

EXECUTIVE SUMMARY

This document constitutes a report from the Centre for HCI Design, City University to the JISC for the results of a foundation study in Information Visualisation in response to the invitation to tender “Funding 11/03: Human-Computer Interaction Design and Visualisation Foundation Studies”.

JISC offers wide-ranging services and resources from bibliographic databases to digital maps to the UK’s further and higher education sectors and the research community. The study investigated how Information Visualisation could best be applied to these services and resources, with particular reference to the JISC Information Environment.

Theoretical Foundations

Information Visualisation has been defined as “the use of computer supported interactive, visual representation of abstract data to amplify cognition” (Card et al, 1999). In recent years a number of influential Information Visualisation techniques have been developed and found application in various domains (e.g. starfield displays (Ahlberg & Shneiderman, 1994a), Bead (Chalmers & Chitson, 1992) and self-organizing maps (Lagus et al, 1996)).

With the spread in the use of the World Wide Web new challenges in Information Visualisation emerged. Many visualisations have been developed for the purpose of browsing large collections of documents, or large data sets, such as FilmFinder (Ahlberg & Shneiderman, 1994) and issues of different information visualizations for navigation (Spence, 2001) have been studied (Zaphiris, Shneiderman & Norman, 2002).

Current Practice

As pointed out in our recently completed Usability Studies for JISC services we believe that Digital Libraries have the opportunity to develop and support user’s idea creation and information seeking processes. These generally involve initial ideas that expand as the task develops. Digital Libraries can support this process by incorporating visualisation techniques to help users develop and widen their search. The KartOO (<http://www.kartoo.com/>) is a characteristic example where the textual interface of

traditional search engines is transformed to an information visualisation where search results are displayed in an interlinked network.

Programme of Work

The programme of work was structured into 4 activities, as detailed below.

Activity 1: JISC Requirements for Information Visualisation

The aim of this activity was to articulate JISC's requirements for Information Visualisation in greater depth. This involved firstly understanding and characterising the broad range of JISC services to establish their specific Information Visualisation requirements (e.g. geospatial systems will have different requirements from portals) and, secondly, investigating current Information Visualisation practices within JISC to identify best practice and opportunities for improvement. Interviews, focus groups and questionnaires were conducted with staff and users of existing JISC services, other digital libraries developers/managers to elicit this information.

Activity 2: Literature Review

An extensive review of literature on Information Visualisation and especially literature that links this discipline with the design of Digital Libraries was carried out to investigate existing theories, frameworks and practices. The review focused on issues relevant to the services offered by JISC, as identified in Activity 1.

Activity 3: Study of Current Practice

This activity was intended to complement the literature review carried out in Activity 2. We interviewed domain experts from the UK and abroad to establish Information Visualisation criteria and best practices for services and resources similar in nature to those offered by JISC. Also we attended the Information Visualisation workshop/tutorial at the British HCI conference and the HCI International conference where we shared our views and also were exposed to a series of views and opinions on the domain of Information Visualisation and HCI. This led to a comparative assessment of similar practices. Our discussions with JISC, domain experts, and our own research guided us in the selection of similar services and resources.

Activity 4: Applying Theory to Practice

The last activity of this project had three main objectives. Our first objective was to evaluate existing information visualisation techniques used by JISC. A number of different JISC services' information visualisation techniques were evaluated in a series of expert (cognitive walkthroughs, heuristic evaluations) and user based (usability testing) exercises with an emphasis on identifying best practice that could be taken up more generally by JISC services and projects.

Our second goal was to engage in the development of Information Visualisation low-fidelity prototypes.

Our team has been very active in applying participatory design for virtual learning environments (Zaphiris and Zacharia, 2001).

Participatory design (PD) (often termed the "Scandinavian Challenge" (Bjerknes, et al., 1987)) refers to a design approach that focuses on the intended user of the service or product, and advocates the active involvement of users throughout the design process. User involvement is seen as critical both because users are the experts in the work practices supported by these technologies and because users ultimately will be the ones creating new practices in response to new technologies (Blomberg & Henderson, 1990).

