (and not by a multidisciplinary team as I always recommend for large sites) I didn’t want to spend money to hire an artist.’ The simplicity that Nielsen argues aids enjoyment and ease of use is not evident at Useit. The site's organization more often conceals, complicates and confuses than clarifies while reflecting a technical rationality that disregards the affective aspects of reception.
In his Alertbox column Nielsen's lists basic things interactive and interface designers should avoid, such as the use of animation, rollover images and sound. Each recommendation is based on assumptions rather than evidence and can be challenged by the creative use of such elements to effectively present layers of information and provide engaging user experiences. Fig.2 Nielsen sees the user primarily as a conductor of tasks within the GUI rather than an individual with agency and specific needs and interests, raising many issues. Nielsen claims that, ‘Users are rarely on a site to enjoy the design’, arguing that ‘polished graphic design probably has little impact on usability’. His writings imply that design only reflects the ‘artistic idea of expressing yourself’, having
nothing to do with the content of a site its use or users. However, it is a fundamental mistake to formulate designed messages based on what needs to be conveyed before first becoming aware of what audiences want and need to understand. Disregarding this often leads to extravagant, generalized or impoverished transmissions of information, which are neither efficient nor functional and most importantly fail to reach their audience in any meaningful way.

http://www.jamesjean.com/

http://www.esao.net/

http://www.mypetskeleton.com/

Figure 2: Drawing sites that represent layers of images creatively yet effectively
Nielsen’s reductionist approach to interface design, which foregrounds language and logic over other semiotic resources and modes of communication, leaves little scope for the inclusion of affective dimensions and diversity in the design or testing of the GUI, running the risk of interactive products suiting, or perhaps more importantly, interesting no-one. The interpretation of user need as functional efficiency likewise fails to consider whether design enhances user understanding and interest or whether an interface creates pleasurable responses. This is despite the fact that market processes indicate that affective elements of design create competitive advantage. Neither can it be assumed that users will automatically adopt the patterns of use behind strictly conceived information structures. By placing stringent limits on communication and reception processes within the interface and by basing these on restricted concepts of use and user, designers ignore the complexity of literacy in new media contexts.

Jakob Nielsen’s idea of functional efficiency and usability testing in the organization and reception of the GUI echoes the productive ideology of capitalist society and its rational ordering of labour. In the pursuit of efficiency capitalism introduced the machine, then information and communications technology, to the process of labour, applying an efficiency model driven by the goal of the continual accumulation of capital. The unfolding of capitalism has seen all forms of social activity defined in terms of such quantitative values. Klaus Krippendorff argues that since the advent of industrial modernism users of technology have served as functional figures in a systematized process where values of efficiency and productivity dominate, that is, as extensions of the machines they use. Countless writers have noted how capitalist production appeals only to a quantitative rationality, creating a deepening alienation of humanity from the basic needs of human existence. It is debatable whether functional efficiency is a value sympathetic to successful communication, challenging its place in a program of user-centered design where the role of the interface is to facilitate understanding and enhance user experience. Alan Cooper stresses the cognitive friction between humans and computers, highlighting ‘the resistance encountered by a human intellect when it engages with a complex system of rules that change as the problem permutes.

In contrast to Nielsen’s views on the straightforwardness of reception through the GUI, the idea of ‘experience design’ embraces the diversity, complexity and multi-dimensional nature of effective interactive design. In Train of Thoughts: Designing the effective Web experience, John Lenker argues that a website ‘must offer more than mere simplicity and practicality to be an effective mass-communications medium. It must also offer easily comprehensible message, emotional and social relevance, as well as aesthetic gratification.'
The key argument in Lenker’s book is that the creators of web sites, under the guidance of usability experts, ‘dull down’ their sites, achieving clear information architecture but commonplace experiences. The consequence is that many sites may be highly ‘usable’ but do not fulfill user’s emotional and psychological needs. Lenker argues that successful information delivery is not about mechanical cognitive processes but what users feel and what their senses and imagination engage with. For Lenker creativity, not usability, should be the driving force behind interaction design. Rather than the fixed and concrete model of information architecture that many interactive designers subscribe to, he proposes that the role of the web designer is to guide users in understanding the content or message of a site. To determine effective strategies for information presentation, he contends that designers focus on the procedural nature of interactions rather than content, approaching the process of reception as a sequence of ‘dialogues between intelligent systems and individuals for the sole purpose of serving their specific interests and needs’.

**Designing for individual users and their specific needs**

This design research explores the need and scope to vary GUI design in the context of commercial information products. The concept of the market place suggests a unity of consumers. By contrast, Michael Hardt and Antonio Negri argue the contemporary ‘multitude’ is ‘fundamentally engaged in the production of differences, inventions, and modes of life, and thus must give rise to an explosion of singularities.’ Hardt and Negri accept that ‘these singularities are, of course, connected and coordinated according to a constitutive process that is always repeated’ but they still describe contemporary societies as existing in a state of ‘paradoxical unity composed only of differences.’ The field of interaction design should follow the lead of media studies in recognizing the fragmented nature of audiences, in which the individualised contexts and practices of audience members make the idea of ‘generalization’ hard to support. Recently website developers have devised specific strategies to predict the needs, desires, and motivations of individual visitors to a site. Alan Cooper, for example, advocates the development of ‘hypothetical archetypes of actual users’, described as user ‘personas’, to help designers better conceive their target audience and determine the best ‘look and feel’ for a site. Cooper suggests that by imagining specific members of the target audience and their unique needs and characteristics designers can develop interactive products that satisfy the needs of many others who have similar interests and profiles. He argues that to be even more effective and satisfy a greater number of users, designers should develop a range of personas, one for each major class of end-user.

In some ways this approach supports the position central to this research, which argues that interface styles should be developed in a range of forms to suit
individual users. However, the motivation for the development of user personas can significantly diminish benefits for users. As Stephen Atkinson and Helen Nixon point out, ‘technologies, texts, and literacies in consumer economies are significantly shaped in response to market forces and the discourses that support them.’ 49 The simulation of user ‘personas’ may only establish ‘artificial subject positions.’ 50 Media companies routinely use sophisticated market and ethnographic research to gather information on the ‘identities, aspirations, and cultural and generational affinities’ of audiences in order to promote those audiences to advertisers. 51 Such attitudes may just mean that the needs, desires and motivations of users are constructed through commercial values and imperatives. 52 When simulated personas construct users simply as differentiated subjects of consumption they restrict the form and content of new media products and user’s interaction with them, reducing the scope to orient form and content to user’s needs and interests, especially their cognitive strengths and preferences.

Bruce Hanington argues that a design process driven by user’s needs, preferences and interests has designer’s empathy with the target audience, not commercial objectives, as its first priority. 53 According to this perspective the designer becomes the agent and advocate for end-users in the design development process. Hanington believes it is vital for designers to immerse themselves in the experience of users from the beginning phases of design in order to build a practical awareness of their needs and perspectives. This may be obvious but it does not mean the process is straightforward. Defining who users are involves complex distinctions that are part of the political discourses of class, economics, ethnicity, gender identity, sexual orientation and cultural literacy. This should not be a matter of assumption but should come from actual knowledge. Yet professional hierarchy, as a primary matrix of the present social structure, creates the inevitable problem of differential perspectives between designers and users.

Designers, like all other professional-technical experts, gain their power, prestige and privilege from their specialized knowledge, based on education, competitive merit and experience. Well-established academic fields of human research such as anthropology, ethnography and sociology have a poor record of establishing reliable knowledge by relating to their human subjects. 54 The history of human research in these fields identifies two kinds of methodological and conceptual issues for designers interested in investigating or working with users. The first is imposing your own values and assumptions on user groups. The second is developing culturally appropriate and sensitive ways to conduct research with users. 55 Designers need to consider the unequal power relations and different cultural literacy of users and researchers in working directly with user groups. Fundamentally, users should not be seen as passive subjects from whom
useful information can be extracted. Examples of research in anthropology, ethnography and sociology show that research is most successful when there is power sharing and collaboration in the research process and it is understood by participants that they have a real stake in the outcome.\textsuperscript{56} User research should be dedicated to producing positive results for all parties but especially users, a difficult prospect in the context of commercial product development.

In the light of such arguments the designer’s challenge is to select the appropriate methods of user research for the design context. For Hanington, methods of user research can be categorized as traditional, adapted or innovative.\textsuperscript{57} Fields like product and packaging design have employed traditional market research in the design process through surveys, interviews and focus groups that sample the opinions of users. During such research, inquirers, who are usually not part of the design team, question participants about their preferences and experience of like products. Designers may or may not contribute prototypes to this process to elicit end-user responses, perceptions and recommendations for improvement.\textsuperscript{58} Such approaches, when performed well, are effective in collecting data from large numbers of people. However, the relationship between the design process and the data acquired through market research is often unproductive because it is only gathered to determine a basic sense of preference, market research being largely based on what already exists.