In this stage of this project, we engaged in innovative participatory focus-group design exercises with users with the goal of evaluating existing information visualisation interfaces/techniques and especially designing low-fidelity prototypes of information visualisation techniques for JISC services. This helped us in recommending adaptations of visualisation techniques and methods used by JISC and others and make them applicable to web-based, end-user-oriented JISC services. Apart from providing low-fidelity prototypes an analysis of the requirements and feasibility for taking these adaptations and designs forward to final designs and implementation is provided.

Our third goal was to develop JISC specific guidelines for designing and evaluating Information Visualisation techniques for JISC services. Building on the existing literature and our prior work in developing usability guidelines for JISC services a comprehensive taxonomy of guidelines for designing and evaluating Information Visualisation is provided. Emphasis was also placed in developing links

between these Information Visualisation guidelines and pedagogical models (e.g. constructivism (Cobern, 1993) and social constructionism (Gergen, 1995)).

In all four activities described above, emphasis was given to the key aspects that JISC emphasises in their call for tender. More specifically, building on our research (Zaphiris & Zacharia, 2001; Armitage, 2002) in investigating the linkage between HCI principles and pedagogical models of web-based learning (e.g. linkage between navigation aids and HCI participatory techniques to enhance learning) our activities above also addressed issues that are directly related to portals and virtual learning environments, emphasizing on how good Information Visualisation techniques/practices can enhance the challenges of online learning for diverse subjects and diverse data types.

Key findings

1. Our PD sessions through input from users and other stakeholders developed representative paper prototypes of IV techniques and methods that are applicable to specific web-based, end user-oriented JISC services.
2. Our PD results section specifically proposes which IV techniques have been suggested for which type of JISC service (portals, images, bibliographic or geo-spatial).
3. Our Usability and Accessibility evaluations revealed valuable information about the benefits and obstacles of use of IV techniques by users. Especially we think that the results of our accessibility should be taken seriously by JISC and others that provide web-based IV enhanced applications online.
4. Our proposed evaluation guidelines provide a starting point for future studies in this area.

Specific findings

Finding from Query Based Techniques

We noticed that the majority of participants of our focus groups, although involved in their majority with the development and maintenance of JISC services, were not familiar with information visualisation. Participants in the geo-spatial focus groups were more familiar with information visualisation as this area is considered to be closely related to the discipline of Geospatial information.

There were misconceptions with participants thinking that IV is simply about maps, 3D games and virtual reality. Some participants were amazed that IV could be applied to applications that didn't consider to be feasible to use IV for.

The majority of participants thought that visual presentations (for example maps) are useful in assisting their search when using digital libraries. Both stakeholders and end users were interested in exploring how the relationships between results could be display – i.e. how the results generated correlate between each other and how users could compare the results at a glance. They thought that information visualisation might be helpful in contributing towards this issue.

For geo-spatial libraries, experts in geo-spatial information systems stressed that the ideal geo-spatial libraries do not only shows the GI data but make it able to link and correlates the GI data with non-GI data – national service/data (e.g. economic and social data, census data) in order to assist them in their research. But in order to do this, it will takes an extensive among of afford by all relevant agencies (especially owners of the data sets).

Participants of the portal, images and bibliographic focus groups, also raised the issue of designing applications that show relationships among data, and these relationships need to be obvious and represented visually.

Replies to our questionnaire showed that the majority of the current and perspective (currently in progress) JISC services do not have any plans to incorporate information visualisation into their design in the immediate future.

Findings from Participatory Design Workshops

Zooming was by far the most popular technique applied to the prototypes followed by Dynamaps. Zoom enables users to magnify specific aspects of the site, whereas Dynamaps permits users to manipulate information from a set of widgets (options) to simultaneously present the data on the interface. The common ground for both of these techniques is that the user controls the level of detail that is presented.