Such research may thus not work very effectively when innovation in the designed outcome is the objective. For example, the quantitative and qualitative data that traditional research produces can be very generalized because it is often acquired in a systematized way. Louis Rosenfeld and Peter Morville also contend that those who participate in market research often cannot tell researchers what they do or do not like, arguing that ‘most people don’t have the understanding or language necessary to be articulate about [such] information.’\textsuperscript{59} Experience from anthropology, ethnography and sociology shows that participants may give false or misleading responses when the nature and process of questioning is ignorant or unsympathetic.\textsuperscript{60} Respondents may give answers they think researchers want or skew their answers as a result of wishing to appear in a favourable light when self-reporting.\textsuperscript{61} Design work based on faulty user research is unlikely to reflect user’s preferences and requirements. Furthermore, if designers do their job designs they should change the way end-users perceive their wants and needs, making design parameters developed before the design process begins problematic while suggesting that designers need to employ different research methods at different stages of the design process.
Usability testing as user research

In the field of interface design usability testing is the principal counterpart to market research and the major component of the design process that involves users, although usability is only one aspect of user experience. Joseph S. Dumas and Janice C. Redish base usability testing on five principles, arguing that (1) the goal of testing is to improve a product’s usability; (2) the participants in testing should represent real users; (3) the participants should do real tasks; (4) during the test process the testers should both observe and record the participants; and (5) the tester should then analyze the data and recommend changes to fix problems. Whether usability testing takes the form of a survey or a formal laboratory observation it has a number of widely discussed shortcomings, though many who apply usability tests consistently overlook these limitations believing it achieves the goal of objectivity. Jeffrey Rubin argues that, ‘Even the most rigorously conducted formal test cannot, with 100 percent certainty, ensure that a product will be usable when released.’ Rubin identifies four basic reasons for this. Testing is always an artificial situation. Test results do not prove that a product works. Participants are rarely fully representative of the target population. Testing is not always the best technique to use. While usability testing challenges designers to consider functionality from the end-user’s perspective it is arguable whether they actually contribute in a significant way to the design process or enrich user experience, primarily because usability testing is often late-stage product testing of ‘high-fidelity’ prototypes conducted after the main product development and design work is complete. Shackel and Richardson confirm that many HCI advocates find that product developers don’t use tests until such a time as the design is fixed and major modifications are too costly to consider.

The question of when and how to incorporate user research into a program of user-centred design is as vexed as what constitutes user research in the first place. The process of this research has exemplified the complexity of these issues rather than solved the challenges they raise. In 1999, the International Standards Organization developed Standard 13407 (ISO/DIS 13407) to describe a human-centred design process based on what it called the ‘Iterative Design Cycle’. ISO/DIS 13407 argues that human-centred design starts with:

an awareness of the need for such a process … then moves into an iterative cycle of design based on an understanding of context of use [which] includes an awareness of the people who will use it, what they will use it for and the conditions under which they will use it. From this understanding a set of requirements, especially usability requirements are drawn up, and a possible design solution is proposed. Following this, that solution is evaluated.

From the perspective of ISO/DIS 13407, an iterative cycle of design aims for
continuous improvement and testing of design outcomes with users throughout the design process until the outcome meets user requirements and the designed product fits the entire context of use. In the context of commercial products research and design iteration are compartmentalized in the design process. Market research is typically conducted before design begins. Usability testing occurs when it is largely complete. The other paradox of usability testing is that although the testing of user tasks and behaviour within the interface is seen as a way to ensure the functional efficiency, legibility and learnability of designed entities, factors such as desirability, emotional response and user experience are often excluded from usability testing.

When usability factors and testing dominate the design process mechanistic, one-dimensional design solutions can be imposed on both designers and end-users, the latter’s role in relation to the interface diminished to a performative response. Moreover, usability testing can never be a road map that tells designers how to apply the results others have gathered to the conception and refinement of design. This is especially the case when testing is conducted into general principles of interface design rather than into specific designs or where testing is not matched against a body of specific user information. By contrast the user-centred design community has argued for design-test iterations to be examined in the context of the design process through the involvement of actual users while being extrapolated through rapid prototyping. Janis Morariu argues that user research should begin in the very early stages of the design process if designers are to fully understand user’s needs and address them in specific ways. Gould and Lewis’s three principles for user research equally emphasize the importance of early focus on user research rather than later product testing.

The shortcomings and difficulties of user testing were demonstrated in a very real way in the context of this research. As part of a practice-based doctorate the designed prototype was necessarily being developed at the same time as theoretical research was still being conducted, the convergence of practice and theory determining the research direction. When the design prototype was operating at a functional level it was tested with users to get feedback on the design strategy and to seek further insights. Twenty students from an art and craft high school in Taipei, Taiwan, were involved in the testing. Each was asked to play the CD-ROM and draw from the screen using the ‘drawing practice’ section. Their drawing activity and the resultant drawings are shown in Figures 3-5. The students were then asked to respond to a twelve-question survey, full results of which are included in Appendix two. The survey also included the opportunity to make independent comments.
Figure 3: Students practice drawing from the drawing practice section of the CD-ROM
Figure 4: Drawings produced by students using QuickTime VR during the evaluative testing
Figure 5: Drawings produced by students using QuickTime VR during the evaluative testing
Although the testing took place with representatives of the target audience, the nature of the test cannot be considered a usability test. The aim of a usability test is to gather information about a product’s problems in order to fix them. By contrast, the test and survey was done to validate the application of theoretical assumptions and design decisions in the prototype. As a sample of the target audience, the test group showed strong preference for the visual basis of the interface design. The survey results also revealed strong preference for the studio metaphor in the navigation system. The voice guide and sound effects were conceived as an effective support for the visual cues and atmosphere, though the survey showed students were far more sensitive to sound than expected, finding it annoying and thereby confirming Koestler’s idea that visual thought processes are an integral mode of thinking. The user testing and survey revealed that the target audiences were comfortable with the mainly visual environment. Even though it was the first time they had used the CD-ROM and not all content sections were available, the students rapidly adapted to the unusual interface environment and freely explored all possible content. The following photos capture student’s immersion in the process of playing the CD-ROM, especially how they shared their experiences with others. Fig. 6

Figure 6: Students using the CD-ROM
The ‘student’s responses’ challenge the principles usability experts have set down for designers that broadly state that simplicity is the major aim in interface design. Reflecting back, however, I realize that when I decided to test the prototype with users and developed the survey materials I had only a partial understanding of how regimes of testing and user research might relate to the design process. The idea of testing and surveying promised a degree of objective validation and empirical evidence. After the testing process I realised that late stage testing has little or no influence over design outcomes because all of the important decisions have already been made beforehand. My experience confirmed the argument that (1) user research needs to begin before design activity is started but (2) reinforced the value of cognitive psychology in guiding designers to format content and the GUI from deeper and more diverse perspectives than user research or usability testing currently achieve. The process of testing and surveying showed how designers are generally poorly equipped to conduct user research, raising the question of whether they should even attempt it, especially if it is possible to work with those who have sound theoretical and methodological knowledge in inquiring into the actions, opinions and responses of human subjects.

Interaction design and cognitive psychology

The field of usability already has its roots in aspects of cognitive science, in which experts are driven by the goals of scientific rigor and empirical testing. Bruce Hanington sees the use of cognitive psychology in user research as an adapted research method that does not grow out of the specific conceptual processes and intellectual culture of design. He likewise criticizes adapted research methods like anthropology and cognitive psychology for mostly not involving users in the design process. Rob van Veggel argues that anthropology and ethnography provide cost effective research methods and insightful information to help designers to translate users’ needs and behaviour into new product designs. Yet, van Veggel’s accounts of his experience as an ethnographer working in new product development teams reveals there is often a clash of intellectual cultures between designers and anthropologists, ethnographic methods and research appearing ‘academic and indecisive’ to designers:

By training, [van Veggel argues] anthropologists are inclined to perceive nuances, complex interrelations, and embeddedness in wider contexts, while designers are trained to look for more concrete problems. And as anthropologists attempt to evoke the multifaceted experiential world of the participants, designers have to come up with a “less is more” solution to the design assignment.

Van Veggel is right in arguing that designers need a deeper understanding of user’s needs and preferences than individual users might be able to articulate. However, among the human sciences anthropology, psychology and sociology
all offer potentially useful information about users that designers should consult throughout the design process.

In particular, the sophisticated information gained from cognitive research can provide designers with valuable knowledge on the psychological makeup of users. Van Veggel argues that psychologists gain understanding by performing tests in controlled, laboratory environments, seeing the knowledge produced as ‘too general, too abstract, and too much divorced from real life situations’ to ‘apply in actual situations targeting specific customers.’73 Where in many design fields characteristics of user’s social and cultural attitudes and outward patterns of use may be most important to design conception, in interaction design cognitive psychology is fundamentally concerned with processes of perception and reception, suggesting their intrinsic relevance to the field. Cognitive psychology does not currently have a developed interest in design reception but represents a rich storehouse of research on human cognitive behaviour that designers can use from the earliest stages of design. The field of HCI already makes extensive use of cognitive science in product development and testing, though it largely approaches the user’s relationship to the interface in the limited dimensions of information processing, focusing on general factors like short-term and long-term memory and particular response biases.74 Research in cognitive psychology represents a much broader field of investigations than this, exploring a range of subjects of relevance to interface design. These include the nature of perception, cognitive processing, learning and problem-solving, human motivation and other presumed internal mental processes more focussed on the individual nature of human cognition. The foremost area of cognitive psychology explores information processing, investigating how information from the world enters through the senses and is used, retained or forgotten. When user experience is the primary concern, cognitive psychology offers designers valuable knowledge about user’s cognition and perception, allowing them to structure and articulate the GUI in ways that reflect how different people process sensory data.