Based on the results of the participatory design sessions we can recommend that the following techniques should be further investigated in terms of appropriateness, usability and accessibility:

- Portals: Dynamaps and Zooming
- Images: Graphical Interface for Digital Libraries, PhotoMesa Image Browser and Generalized Query Previews
- Geospatial: Zooming
- Bibliographical: Graphical Interface for Digital Libraries

The participatory design method was an effective approach to get feedback on how information visualisation can be applied to web services.

Findings from Accessibility and Usability Evaluations

Information visualisation relies heavily on the use of graphical representation of the data. It is unlike average web sites, which provide textual information on the pages for users to comprehend. Certain services used a number of visualisation techniques such as dynamic queries and zooming and the user was required to manipulate the data which was hidden behind the use of menus to gain an insight into the information available. However, the blind user had great difficulty interacting with the data because the software component used (Java) was not compatible with the screen reader.

There are a number of usability problems associated with the use of information visualisation, mainly with the users in understanding the data and successfully using the service. Services applying information visualisation should aim to make the site simplistic as possible, though this may not always be the case due to the nature of the information. It is recommended that the criteria represented in the IV usability evaluation guidelines be used as basic guideline for the development of such services.

Suggestions to practitioners

Practitioners could apply the usability evaluation guidelines proposed in this study as a means for assessing the usability and accessibility of IV techniques used in the services. For JISC practitioners, the usability and accessibility guidelines could be adopted into the evaluation of IV for the JISC Information Environment.

Furthermore, our Participatory Design exercises can act as a step by step guide to practitioners who are interested to employ a user-centred design methodology for their IV services.

Suggestions to researchers

One of the key areas that we believe JISC and other researchers might find worth investigating is the area of accessibility of Information Visualisation. Given the visual aspects of IV one can immediately realise the challenge embedded in this area. But, we strongly believe that there is a need for an in-depth exchange of ideas, findings and studies that will find means and methods for developing IV techniques that can be accessible for people with disabilities.

A further area of research could be projects that try to study in more depth specific application areas of IV (e-learning for example) and the effectiveness (learning) of such techniques for HE and FE.

Report Structure

This report summarises the results of Activities 1, 2, 3 and 4 above. For that reason a separate chapter is provided for each activity. Finally the report is concluded with a conclusions and discussions chapter where final remarks are noted.

Throughout this report for consistency we use the term digital libraries to refer to the services funded and supported by JISC Information Environment.

TABLE OF CONTENTS

<u>CHAPTER</u>	<u>PAGE</u>
EXECUTIVE SUMMARY.....	3
TABLE OF CONTENTS.....	8
LIST OF TABLES.....	11
LIST OF FIGURES.....	12
1. INTRODUCTION.....	ERROR! BOOKMARK NOT DEFINED.
1.1. Theoretical Foundations.....	Error! Bookmark not defined.
1.2. Current Practice.....	Error! Bookmark not defined.
1.3. Programme of Work.....	Error! Bookmark not defined.
Activity 1: JISC Requirements for Information Visualisation.....	Error! Bookmark not defined.
Activity 2: Literature Review.....	Error! Bookmark not defined.
Activity 3: Study of Current Practice.....	Error! Bookmark not defined.
Activity 4: Applying Theory to Practice.....	19
1.4. Report Structure.....	Error! Bookmark not defined.
2. LITERATURE REVIEW.....	ERROR! BOOKMARK NOT DEFINED.
2.1. What is Information Visualisation (IV)?.....	Error! Bookmark not defined.
2.2. Information Visualisation and Digital Libraries.....	Error! Bookmark not defined.
2.3. The application of Information Visualisation to Digital Libraries.....	Error! Bookmark not defined.
Searching.....	Error! Bookmark not defined.
Navigation.....	Error! Bookmark not defined.
Browsing.....	Error! Bookmark not defined.
2.4. Commercial applications of Information Visualisation.....	27
2.5. Taxonomies of Information Visualisation Techniques.....	Error! Bookmark not defined.
3. STUDY OF CURRENT PRACTICES.....	ERROR! BOOKMARK NOT DEFINED.0
3.1. Objectives and Methodology.....	Error! Bookmark not defined.0
3.2. Interviews.....	Error! Bookmark not defined.0