This research uses Howard Gardener’s MI theory as an alternative (or supplement) to other models of user research in being built around a set of circumstances where it is possible to identify user groups as having specific cognitive preferences. Recognising the unique nature of intelligence in specific user groups opens up the understanding of reception in interaction and GUI design, allowing designers to provide users with the conceptual stimuli and information formats targeted to their cognitive strengths while triggering interest, understanding and enjoyment. In this blooming information age, where technological developments have multiplied the forms of information, it is not acceptable for limited concepts of legibility to be the only judgmental criteria. In his influential text *Emotional*
Design: why we love or hate everyday things, Donald Norman proposes a theory of ‘emotional design’ by locating design creation and reception in the subconscious and emotional processes rather than rational and functionally oriented directions. For Norman, ‘emotions are inseparable from and a necessary part of cognition.’ It is the argument of this research that matching interface design to the way people think is a fundamental component of creating usable and pleasurable interface designs when user groups are known and product content suggests this.
User-centred design from a ‘multiple intelligences’ perspective

Modernism conceived design as a universal form of representation and communication. The predominant theory of human cognition in the twentieth century was also based on general principles. Cognitive science argued for the idea of a single or ‘common’ intelligence quantifiable by a single Intelligence Quotient (IQ) test. The IQ test was first developed by Alfred Binet in the early twentieth century, Binet arguing:

> It seems to us that in intelligence there is a fundamental faculty, the alteration or the lack of which, is of the utmost importance for practical life. This faculty is judgment, otherwise called good sense, practical sense, initiative, the faculty of adapting one’s self to circumstances. A person may be a moron or an imbecile if he is lacking in judgment; but with good judgment he can never be either. Indeed the rest of the intellectual faculties seem of little importance in comparison with judgment.

With its strong emphasis on rational judgment, Binet’s theory of a fixed and quantifiable intelligence presented logic and linguistics as fundamental to human intellectual performance, helping people to deal with knowledge in all aspects of life. IQ tests based on Binet’s theory measured an individual’s intellectual ability in a few specific areas. These were primarily the binaries of verbal and linguistic and logical and mathematical, their framing reflecting their inventor’s ideas about what was significant in human intelligence conceived as a set of hierarchical, numerical relations, becoming a widely used indicator of individual’s academic performance and life prospects.

Though IQ was once seen as a useful tool for understanding individual intellectual difference, many scientists are now convinced there is no unitary intelligence and no single measure of intellectual ability. For example, the results of Robert Sternberg’s 1997 Yale Summer Psychology Program Study, which explored the diverse ways students work and learn, contradict the idea of general intelligence, Sternberg arguing:

> When we did a statistical analysis of the ability factors underlying performance on our ability test, we found no single general factor (sometimes called a g factor or an IQ). This suggests that the general ability factor that has been found to underlie many conventional ability tests may not be truly general, but general only in the narrow range of abilities that conventional tests assess.

Sternberg’s 1997 study built on several decades of research into human cognition that challenged the previously long-standing belief in intelligence as
a single, static entity. This began with Dr. Roger Sperry's work revealing that
the left and right sides of the human brain exhibit different modes of thinking,
for which he won the 1981 Nobel Prize in Medicine. According to Sperry the
left hemisphere is rational, analytical, logical and linear and governs verbal
and linguistic functions. The right side drives the more artistic, imaginative,
emotional, musical, holistic and sensory side of cognition. Sperry's findings
opened paths to more sophisticated views of intelligence, suggesting the need
for a reassessment of human intellectual capacities outside the axis of the
logical and linguistic. In particular, Sperry argued that there are two basic
modes of thinking, verbal and nonverbal, representing the left and right
hemispheres respectively.

Robert Sternberg and Howard Gardner have likewise stressed there is no single
number to capture the complexity of human performance in the real world.
In their landmark work on intelligence, both explore the variety of intellectual
abilities and argue it is possible for people to cultivate them all, providing much
to reflect on for developers and designers of IMM products. A long-time critic of
standardized psychological testing, Sternberg argues society must go beyond IQ
tests to focus on 'successful intelligence', which he sees as the ability to adapt,
shape and select environments to accomplish one's goals. In his book Successful
Intelligence: How Practical and Creative Intelligence Determine Success in Life,
Sternberg states that, 'IQ based academic intelligence is customarily measured
by the ability to solve well-constructed problems whereas real world successful
intelligence is the ability to solve ill-structured problems.' Sternberg's extensive
writings on human intelligence represent conventional notions of intelligence
as denying the variety and potential of human mental ability. His work views
intellectual ability as dynamic and flexible rather than static and fixed, arguing
that those with successful intelligence, 'may or may not succeed on conventional
test, but they have something in common that is much more important than
high test scores. They know their strengths; they know their weaknesses. They
capitalize on their strengths; they compensate for or correct their weaknesses.'

Sternberg argues that humans need creative and practical abilities as well
as analytical skills to succeed in their life pursuits and that intelligence is a
developing and changeable entity that is dependent on context. Those with
successful intelligence think well in three different ways—analytically, creatively
and practically. Analytical intelligence is used to judge an idea and to solve
problems. Creative intelligence is used to design ideas and to determine the
problems that the analytical intelligence solves. Practical intelligence is used
to apply these ideas and solutions in real life. Conventional standards of
intelligence reward only the performance of analytical intelligence rather than
challenging people to develop their talents in all three areas. While everyone
has at least one strong point among these three dimensions of intelligence, Sternberg argues, ‘It is more important to know when and how to use these aspects of successful intelligence than to just have them.’ Sternberg’s writings imply that the development of information products around logic and linguistics reflects an impoverished view of human intellect and cognitive capacity. This is unsustainable in an era in which information and information and communications technology are a central component of economic production and contemporary citizenship, and where change occurs at an unprecedented pace and scale. As Nita Cherry argues, ‘The consequences [of such change] are profound, the opportunities and challenges both exciting and disturbing. Every day, we see the creation and convergence of new and diverse knowledge streams from a range of disciplines and fields. Every day, human beings must find ways to translate this knowledge and capability into effective practice.’

It is vital that interface and interaction designers reframe design principles according to broad social and technological change as an intrinsic part of their professional responsibility.

The theory of multiple intelligences

In 1983 Howard Gardner’s book *Frames of Mind* added to the general upheaval in scientific thinking about human cognition by advancing his theory of multiple intelligences. To challenge the traditional concept of intelligence Gardner looked for evidence of diverse cognitive abilities from evolutionary biology, and experimental and psychometric psychology. This included studies of prodigies, gifted individuals, brain-damaged patients, idiot savants, normal children and adults, experts in different lines of work, and individuals from diverse cultures. Gardner’s clinical work with brain-damaged patients led him to see that the different forms of human intelligence operated independently, suggesting the existence of multiple intelligences. For example, patients who had lost visual and spatial thinking could not recognize the faces of people but could still read and talk. They could name the parts of the face as eyes, nose and mouth but could not put the actual features of a human face together visually to recognize a friend or relation. Such individuals even used details of clothes or voice to know whether a person was a man or woman. For Gardner, the example of prodigies and idiot savants demonstrated that intelligence was not a single entity. Prodigies show extraordinary talent at a very early age in particular areas but are often quite average in other areas of intelligence. Idiot savants show remarkable ability in areas such as drawing, music or memory but have only limited language or social skills. Gardner argues that from an evolutionary perspective it makes more sense to see humans as having multiple, relatively autonomous mental faculties.
Gardner goes even further than Sternberg in arguing that IQ tests measure only a sub-set of human intelligence. From an understanding of intelligence as contextual and cultural, Gardner proposes that individuals perceive the world through at least eight different intelligences, these being verbal/linguistic, logical/mathematical, visual/spatial, bodily/kinesthetic, musical/rhythmic, interpersonal, intrapersonal and naturalist. His work demonstrates that each person possesses each of these intelligences but they differ in their degree, creating the variety of intelligence, which he describes as being as diverse in its composition as the human face. Following Gardner’s work IQ tests have been criticized for emphasizing the logical and linguistic over other cognitive capacities, failing to explain the breadth of semiotic resources available for human cognition or the basis of creativity and originality while disregarding socio-cultural factors and motivation in the role of human understanding; a set of salient warnings for interaction and interface design.

Gardner’s work argues that general intelligence theory is based on many false assumptions, including the premise that intellectual ability does not change with age, training, life experience, social and cultural background or context. Through his research Gardner has explored the mental abilities underlying the diverse range of actual human accomplishments found across cultures. He proposes that the variant of intelligence relies on personal context, as well as biological and psychological potentials based on the interaction of individual genetics, life experience and cultural circumstances. Initially, he defined intelligence as ‘the ability to solve problems, or create products, that are valued within one or more cultural settings.’ More recently he has refined this to explain intelligence as ‘a biopsychological potential to process information that can be activated in a cultural setting to solve problems or create products that are of value in a culture.’ If the intelligences are the neural potentials that will or will not be activated, how information is delivered to individuals could be the trigger for that potential. Applying this to design, the assumption is that if information can be represented in ways that suit the specificity and diversity of intelligence it is possible for individuals to express their intellectual strengths completely.

Gardner especially asserts that ‘intelligences are potentials, not things that can be seen or counted.’ For Lorrie Shepard, ‘Tests measure what is. If they misrepresented what is, they would be considered biased; but tests are not expected to estimate what might have been under different circumstances of schooling or early development.’ While IQ test fails to show diverse forms of human ability they tell nothing about how to cater to it, especially in the non-verbal realm. As early as 1972 Ruth Hubbard argued ‘IQ tests ignore much in us that is artistic, contemplative and nonverbal. They were constructed to predict
success in the kinds of schools that have prevailed in Europe and the United States.\textsuperscript{99} The history of the IQ test provides a cautionary tale for information design. Strategies of information design, whether in print or digital contexts, privilege linguistic and logical thought processes, disregarding the diversity of forms of communication and representation, the range of conceptual literacies bound up in individuals and groups, and the potential for literacies ‘to evolve and shift in response to social and cultural change’.\textsuperscript{100} The rise of information and communications technology is a prime example of such a context for change.

**Human symbolic systems and intelligence**

While contesting the idea of intelligence as a single capacity based around a combination of linguistic and logical, mathematical skills, Gardner argues that different intelligences are conveyed through identifiable symbolic systems, which have developed over time to facilitate expertise and understanding in a discipline.\textsuperscript{101} Gardner views the existence of these symbolic systems as ‘one of the best indicators of intelligent behavior’, with each intelligence having its own conceptual medium, their purpose being to convey information and ideas in meaningful and relevant ways.\textsuperscript{102} Gardner sees each symbolic system, such as written and spoken language, numerals, gestures, maps, charts, drawings and musical patterns, as allowing people to exhibit specific understanding, as unique to itself and vital to completing the set of tasks within a field.\textsuperscript{103} The implication here is that the conceptual core of information reveals a target audience’s cognitive style, suggesting how information can be conveyed to enhance understanding and enjoyment.

Gardner’s theory advances the idea that all individuals possess different intellectual strengths, supporting the proposition that the design of information should take this difference and diversity into account. Currently, the presentation of information in countless contexts emphasizes linguistic and logical intelligence. It assumes that by providing everyone with the same information everyone is equally provided for. In fact, it is exactly the opposite because the emphasis on text-based information and textually-defined information hierarchies disregards individual cognitive needs and differences. This attitude equally overlooks Carey Jewitt’s argument that, ‘reading and writing are and have always been multimodal’ requiring ‘the interpretation and design of visual marks, space, colour, font or style, and, increasingly image, and other modes of representation and communication.’\textsuperscript{104}

When Gardner developed his theoretical model of multiple intelligences he did not anticipate its use in fields other than psychology. However, immediately *Frames of mind* was published MI theory created strong interest among educators around the world, revolutionising many aspects of teaching and
learning. In the context of teaching and learning, Gardner argues, ‘these differences challenge an educational system that assumes that everyone can learn the same materials in the same way and that a uniform, universal measure suffices to test student learning’. \(^{105}\) Gardner contends that since people learn in identifiably distinctive ways, ‘The broad spectrum of students—and perhaps the society as a whole—would be better served if disciplines could be presented in a number of ways and learning could be assessed through a variety of means.’ \(^{106}\) MI theory has obvious relevance to information and interface design in demonstrating that people take in, retain and manipulate information in identifiably distinct ways and that these are largely oblivious to MI theory. Gardner’s writings suggest the continual need to provide individuals with customized opportunities to apply their intellectual ability in ways that are consistent with their preferred perceptual competencies and behaviours. MI theory provides valuable insights into cognitive strengths and preferences, guiding designers to create more engaging and effective experiences for a wider variety of users by configuring design elements in specific ways. By understanding individual cognitive strengths and preferences designers can allow audiences to be more successful, engaged and fulfilled in the reception and interpretation of information. Moreover, the experience of information is likely to be successful in the context of IMM, Gardner arguing that, ‘new technologies make the materials vivid, easy to access and fun to play with—and they readily address the multiple ways of knowing that humans possess.’ \(^{107}\)

**The nature of visual intelligence**

Gardner defines the linked capacities of visual and spatial intelligence as the ‘ability to form a mental model of a spatial world and the ability to operate using that model.’ \(^{108}\) Diverse groups from engineers, surgeons, sculptors and painters to early mariners who navigated without instruments demonstrate highly developed spatial intelligence. In *Multiple Intelligences*, Gardner in fact explains visual/spatial intelligence using the historical example of ancient sailors, for whom:

> The positions of the stars, as viewed from various islands, the weather patterns, and water colour [were] the only signposts. Each journey is broken into a series of segments; and the navigator learns the position of the stars within each of these segments. During the actual trip, the navigator must envision mentally a reference island as it passes under a particular star and from that he computes the number of segments completed, the proportion of the trip remaining, and any corrections in heading that are required. The navigator cannot see the islands as he sails along; instead he maps their locations in his mental ‘picture’ of the journey. \(^{109}\)

This example suggests how highly developed human visual/spatial intelligence
can be. According to Campbell and others, the likely tendency of a person with strong visual/spatial intelligence is their use of visual images, both inner mental images and outer graphical images, as aids in recalling and interpreting information. The preference for visual form leads such individuals to see things in multiple ways. For example, when observing an object it is easy for those with high visual/spatial intelligence to see both the negative space around a form and the form itself or to perceive one form ‘hidden’ in another. Such individuals are also able to perceive both obvious and subtle patterns, including abstract patterns. When a designer conveys information to a visually intelligent audience it can be presented most effectively, in whole or in part, in visual forms like charts, diagrams, outlines, concept maps and sequences of visual images.

While presenting information in visual form can trigger the motivation and understanding of visually intelligent audiences, the relationship of vision to conceptual processes is both highly complex and obscured by its own set of assumptions. The idea that the senses are only receptors of external stimuli to be mediated and made sense of by the intellect is an entrenched but inaccurate belief. Drawing on recent breakthroughs in vision research, Donald Hoffman contends that vision is not just a matter of passive perception. It is an intelligent process of active construction. Semir Zeki argues that the process through which human brains perceive visual information and develop spatial awareness constitutes abstract thought. In the quest for knowledge from visual information, Zeki maintains that we ‘generate’ the visual image in the brain by ‘discarding’, ‘selecting’ and ‘comparing the selected information to its stored record.’ For Zeki, the visual centres of the brain filter and compose visual elements into an intelligible image, constructing meaning from raw sense data in a way that is already a form of thinking.

If seeing is a form of knowing those who favour visual/spatial intelligence are engaged in sophisticated processes of abstract thought. Barbara Seels sees those with advanced visual ability such drawing students as having ‘the ability to both understand and make visual statements.’ In certain cultural contexts visualisation skills are not only highly respected but theorized and developed. For example, Frederick Frank describes how the state of Zen can help the drawer to see from a wider and higher perspective and to sense the details and beauty often ignored in seeing. The intelligibility of vision involves the drawer in a selective and personalized activity but since these processes happen at an unconscious level we are often not aware of this powerful ability. Designers, who are likely to have high visual/spatial intelligence themselves, could be far more adventurous in formulating visual messages to enhance understanding, communication and thinking, not only for those with advanced ability in interpreting visual meaning but for all audiences.
Drawing education and cognitive psychology

Howard Gardener’s work suggests that as a self-selecting group with strong interests in things visual, Taiwanese drawing students aiming to enter tertiary art and design programs are likely to have an enhanced capacity to think visually and orient themselves spatially. Scientific research into visual intelligence has already had a strong influence on drawing education, suggesting some specific approaches designers could use to harness visual intelligence to the design of the GUI. Investigation into brain lateralization provides significant understanding of how individual brains develop and implement visual understanding and creativity. Betty Edwards’s landmark book, *Drawing on the Right Side of the Brain*, uses Sperry’s ‘split brain theory’ to argue that individuals use the right side of the brain to process the scene before them when drawing. For Edwards, this makes the cognitive processes that support drawing unusual:

Realistic drawing of a perceived image [she writes] requires the visual mode of the brain, most often located in the right hemisphere. This visual mode of thinking is fundamentally different from the brain’s verbal system—the one we largely rely on nearly all of our waking hours. For most tasks, the modes are combined. Drawing a perceived object or person may be one of the few tasks that require mainly one mode: the visual mode largely unassisted by the verbal mode.

Edwards contends that people who rely on nonverbal cognition to process information typically make leaps of insight based on incomplete patterns, hunches, feelings and visual images. The implication is that such individuals create vivid mental images to make sense of things and are prepared to negotiate their way through a task or context on the basis of visual intuition, most likely enjoying the challenge of such an approach in opposition to the imperative to negotiate information within the GUI in functionally efficient ways using text-based hierarchies. Ann Marie Seward Barry reinforces this by arguing that high visual intelligence is a quality of mind developed to the point of critical perceptual awareness in visual communication.

Such ideas have encouraged researchers in art education to develop methods to encourage people to process information through the right brain to enhance creativity and visualisation skills. Edwards, for example, developed innovative techniques such as upside-down drawing to shift brain mode from logical left to imaginative right brain to allow a wide spectrum of people, not just talented drawers, to develop non-linear and holistic drawing skills. The upside-down technique aids visualisation because it presents the brain with a task that language systems reject, thus allowing the right side of the brain to attain its full capability for drawing. When an image is executed upside down, the visual clues don’t match the literal object in front of the drawer. Even well-known faces are difficult to recognize and name, and the brain becomes confused. Edwards
argues art educators can ‘use this gap in the abilities of the left hemisphere to allow right brain to have a chance to take over for a while.’ A related technique is contour drawing, introduced by Kimon Nicolaides in his 1941 book *The Natural Way to Draw*. Contour drawing uses complex abstract images to confuse the logical left brain and allow the brain mode to shift across to the right. This technique has been widely used by art teachers to get students to draw more freely by ‘turning off’ the left brain.

**Hypertext and visual thinking**

Similar innovations are needed in interaction and interface design to allow a diversity of users to get the most out of interaction process by stimulating a greater range of cognitive processes in the reception of the GUI. Where usability principles advocate the quest for order and efficiency in the design of the GUI, cognitive science suggests that the human brain is much more flexible and intuitive in accessing and interpreting information, the arts being an evident example of alternative ways of discovering and knowing to that of the dominant paradigm of technical-rationality. The esteemed educationalist Elliot W. Eisner contends that common confusion about the nature of the human mind, knowledge and intelligence means we easily overlook the intellectual character and benefits of the arts:

> Artistic tasks, [he writes] unlike so much of what is now taught in schools, develop the ability to judge, to assess, to experience a range of meanings that exceed what we are able to say in words. The limits of language are not the limits of our consciousness. The arts, more than any other areas of human endeavour, exploit this human capacity.

The conventional belief, however, is that the logical structures of language are necessary for thought while being intrinsic to the expression of intelligence. Current research and debate in the field of IMM focuses mainly on the use of hypertext as the chief mechanism for the structuring and transfer of information. This emphasis sees networks of words as the primary means of negotiating IMM products yet also suggests alternative forms of apprehension since hypertext transcends the dimension of the logical and linguistic in important ways.