3.3. Focus Groups.....	Error! Bookmark not defined.	1
3.4. Questionnaires.....	Error! Bookmark not defined.	3
3.5. Results	Error! Bookmark not defined.	5
Summary of the Interviews	Error! Bookmark not defined.	
Summary of the Focus Group Findings		79
Summary of Questionnaires	Error! Bookmark not defined.	0
4. APPLYING THEORY TO PRACTICE	ERROR! BOOKMARK NOT DEFINED.	2
4.1. Participatory Design.....	Error! Bookmark not defined.	2
<i>The Participants</i>	Error! Bookmark not defined.	2
<i>Equipment</i>	Error! Bookmark not defined.	3
<i>The participatory design session</i>	Error! Bookmark not defined.	3
<i>Results of the PD Sessions</i>	Error! Bookmark not defined.	6
<i>Data from questionnaires</i>	Error! Bookmark not defined.	
<i>Results for Portals</i>	Error! Bookmark not defined.	
<i>Results for Images</i>		97
<i>Results for Geospatial</i>	Error! Bookmark not defined.	
<i>Results for Bibliographical</i>	Error! Bookmark not defined.	
<i>PD Sessions Discussion</i>	Error! Bookmark not defined.	
4.2. Accessibility evaluation of IV techniques	Error! Bookmark not defined.	
<i>The Participants</i>	Error! Bookmark not defined.	
<i>Accessibility Evaluation Results</i>	Error! Bookmark not defined.	
4.3. Usability Evaluation.....	Error! Bookmark not defined.	
<i>Usability Evaluation Participants</i>	Error! Bookmark not defined.	
<i>Usability Evaluation Results</i>	Error! Bookmark not defined.	
5. CONCLUSIONS.....	ERROR! BOOKMARK NOT DEFINED.	
5.1. Key findings	Error! Bookmark not defined.	
5.2. Specific findings.....		134
5.3. Suggestions to practitioners	Error! Bookmark not defined.	

5.4. Suggestions to researchers Error! Bookmark not defined.

APPENDIX 1: IV USABILITY EVALUATION GUIDELINESERROR! BOOKMARK NOT DEFINED.38

APPENDIX 2: SUMMARIES OF INTERVIEWS ERROR! BOOKMARK NOT DEFINED.

APPENDIX 4 : PARTICIPATORY DESIGN DOCUMENTSERROR! BOOKMARK NOT DEFINED.

REFERENCES ERROR! BOOKMARK NOT DEFINED.

LIST OF TABLES

<u>TABLE</u>	<u>PAGE</u>
Table 1: Top-Ten Problem Lists	35
Table 2: Taxonomy of Information Visualization User-Interfaces by DataType (North, 1996)	Error! Bookmark not defined.
Table 3: Summary of specific visualisation techniques with reference to the Reference model for Visualisation (Card et al, 1999)	62
Table 4: Taxonomy of Information Visualisation Techniques (Card, 2003)	63
Table 5: Information Visualisation Taxonomy for Digital Libraries (For JISC Information Environment)	65
Table 6: Information Visualisation Taxonomy for Digital Libraries by task.	Error! Bookmark not defined.
Table 7: Table of techniques used	Error! Bookmark not defined.
Table 8: Information visualisation techniques used by Portal participants	Error! Bookmark not defined.
Table 9: Information visualisation techniques used by Image participants	Error! Bookmark not defined.
Table 10: Information visualisation techniques used by Geospatial participants	Error! Bookmark not defined.
Table 11: Information visualisation techniques used by Bibliographical participants	Error! Bookmark not defined.
Table 12: Table with Aggregated Ratings	Error! Bookmark not defined.
Table 13: Average Ratings per Category of Service	Error! Bookmark not defined.