The idea of linked information goes back to a 1945 text by Vannevar Bush who, as director of the United States Office of Scientific Research and Development, imagined a microfilm reader that would give access to humanity’s growing store of knowledge by allowing users to search for information by typing key words into the apparatus. Then, in 1965, well before the development of the personal computer and the World Wide Web, Theodor Nelson invented the term hypertext to describe the mechanism of linking dynamic, heterogeneous collections of documents and multimedia. For Nelson tracing linked words from one document to another would allow readers to follow ideas through
a range of information sources. He saw an implicit creativity in hypertext that disrupted the conventional linearity of text. When the technical means to realize these visions became available through the personal computer and the World Wide Web, academics in the fields of language and literature stressed the creative rather than practical dimensions of hypertext. Approaching hypertext as an extension of poststructuralist theories of textuality and meaning, they argued that hypertext transforms readers from passive receivers of information into 'agents' who construct their own meanings and experiences.¹²⁸

For George Landow, for instance, the capacity of users to follow individual paths through information in ways that do not conform to the linear order of printed text reflect the influence of reading on writing. In *Hypertext: The Convergence of Contemporary Critical Theory and Technology*, Landow claims that the hyperlink has transformed the basic idea of 'text' so that it no longer means discrete bodies of information that are read but chains of electronically linked documents and other diverse materials, including image, sound and data.¹²⁹ Landow argues that hypertext allows 'one to create and perceive interconnections', suggesting the need for information structures and styles of interface design beyond the formulaic and functional orientation of current approaches.¹³⁰ In fact, Michael Joyce describes hypertext as an implicitly visual form that 'embraces information and communications, artistic and affective constructs, and conceptual abstractions alike into symbolic structures made visible on a computer-controlled display'.¹³¹ For Joyce, digitally linked materials are best approached as visual, spatial structures. The function of connecting diverse materials in virtual space challenges audiences and designers to discard the conception of information as linear, suggesting the need for alternative, non-textual information structures that allow users to understand what they are engaged in. Strategies of visual mapping, which echo the inherent spatial dimension of hypermedia, may be the best way for all users of IMM to 'see' the structure of linked material in IMM products and orient themselves as they interact with it.

The presentation of information through the hyperlink and IMM may bring left logical cognitive processes into direct tension with the basic form of information and the mental processes required to navigate it. The following table, developed by the educator J.E. Bogen in 1975, contrasts the different functions and characteristics of the left and right hemispheres of the human brain.¹³²
User-centred design from a multiple intelligences perspective

The location of the different modes of thought, however, is perhaps not as important as the differences between the different modes of thought, especially between intuitive thought processes and logical thought processes. Bogen’s list highlights the potential range and complexity of human cognition, challenging interface designers to develop ways to harness this diversity. The fundamental division between intuitive and logical thought processes suggests very different ways of responding to the GUI. Jerome Bruner argues that, ‘In general intuition is less rigorous with respect to proof, more oriented to the whole problem than to particular parts, less verbalized with respect to justification and based on confidence to operate with insufficient data.’

Stephen Wilson contends that the visual thinking ‘often explores different inquiry pathways, conceptual frameworks, and cultural associations than those investigated by science and engineers’. In this design project, the GUI is developed to activate user’s visualisation strengths and encourage them to engage with the interface intuitively. This is achieved through the predominance of visual cues that stimulate visual thinking and, most importantly, encourage the pleasure in visual interpretation and visual processes fundamental to drawing.

**Conveying tacit drawing knowledge to visually intelligent audiences**

Where the primary aim of GUI design is to facilitate communication between information and audience, designers need to be responsive to the nature of the information they impart. As well as requiring high bodily/kinaesthetic and visual/spatial intelligence drawing also revolves around tacit knowledge. Michael Polanyi proposed the idea of tacit knowledge in 1958 to describe knowledge common to daily life, encompassing skill, understanding and unspoken judgment. In contrast to the paradigm of reasoned and critical interrogation

<table>
<thead>
<tr>
<th>Left hemisphere</th>
<th>Right hemisphere</th>
</tr>
</thead>
<tbody>
<tr>
<td>intellect</td>
<td>intuition</td>
</tr>
<tr>
<td>convergent</td>
<td>divergent</td>
</tr>
<tr>
<td>digital</td>
<td>analogic</td>
</tr>
<tr>
<td>secondary</td>
<td>primary</td>
</tr>
<tr>
<td>directed</td>
<td>free</td>
</tr>
<tr>
<td>propositional</td>
<td>imaginative</td>
</tr>
<tr>
<td>analytic</td>
<td>relational</td>
</tr>
<tr>
<td>lineal</td>
<td>nonlineal</td>
</tr>
<tr>
<td>rational</td>
<td>intuitive</td>
</tr>
<tr>
<td>sequential</td>
<td>multiple</td>
</tr>
<tr>
<td>analytic</td>
<td>holistic</td>
</tr>
<tr>
<td>objective</td>
<td>subjective</td>
</tr>
<tr>
<td>successive</td>
<td>simultaneous</td>
</tr>
</tbody>
</table>

*Table 1: Bogen’s list of the organization of the brain*
in the sciences, Polanyi saw tacit knowledge as a form of knowing that cannot readily be described in words.\textsuperscript{135} He characterized much of humanity’s most valuable knowledge as rich in understanding but defying explanation by explicit reasoning.\textsuperscript{136} Furthermore, since the experience held by individuals in things like physical skills is unique to them, tacit knowledge is usually built up over time through observation and practice, making such knowledge difficult to formalize or articulate in a systematic, verbal manner.

Polanyi argues that the ‘explanations’ through which tacit knowledge is imparted ‘must be understood as a particular form of insight’ that demonstrate the principle that ‘we know more than we can tell.’\textsuperscript{137} He was especially interested in how tacit knowledge was formed from a range of conceptual and sensory information, drawn together in the effort to make sense of things in ways quite opposite to the formal validation and refutation methods used in establishing scientific knowledge. For Polanyi, visual perception is central to the ‘know-how’ in tacit knowledge, since it represents a way of seeing the world in gestalts.

Korthagen and Kessels describe the concept of gestalts as ‘the dynamic and holistic unity of needs, feelings, values, meanings and behavioral inclinations triggered by an immediate situation’.\textsuperscript{138} The gestalts, or perceptions, gained through direct experience constitute ‘tacit knowledge’, and are formed through a process of perception, interpretation and response that occurs instantaneously and unconsciously.\textsuperscript{139} It is this order of complex, intuitive applied knowledge that is central to drawing. Betty Edwards argues that:

learning to draw means learning to access at will that system in the brain that is the appropriate one for drawing … accessing the visual mode of the brain … causes you to see in the special way an artist sees. The artist’s way of seeing is different from ordinary seeing and requires an ability to make mental shifts.\textsuperscript{140}

Conveying drawing knowledge should respect the way those with high visual intelligence process information while they are engaged in the task of drawing, providing learners with an intuitive and immersive interactive environment that stimulates aesthetic processes and the ability to see rather than just to look.

Despite the pivotal place of tacit knowledge in human existence, Richard Cherwitz and James Hikins argue that language is entrenched as the primary and legitimate form of human understanding, establishing a specific epistemological relationship between human communication and knowledge.\textsuperscript{141} Michel Foucault’s theory of communication likewise sees language and knowledge as completely interwoven, Foucault arguing that, ‘They share, in representation, the same origin and the same functional principle; they support one another, complement one another, and criticize one another incessantly.’\textsuperscript{142} Foucault’s archaeology of the Western episteme represents the individual as wholly constituted through the knowledge
and power entrenched in language. Similarly, Jacques Derrida’s account of
language as an arbitrary signifying system without positive values nonetheless
gives words precedence over being and acting.

The fusion of language and knowledge is challenged by the nature of
tacit knowledge in areas like the arts. Visual communication scholars often
maintain that visual rather than verbal thought is the primary form of human
consciousness. Before there was language, cave dwellers drew pictures of
animals and other important influences within their experience on cave walls,
suggesting that visualization abilities developed before speech. S. I. Hayakawa
asserts that vision determines ‘perhaps even more subtly and thoroughly than
verbal language, the structure of our consciousness’. We extract visual
information from the world around us to achieve a certain level of understanding
without any verbal interpretation. Thomas Sebeok argues that the emphasis on
language in many societies over other forms of communication has ‘delayed
the study of communication’, an observation born out by the development
of interface and interaction design. Unlike language development, visual
ability remains relatively untutored in many societies. For James J. Gibson
visual perception is ‘richer and more inexhaustible’ and more open to personal
interpretation’ by comparison to language, which while a fluid and evolving
system of meaning is tied to dictionary definitions and the rules of grammar.
The individual interpretation of visual meaning, by contrast, does not depend on
a customary system for assigning meanings to visual elements. The interpretation
of paintings, for instance, is both highly subjective and projective, placing
significant perceptual and intellectual demands on the viewer. It is also possible
that visual thinking is freer and more capable of representing certain abstract
and innovative thought, Arthur Koestler arguing that, ‘true creativity often starts
where language ends.’

Western thought generally distrusts such forms of knowledge and they are
poorly catered for by instructional materials, drawing being a case in point. While the purpose of this research is not to argue that visual communication is
superior to language, the understanding that visual and verbal thought are two
structurally and functionally distinct systems of human cognition is fundamental
to the development of the designed prototype. Although language and image
are powerful forces when applied in the right context, this research proposes
that the tacit knowledge intrinsic to drawing is best conveyed using the visual
approaches implicit in the visual/spatial and bodily/kinaesthetic intelligence
of those who are most likely to be interested in such knowledge. For Sandra
Moriarty visual communication processes are different from language based
communication because of the way observation impacts upon thinking. Although language may be effective in explaining theoretical aspects of drawing
it fails to transmit the observational and manual activity that is central to drawing skill. The skills and understandings involved in drawing are gained through experience and represent a form of contextualized knowledge that relies on accumulated insights, sensations, and manual facility best conveyed through practice and exposure to examples and demonstrations.

Arthur Koestler contends that verbal and linguistic processes represent a conflicting set of cognitive operations, the linguistic disturbing the formation of visual imagery. He argues that even though words are essential tools for formulating and communicating thoughts, for the visual thinker they ‘can also become snares, decoys or strait-jackets.’ To support modes of thought preferred by those with high visual intelligence, the GUI is configured in mainly visual terms, text based navigation systems and information hierarchies being purposely reduced or avoided. The design prototype uses abstract design elements to suffuse the user in the visual processes of the right brain—the optimum brain mode for observing and drawing. The abstract, visual character of the interface is opposite to the established principles of IMM design, which mainly focus on the logical identification, organization and navigation of information. Fig. 7

Figure 7: Abstract and complex interface design

**Graphical User interface and visual communication**

As the field of digital information design has evolved, new perspectives beyond simple utility have emerged. As early as 1995 Nanard and Nanard argued that new developments in IMM should ‘take into account aesthetic and cognitive aspects … that [the] traditional software engineering environment does not support.’ Yet research into the affective aspects of visual interface design
remains relatively underdeveloped and there being few legitimated examples of ‘successful’ alternative interfaces for designers to learn from. The connection between IMM research and the field of information visualization has not been broadly made, limiting designer’s understanding of the possibility of developing tailored visual interfaces for specific audiences. Cognitive psychology provides strong insight into how visual imagery and perception play an active role in knowledge and understanding. Without this cross-fertilization, design only adds an aesthetic skin to text-based information.

Edward Tufte’s book *Envisioning Information* argues that information visualization can clarify information and aid understanding in a broad range of circumstances. His text demonstrates how complex ideas and information can be displayed by visual means such as maps, charts, computer interfaces and stereo photographs. For Tufte, the ‘vocabulary’ or ‘syntax’ of visual language is especially important in triggering viewer’s conceptual processes. Johannes Itten’s canonical 1919 theory of the language of vision pioneered the idea that visual elements can be formed into intelligible meanings. Itten’s idea of visual language is a metaphor that compares the structure of a picture, diagram or page layout to the grammar or syntax of language, visual meaning being composed of elements such as dots, lines, shapes, textures and colours organized as contrasting or complementary arrangements. Building on Itten’s work, in 1944 Gyorgy Kepes, another former Bauhaus teacher, proposed the idea of design as a ‘language’ founded on abstraction, arguing that, ‘Just as words can be put together in innumerable ways to form meanings, so the visual elements [of design] can be brought together.’

As modernists, Itten and Kepes sought to discover a pre-existing order and form to the visual elements of art and design in ways paralleling science’s empirical investigation of human perception. While not suggesting a return to modernist principles of the universality of the visual sign, the idea of visual language expands the range of strategies in GUI design, embracing cognitive difference and empowering individual users. Both cognitive psychologists and neurologists have found that the senses and emotions are direct forms of cognition and understanding. As such knowledge and understanding cannot simply be a verbal entity based around the structures of language. Harnessing the affective dimensions of perception to information visualization through aesthetics and design should enhance understanding. GUI design based on visual elements has the potential to orient the form and structure of information, navigation systems and interaction processes to the cognitive capacities of visually intelligent users and the inherent nature of the drawing task.
The application of multiple intelligences theory to interactive multimedia technology

Although information is plentiful in this computer age what is lacking is the intellectual work to transform it into useable and compelling knowledge. Howard Gardner’s MI theory suggests that the differential nature of human intelligence is fundamental to how individuals and groups process information, challenging designers to use IMM’s multimodal communicative channels to create aesthetically rich and evocative GUI environments that orient content delivery to audience’s specific perceptual preferences. Shirley Veenema and Howard Gardner argue that IMM technology means there is little need for information to be text dominated. They citing the example of a CD-ROM on the American Civil War informed by MI theory they argue that, ‘the mind is neither singular nor revealed in a single language of representation, our use of technologies should reflect that understanding.’

They approached the design of the CD-ROM so that audience members were introduced to multiple perspectives of the battle, the use of media giving users the opportunity to access the information through different representations. Source material was selected in a range of symbolic forms to accommodate the different intelligences, including things like journalist’s accounts from the time, contemporary photographs, drawings, and telegraph and signal reports. The diversity of information allowed individual users to explore the history of the Civil War through their preferred cognitive approaches, demonstrating the scope of IMM technology to cater for different types of intelligence and allowing users to form rich representations and cultivate deeper understanding.

The implications for individuals and society of ignoring intellectual diversity are high. Michael Hardt and Antonio Negri argue that just as modernization and industrialization transformed the ‘processes of becoming human and the nature of the human’, the transition to postindustrial society has created a new economic and social paradigm they call ‘informatization.’ In a postmodern, service-oriented and information-based society the ‘new mode of becoming human’ is anchored in ‘the cybernetic intelligence of information and communication technologies.’ Negri and Hardt contend that ‘Interactive and cybernetic machines [have] become a new prothesis integrated into our bodies and minds and a lens through which to redefine our bodies and minds themselves.’ Moreover, the ability to engage with such technologies will be the mark of full global citizenship in the future, if this is not already the case.

To configure the GUI in ways that privilege linguistic and logical intelligence shuts out significant groups from full participation in the knowledge and
The application of multiple intelligences theory to interactive multimedia technology

communication society, wasting the diversity of human talents as well as being directly discriminatory.

Veenema and Gardner’s work shows how content can be presented in a range of forms. The work of ensuring diversity in the ways in which interaction processes and the GUI are configured through design is still to be done. Moreover, although there is a vast literature on the application of new, screen-based technologies to formal education almost no writers consider the application of IMM to the acquisition of tacit knowledge. Consequently there are few models of IMM that start from a non-linguistic base and few guidelines for the IMM industry in the development of products presenting tacit knowledge. For Alessi and Trollip the primary problem with IMM products is that they fail to provide an environment in which the user is able to ‘construct their own meaningful and individualized’ ways of receiving information. Brenda Laurel argues that the principal issue with all information and communication technology is how to best present information within the interface, identifying the constant dilemma for designers in their role of mediating between users and content. Yet today IMM products are mostly formulated in the ways product developers favour rather than those suited to the individual needs of users.

While there is no ‘right way’ to reflect cognitive preferences or construct the interface between IMM technology and users, the key to GUI design is to facilitate access to information so that technology disappears, use becomes intuitive, content moves into the foreground and the interactive experience is absorbing. Howard Gardner argues that, ‘At the heart of any arts education process must be the capacity to handle, to use, to transform different artistic systems—to think in and with the materials of the artistic medium.’ There are few IMM products that incorporate visual and audio interactions in a structured drawing instruction process. Shelley Carr describes an activity in the Kid Pix program that uses the landscape photographs of Ansel Adams as a visual resource for students to explore tonal value and texture in their black and white drawings. After selecting a photograph, students study the details and observe the proportions and composition of objects in the picture, then draw on the screen with a paint program. As the students draw with the computer they convert the different tonal values of the photograph to the tonal values of colours selected from the menu, making their pictures more individualized and abstract as they work and thereby learning about different aesthetic possibilities. This example shows how the computer can be used as a platform for creative extension. However, although the computer can encourage visual and conceptual experimentation it is not currently possible to replace actual drawing on paper with its technological simulation. The design prototype gives learners access to drawing knowledge in a digital context in order to shift
their relationship to this knowledge to one of active engagement while still anticipating that the translation of knowledge into practice will take place on paper. The prototype addresses basic problems in the atelier system of drawing, such as the fact that novice drawers are often unable to move on if they get lost in some critical step and the drawing master is unavailable. The application of technology takes drawing knowledge outside the studio context, allowing students to work independently and to engage in self-initiated analysis and problem-solving within the drawing task.

**Current media products for teaching drawing**

Drawing knowledge is traditionally transmitted in the studio environment with students learning by practice under the guidance of a drawing master who demonstrates the integral skills of the discipline as required by the exercise and the student’s stage of development. The master-apprentice relationship serves the valuable function of addressing the individual learner’s needs and deficiencies. The master’s greater experience and ability reveals the critical steps and skills involved in executing a drawing through demonstration. An experienced teacher can ‘show’ solutions when novice drawers can’t ‘see’ them, while the studio environment provides a motivating atmosphere that inspires students by observation of other’s work, talk between peers and a link to artistic tradition. Although high academic drawing skills are required for entry into tertiary art and design programs in Taiwan it is rare for students to see how a drawing is executed from beginning to end due to the limitation of class time. Seeking external support in the form of extra tuition or additional learning materials is usually vital if students are to achieve the required standard of drawing. *Fig. 8* A range of Chinese language CD-ROMs, web sites, and videos that teach academic drawing skills are available but all are oblivious to advanced thinking in art education. The poor quality of such products means that most of students prefer to buy ‘how to’ books rather than digital products. Much of the failure of existing products rests on the primarily written and verbal basis of the information. The impoverished handling of examples and demonstrations is also a deficiency, imposing lockstep learning processes on the learner drawer rather than supporting divergent, self-paced practice and individual experimentation. Products equally fail to harness the unique qualities of IMM to information provision and are tedious to watch, with lengthy explanations and demonstrations.
Figure 8: The required standard of drawing
The following images were captured from existing VCD titles. Fig. 9 Most originate from mainland China, which has higher drawing skills than Taiwan but uses very traditional teaching methods. The examples are outstanding in representing academic drawing skills in great detail and include some inspiring lectures by renowned drawing masters. However, they share the common shortcomings of most instructional VCDs on drawing. For example, though a linear structure can capture the drawing process in detail, the vast amounts of information can be overwhelming, making learners lose focus and affecting the inclination to learn.