LIST OF FIGURES

<u>FIGURE</u>	<u>PAGE</u>
Figure 1: Visual Thesaurus search results	Error! Bookmark not defined.
Figure 2: Kartoo Search Results	Error! Bookmark not defined.
Figure 3: Kartoo Search Results with highlighted links	Error! Bookmark not defined.
Figure 4: Concept Space – View 1	Error! Bookmark not defined.
Figure 5: Concept Space – View 2	30
Figure 6: Electronic Resource Map	30
Figure 7: Resource Finder	31
Figure 8: Resource Finder displayed search results	31
Figure 9: Netscan Treemap results	32
Figure 10: Treemap view of real time stock prices	33
Figure 11: TimeSearcher	Error! Bookmark not defined.
Figure 12: Hierarchical Clustering Explorer	Error! Bookmark not defined.
Figure 13: DataLens – Pocket PC	40
Figure 14: DataLens – Desktop Version	40
Figure 15: Dynamap – View 1	41
Figure 16: Dynamap – View 2	42
Figure 17: Excentric labelling	43
Figure 18: Treemap - View 1	44
Figure 19: Treemap – View 2	45
Figure 20: Fisheye View	46
Figure 21: GRIDL	Error! Bookmark not defined.
Figure 22: LifeLines – View 1	Error! Bookmark not defined.
Figure 23: LifeLines – View of Medical Records	Error! Bookmark not defined.
Figure 24: PhotoFinder – View 1	50
Figure 25: PhotoFinder – View 2	50

Figure 26: PhotoFinder – View 3	50
Figure 27: PhotoFinder – View 4	50
Figure 28: CounterPoint	51
Figure 29: PhotoMesa	52
Figure 30: Query Previews	53
Figure 31: SpaceTree	54
Figure 32: WebTOC	56
Figure 33: Reference model for visualization (Card et al.,1999).....	61
Figure 34: Portals affinity diagram.....	88
Figure 35: Portals Group 1	91
Figure 36: Portals Group 2	92
Figure 37: Portals Group 3	93
Figure 38: Portals Group 3, associated genres screen.....	94
Figure 39: Portals Group 3, Arabic Music screen.....	94
Figure 40: Portals Combined Prototype 1	95
Figure 41: Portals Combined Prototype 2	Error! Bookmark not defined.
Figure 42: Images affinity diagram	Error! Bookmark not defined.
Figure 43: Images Prototype of Group 1	100
Figure 44: Images Prototype of Group 2	101
Figure 45: Images Prototype of Group 3.....	102
Figure 46: Images Combined Prototype.....	103
Figure 47: Geospatial affinity diagram.....	105
Figure 48: Geospatial Prototype of Group 1, Screen 1	Error! Bookmark not defined.
Figure 49: Geospatial Prototype of Group 1, Screen 2	Error! Bookmark not defined.
Figure 50: Geospatial Prototype of Group 2.....	Error! Bookmark not defined.
Figure 51: Geospatial Prototype of Group 2, menu option.....	Error! Bookmark not defined.
Figure 52: Geospatial Prototype of Group 2, menu option examples.....	Error! Bookmark not defined.
Figure 53: Geospatial Combined Prototype, screen 1	Error! Bookmark not defined.

Figure 54: Geospatial Combined Prototype, screen 2 **Error! Bookmark not defined.**

Figure 55: Bibliographical affinity diagram **Error! Bookmark not defined.**

Figure 56: Bibliographical Prototype of Group 1 **Error! Bookmark not defined.**

Figure 57: Bibliographical Prototype Group 2 **Error! Bookmark not defined.**

Figure 58: Bibliographical Prototype Group 3, screen 1 **Error! Bookmark not defined.**

Figure 59: Bibliographical Prototype Group 3, screen 2 **Error! Bookmark not defined.**

Figure 60: Bibliographical Combined Prototype **Error! Bookmark not defined.**