VCD 1  How to draw

VCD 2  Drawing for enrollment test

VCD 3  Drawing: head drawing volume 1

VCD 4  Drawing: head drawing volume 2

Figure 9: Examples of current drawing teaching VCDs
CD-ROMs and web sites devoted to drawing instruction are mostly provided by museums, universities, art institutes, art studios, and individual artists. They appeal to different audiences and have different outcomes but most demonstrate drawing skills and knowledge in one of two main ways. One is text-based, using descriptions of drawing skills supported by examples. Products use limited still and moving images with text descriptions to explain the ‘doing’ process, visual information only provided to illustrate verbal explanations, such explanations matching neither drawer’s perceptual behaviour and intellectual strengths nor the nature of tacit knowledge. Fig. 10 The other is image-based and presents a large number of small images without any supporting information about how each drawing is made. Fig. 11 An advantage of the World Wide Web is that information can be periodically updated, encouraging users to visit a site frequently. However, the limitation of bandwidth means the content of image and sound is reduced. Most drawing web sites operate like electronic books and are not well oriented to the cognitive strengths and preferences of visually intelligent users, especially when engaged in the process of drawing.

Figure 10: Two examples of text-based instructional Web sites for drawing

http://www.learn-to-draw.com
http://www.ceiba.cc.ntu.edu.tw
Figure 11: Two examples of image-based instructional Web sites for drawing

http://artlab.org.uk/drawing/full-index.htm

http://www.jdhillberry.com
For the target audience the use of IMM products such as CD-ROMs and the World Wide Web is part of their daily activity but books and drawing classes remain the main source of drawing knowledge. This situation reveals the media awareness and discernment of contemporary audiences, poorly conceived and designed IMM products failing to sell. The poor uptake of such products also suggests that relying on designer intuition or the functionality of new media is not an effective way to create successful communication. Contemporary users are sensitive to the information they receive. They can be impatient and irrational but it is not the user's responsibility to conform to designer's conceptions of correct design. Rather, it is the designer's job to make the experience of content engaging and meaningful. It is also a fundamental mistake to privilege technology over content and design. Lev Manovich argues that emerging media automatically encompasses something of its communicative function. 'Today' he writes 'we are in the middle of a new media revolution—the shift of all culture to computer-mediated forms of production, distribution and communication. The computer media revolution affects all stages of communication.' Manovich traces the history of new media from the invention of photography to our present digital era, exploring the different ways information has been captured, processed and distributed. His text emphasizes the need for any new media to communicate a message, the implication being that in working in IMM the designer's role is to bridge the divide between information and technology by orienting both to user's needs, preferences and interests.

**Design practice for conveying drawing knowledge**

The design prototype translates the best qualities of traditional studio teaching methods and experiences to a new immersive, technological context, based around the specific cognitive capacities of the visually intelligent user. The use of visual metaphors is fundamental to this. Sallie Gordon argues that such metaphors help familiarize audiences with the structure and organization of information, allowing them to use prior knowledge and experience to give structure to abstract concepts within the GUI and to learn how to use a computer system. The use of metaphors has a long history in computer operating systems, helping users to learn the elements and processes of the interface. The most famous visual interface metaphor is Apple's 'desktop metaphor'. While there are no actual folders or trash bins in a computer such metaphors, especially when enlivened with animation and sound, allow users to do things with the systems of the computer intuitively. The use of metaphors enhances recognisability and recollection through the primarily visual and audio environment of the GUI, providing, as Donald Norman argues, an instant expectation for users about what is going to happen, and harnessing user's satisfaction to the task of system use.
The design prototype uses the drawing studio as a metaphor for the conceptual space of the program and adopts attributes of the studio to represent various elements of the global and local navigation systems. The use of metaphors encourages drawing students to explore the program intuitively and to understand what its various elements are and how they work. Features and implements of the drawing studio add recognisability to local information structures and navigation systems. An easel, for example, represents the area where a range of technical knowledge about drawing is presented. A palette represents the control panel. Fig. 12 Research confirms that visual elements play an important part in information accessibility.\textsuperscript{177} Visual hints supported by aural cues identify the majority of features within the CD-ROM. Those with high visual intelligence are likely to enjoy the challenge of interpreting visual symbols, including visual elements of a highly abstract nature. Users can choose any available action without having to remember its name or description simply by recalling a colour or a symbol. Fig. 13 The different coloured pages, for example, link with the same coloured balls, allowing users with a strong capacity for abstract, visual recognition to determine where they are in virtual space at any given point. Fig. 14 The virtual production of space through software creates a user experience that incorporates the material and aural qualities of the studio environment, restoring the sense of physical experience in an age of escalating technological mediation and information overload.

\textit{Figure 12: Local navigation system indicated by visual metaphor}
Figure 13: Intuitive visual cues indicate the navigation process
Figure 14: Throughout the CD-ROM coloured balls link the same coloured pages
The complex and subtle of nature of tacit knowledge is the major challenge in teaching drawing through IMM. Stuart Card and others contend that visual elements can convey more information, lead to fewer errors and be more engaging for the user, especially where the visualization of information is not just a case of the addition of illustrations. To best present how artists draw, the drawing process was photographed at intervals. Fig. 15 Once the drawings were divided among the different subjects and levels of drawing skills the challenge was to develop visual means to show process. Figs. 16-19 Still images, video footage, animation and QuickTime VR harnessed the power of the computer to present complex drawing processes and knowledge using time and sequence while emphasizing important details that are easily missed. For example, in the ‘Drawing demonstration’ section, the drawing process is divided into 12 to 30 steps. As users look at any individual step in the drawing, the previous and subsequent steps are highlighted in colour to show progression. By comparing any three steps, the user can visualize the sequence to advance and ultimately complete a drawing. Fig. 20 The 2D animation of the drawing process enhances the dynamic formation of drawing and highlights the key steps in the process. It also provides an image map of the number of areas in a drawing that have changed from step to step, and the nature and extent of the changes. Fig. 21 In the ‘Drawing practice’ section Quick Time VR presents 3-dimensional environments that allow the user to set up their own compositions and engage in drawing practice. Fig. 22

The external ‘Web Gallery’ demonstrates how a virtual community could be developed to address the isolation of practicing drawing through a CD-ROM. The Web Gallery provides users with opportunities to connect with a broad community of user who like themselves are striving for entry into tertiary art and design programs. There users can upload their works, see the work of others, discuss their work with master drawers and drawing teachers, providing something of the social context of the drawing studio. Fig. 23 Unlike the visual environment of the CD-ROM, text is included in the interface design of the Web gallery, relating it to the more ‘left brain’ activity of the Web site. As a prototype design the web site has been converted to a CD-ROM format. When the ‘red ball’ is clicked the interface to which the user is transferred may look like a website but all the web pages are delivered through the CD-ROM. Fig. 24
Figure 15: Work process with artists
Figure 16: The different subjects and levels of drawings presented in the 'drawing demonstration' section
Figure 17: The different subjects and levels of drawings presented in the 'drawing demonstration' section
Figure 18: The different subjects and levels of drawings presented in the ‘drawing demonstration’ section
Figure 19: The different subjects and levels of drawings presented in the ‘drawing demonstration’ section
Figure 20: Changing colours allow the user to visualize the drawing sequence
Figure 21: Animated drawing sequence
Figure 22: 360° QuickTime VR allows students to set up their own composition for drawing.
Figure 23: The ‘Web Gallery’
Figure 24: The red ball leads users to the ‘Web Gallery’
Conclusion and future study

This research has explored a core issue in user-centred design in interactive multimedia, proposing one way of establishing preliminary knowledge about users through recourse to cognitive psychology. It highlights the challenge of information delivery within the context of interface and interaction design, where knowledge and how to acquire it is understood as a deeply variable and personal thing, gained through a combination of sensory input and organised according to diverse personal schema. The text has argued that there is a basis of reason in usability experts and the HCI community calling for simplicity in GUI design. However when simplicity and functional efficiency are pursued at all cost the communicative power bound up in IMM is lost, as are the diverse creative strategies available through design. Generic approaches to interface design fail to deal with the heterogeneous composition of audiences and depend on the untenable position that all users are the same and have the same needs.

Ignoring the needs of audiences becomes acute when designers aspire to the principle of ‘form follows function’ rather than grounding design in user research. Typically designers confirm their knowledge and methods through design practice but without research it is impossible to claim the adequacy, communicational fidelity or user satisfaction of any so-called ‘good design’. To fully utilize visualization skills and create successful communication with users Dietmar Winkler argues designers must base their work on an ‘understanding of the human acquisition of knowledge, retention and comprehension, as well as perception and language.’ The value of MI theory in a process of user-centred design is suggested by the application of MI theory in education. Mindy L. Kornhaber, a researcher with Project Zero, identifies a number of reasons why teachers and educationalists have responded positively to MI theory, often dramatically changing their approach to teaching and learning. For Kornhaber, Gardner’s theory:

validates educators’ everyday experience: students think and learn in many different ways. It also provides educators with a conceptual framework for organizing and reflecting on curriculum assessment and pedagogical practices. In turn, this reflection has led many educators to develop new approaches that might better meet the needs of the range of learners in their classrooms.

Kornhaber’s comments hint at why communication designers may lack interest in cognitive psychology, their primary contact being with the clients who commission design projects rather than the audiences who use them. The
Conclusion and future study

nature of the design industry means designers have little knowledge of how audiences experience their work. Emerging philosophies of user-centred design challenge this state of affairs, moving theories of the user, such as MI theory, into the foreground of design.

I have argued that in the field of interface and interaction design, MI theory provides a viable way of understanding the needs of users when they represent a specific group of people with identifiable cognitive preferences, allowing designers to orient their work to the different perceptual and conceptual styles of users. The challenge of Gardner's work is how to harness the uniqueness and complexity of human intelligence through interface and interaction design, implying that designers should stop providing everyone with the same information in a standard form. Gardner's work is implicitly recognized in some of the literature on GUI and IMM design, Nathan Shedroff, for example, arguing that:

> the key to the development of cognitive models [of design] is the diversity of people's learning styles and abilities ... Since everyone has different skills and experiences, no one way of organizing data is capable of creating understanding for everyone ... Multiple views and other redundancies may seem like a waste of time and resources, but the duplication is critical to creating understanding for a variety of people.

As Shedroff intimates, MI theory both highlights the dilemma of individual difference for interface design and identifies a broad, new field of research for design. While such investigations exceed the scope of this practice-based study, which speculatively explores Gardner's ideas through experimental design work into the development of a commercial product. Gardner's work throws doubt on the ability of current GUI design to successfully communicate with users due to its one-dimensional nature.

This research asserts that if designers accept the complexity and diversity of the human mind then GUI design must change. In their current form IMM products mostly neglect the potential of IMM technology to cater to individual's unique qualities of perception and conception. Changing this situation will be a long-term process involving diverse research, collaborative effort and wide-ranging design exploration. This project's contribution to the diversification of GUI formats is in exploring how GUI can be oriented to the needs of a specific user group—those with high visual intelligence—in the transmission of tacit knowledge, contrary to the current situation where text largely governs the structure and articulation of the interface. It also suggests that interface design structured around visual cues might be equally useful to the general user in seeking to understand the abstract, spatial nature of linked information.
and media. Howard Gardner argues that visual/spatial intelligence is intrinsic to human conception and an important conceptual skill in negotiating the world. MI theory suggests the potential of designers to cater for other forms of intelligence in the design of the GUI when the substance of information suggests the specific cognitive makeup of user groups. For example, a GUI for those with a high measure of musical intelligence might have a predominance of audio cues. Interfaces for general audiences might cater to a range of intelligences through the combination of elements to the provision of alternative interface designs. At the most fundamental level MI theory challenges designers to be more adventurous in how they conceive the GUI, pushing design into new territory.

While the application of Gardner’s ideas is a speculative one, based on hypothesis and the formulation of an experimental design to validate the thesis about the role of visual cues in interface design, there is ample scope for future researchers to test differently formed GUI designs against individual user’s cognitive strengths. The research demonstrates how IMM technology can take into account a target audience’s perceptual behaviour to create more varied, stimulating digital environments that go beyond simple usability to achieve more absorbing learning experiences. The research asserts that different audiences require different forms of representation and symbolic systems. The issue of user experience and understanding cannot be solved from the standpoint of designer’s personal experience or standard market research. MI theory provides designers with a tangible basis for understanding users before the design process starts. By incorporating a well developed understanding of human factors in the design process, GUI designers can begin to determine if their approach can support the specific needs of the user group. This should not only ensure success in the market place but also stimulate innovation in design. MI theory allows designers to immerse themselves into the user’s world. To ensure the quality of user experience requires user’s involvement from the early stages of design process but neither should user’s lack of insight into what is possible in design limit design invention. MI theory gives designers an important insight into the world of the user to fire the early stages of the design process so that together users and designers might arrive at truly innovative and satisfying design outcomes.
Notes

17. *Ibid*.
22. Shedroff, p. 10.
29. Nielsen, p. 22.
32. *Ibid*.
34. Nielsen, p. 7.
36. Jakob Nielsen began publishing his Alertbox column in 1995, which became one of the main sources of usability information for designers.
37. Nielsen, p. 92.
42. Lenker, p. 6.


55. *Ibid.*


64. *Ibid.*


72. Van Veggel, p. 15.

84. *Ibid*.
86. *Ibid*.
90. *Ibid*.
92. Howard Gardner originally proposed the existence of seven intelligences. He recently added naturalist intelligence to this list and suggested there may be others including spiritual and existential.


121. Edwards, pp. 55-64.
128. For example, George Landow argues that ‘hypertext has much in common with some major points of contemporary literary and semiological theory, particular with Derrida’s emphasis on decentering and with Barthes’s conception of the readerly versus the writerly text. In fact, hypertext creates an almost embarrassingly literal embodiment of both concepts, one that in turn raises questions about them and their interesting combination of prescience and historical relations.’ George Landow, *Hypertext: The convergence of contemporary critical theory and technology*, Baltimore, Johns Hopkins University Press, 1992, p.32.
129. Landow.
140. Edwards, p. 55.
143. Campbell and others, p. 96.
147. Koestler, p. 177.
152. Ibid.
155. This theory was elaborated in Johannes Itten’s Basic Course at the Bauhaus, initiated in Weimar in 1919.
160. Ibid.
161. Ibid.
163. Ibid., p. 289.
164. Ibid., p. 291.
165. Ibid., p. 290.

182. Project Zero is an educational research group at the Graduate School of Education at Harvard University. Project Zero’s mission is to understand and enhance learning, thinking, and creativity in the arts, as well as humanistic and scientific disciplines, at the individual and institutional levels. See: http://www.pz.harvard.edu/


185. Shedroff, p. 72.
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Appendix One

Content directory
Translation of audio guide for 'Main page'

Audio: Page welcome

‘Conversation
The conversation in you
The conversation between you and the silence
The conversation between you and the drawing

Click the different coloured balls to explore the beauty of drawing!’
Translation of audio guide for global navigation of ‘Drawing demonstration’

Audio: Page welcome

This is the drawing demonstration.
Search for your favorite artist’s drawing

Audio on mouse over: ‘drawing learning in the studio’
Audio on mouse over: ‘art gallery’
Audio on mouse over: ‘drawing practice’
Translation of audio guide for local navigation of 'Drawing demonstration'

Audio on mouse over: 'Hi, everybody, I’m Guo Xiao-hai'

Audio: Page welcome
'Compare the images and see how Xiao-hai constructs the drawing.'

Audio: Page welcome
'Listen to what the artist says!'

Audio on mouse over: 'go back to main page'

Video: Artist talking about himself and his ideas on drawing.
Translation of audio guide for global navigation of 'Drawing studio'

Audio: Page welcome
‘Welcome to the drawing studio!’

Audio on mouse over:
‘positive and negative space’

Audio on mouse over:
‘tonality’

Audio on mouse over:
‘light and shade’

Audio on mouse over:
‘art gallery’

Audio on mouse over:
‘drawing practice’

Audio on mouse over:
‘drawing demonstration’
Translation of audio guide for local navigation of 'Drawing studio'

Audio: Page welcome
'The outline conveys the border between positive and negative space, determining the accuracy of the drawing.'

Audio: Page welcome
'Observe the relationship between light and shadows. Feel how the mood of the drawing can change.'

Audio on mouse over:  'go back to the main page'

Audio: Page welcome
'Compare tonal changes and how they can add drama to the drawing.'
Translation of audio guide for global and local navigation of 'Drawing practice'

Audio: page welcome
'This is the drawing practice section. Move the QuickTime VR to the composition of your choice.

Try to draw!
Post your drawing on the Web site and join the competition!'
Translation of text for 'Web gellery'

- Link to ‘Chat room’
- Post your drawing for the next competition
- The winner of the on-line vote
- The winner’s words
- The last competition winner
- Comments from artists about the drawing
- Previous winners
- On-line discussion of drawings from the site's community
Appendix two

The following is the results of the survey from the target audience. The red numbers indicates the results.

How long have you been learning to draw?
1 year          0
2 years       13
3 years         2
4 years         3
5 years         1

In what contexts have you learnt to draw? (please tick all relevant boxes)
school                                18
private drawing studio        13
friends                                  1
relatives                                1
individual practice                 9

What resources have you previously used to help your drawing? (please tick all relevant boxes)
book                                      17
CD-Rom                                        1
television                                      4
web site                                           0
video/VCD                                         1

1. There is no text in the CD-Rom interface. Please grade the effectiveness of the pure visual and audio environment of the CD-Rom.

   excellent  2         great  8         acceptable 8         not satisfied 2         poor   0

2. How appropriate did you find the visual design of the CD-Rom to the activity it supported?

   excellent  3         great  11       acceptable 6         not satisfied 0           poor   0

3. Please grade the experience of navigating through the CD-Rom.

   excellent  1         great  14       acceptable 4         not satisfied 1           poor   0

4. Please grade the value of the visual metaphor of the drawing studio to the overall design and effectiveness of the CD-Rom.

   excellent  4         great  12       acceptable 4         not satisfied 0           poor   0

5. Please grade the role and design of the buttons.

   excellent  3         great  7         acceptable 4         not satisfied 5           poor   1

6. Please grade the effectiveness of the colour-coding of the design.

   excellent  5         great  8         acceptable 7         not satisfied 0           poor   0
7. Please grade the usefulness of the voice guide in the CD-Rom.
   excellent 0   great 11   acceptable 9   not satisfied 0   poor 0

8. Please grade the role of the sound effects (environmental sounds and button sounds) in the CD-Rom?
   excellent 0   great 10   acceptable 9   not satisfied 1   poor 0

9. Please grade the effectiveness of the animation sequences in understanding the drawing process?
   excellent 5   great 10   acceptable 5   not satisfied 0   poor 0

10. Please grade the effectiveness of the CD-Rom as a learning environment for drawing.
    excellent 2   great 10   acceptable 8   not satisfied 0   poor 0

11. Please grade the effectiveness of the CD-Rom in allowing you to learn at your own pace and in an individual way.
    excellent 0   great 10   acceptable 9   not satisfied 1   poor 0

12. Is this CD-Rom helpful in skills acquisition for art and design in general?
    excellent 3   great 12   acceptable 5   not satisfied 0   poor 0
A list of publications produced by the candidate as a result of the project
