WILL WE BE LOST WITHOUT PAPER MAPS IN THE DIGITAL AGE?

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by

PAUL HURST

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Abstract

Background. *Paper has been the format of choice for disseminating geographic information for millennia, however the arrival of the Internet combined with recent advances in digital technology have created new modes of map consumption. This study focuses on our ongoing relationship with both paper and digital/online maps and aims to confirm the future viability of paper as a map format. The decision to embark on this research topic was the result of the author's lifelong admiration and professional experience of paper maps combined with an ardent interest in the evolution of cartography in the digital age.*

Aim and Objectives. *The overall aim of this research was to investigate the current and future role of paper mapping in a society where access to online digital mapping is freely available and accessible. The objectives set to achieve this aim included; identifying key map issues, investigating current map use, defining future map requirements and investigating map usability and user perception across both paper and digital map formats.*

Methods. *This research was conducted by triangulation and followed an inductive mixed methods approach. It consisted of three main research instruments of; a literature review, an online map use survey (766 respondents) and a task based user study (12 participants). The methods employed in this research allowed a unique and focussed piece of research to be conducted that was neither constrained by the use of a single research instrument or biased by any pre-existing themes or theories.*

Results. *The online questionnaire provided significant proof that the paper map format is viable. However, it also showed that paper maps have a number of limiting factors such as scalability, size and cost that must be addressed if the format is to survive. The questionnaire also revealed a number of limitations of digital/online maps that are likely to contribute to papers sustained popularity, such as poor print quality and problems with accuracy and reliability. The task based user study further confirmed the relevance of the paper map format. It demonstrated that although inefficient for route finding and route planning, paper is the optimum choice for navigating on foot as defined by participants of all geographic skill levels.*

Conclusions. *From analysing the results of all the research instruments it is clear that paper maps still have a place in the digital age, but it is apparent their use is both highly contextualised and specific to individual requirements. There are also a number of essential attributes of both paper and digital/online maps that must be included in future products to ensure continuing user satisfaction with both formats.*

Acknowledgements

Firstly, I would like to thank all those that participated in both the online questionnaire and the task based user study, without their valuable input I would not have acquired such an excellent dataset to analyse.

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Chapter 1 - Introduction

Background

For millennia, paper has been a successful medium for communicating information of all descriptions from the spoken word to geographic information. Its success as a universal medium is due in part to its tangibility, flexibility and low cost. It has long been believed that technology would reduce and maybe replace the traditional paper means of transmitting information, yet paper still remains ubiquitous. It has often been cited that the age of the 'paperless office' is here and that paper is fast becoming an outdated format. Yet it is evident in offices across the country that the requirement and reliance on paper has barely changed. However, can we realistically assume that paper as a means of disseminating geographic information will follow the same trend? Will new technology lead to a reduction in use or signal the disappearance of paper as a means of communicating geographic information? It is clear that the paper format is under threat and to survive it must evolve to meet the changing needs of the digital world.

Since the advent of the World Wide Web the world has been in the grip of a technological and information revolution. This revolution has affected every aspect of our daily lives including our relationship with Geo-Spatial Information (GSI). Historically we have used printed paper maps to fulfil our geographic needs ranging from travelling to work to conducting and enjoying our leisure time. However, the increasing availability and quality of digital maps available across the Internet is now providing a realistic alternative to the traditional map format. Peterson (2005) claims that digital map technology has revolutionised how we interact with maps, but can we realistically assume that digital multimedia will become the 'new cartography' (Olson, 1997). If so, will this change in interaction bring paper map use to an end or simply provide an alternative mode of consumption.

Research Overview

In brief, this research aims to discover whether paper maps still have a valid place in the contemporary web enabled and digital society. Initially a review of literature will provide research focus through analysing the work of other experts in the field. The project will then employ a number of research instruments to investigate the topic in detail. Finally all the research findings and themes will be integrated and analysed to answer the overall research question.

Purpose

The purpose of this project is to reveal what effect digital mapping has on our daily lives and to discover whether it can replace paper mapping completely and indefinitely. If paper mapping still has a future role in the digital age then this project will identify what it must provide to compete against the plethora of online digital map products currently available. It is expected that through the course of this project these questions and many others will be answered providing both an account of current digital and paper map use and an insight into the future of mapping in the digital age. The decision to choose this topic for research is twofold; the author has both experience in the field of paper and digital map creation and a lifelong love of paper map products. It has become apparent to the author that over the past decade the way in which we consume geographic information has changed dramatically which has resulted in a sharp decline in our requirement for paper map products. This decline in paper map use combined with the author's keen interest in the topic and high level of professional experience has provided both the drive and desire to investigate this phenomenon further by conducting a piece of original research.

External Support

The project is being conducted in association with the research department at Ordnance Survey (OS) based in Southampton. The OS are the UK's primary commercial mapping agency and are responsible for the provision of both paper and digital mapping across the UK. In addition, the research will benefit from the support and assistance of both military staff and students serving at the Royal School of Military Survey (RSMS) based in Hermitage, Berkshire. The RSMS is responsible for providing academic and vocational training to serving members of the British Army across numerous geographic and map related subjects.

Research Aim

The aim of the research project is to investigate the current and future role of paper mapping in a society where access to online digital mapping is freely available and accessible. The specific research question is as follows:

"Will we be lost without paper maps in the Digital Age?"

Research Objectives

In order to answer the research question the project will be based around the following broad objectives:

- Identify the key issues relating to map use across both paper and digital formats and investigate future developments in map design and availability.
- Investigate the current use of both paper and digital mapping and identify future mapping requirements.
- Determine the potential developments and future requirements of paper and digital maps in the digital age.
- Investigate how users carry out a number of tasks using paper and digital maps in order to determine which format is used most effectively and why.
- Determine whether user perceptions of paper and digital map use are coincident with their ability to use both formats.
- Make recommendations regarding the future of mapping in the digital age based on the research findings and identify any further research opportunities related to the topic.

Report Structure

The research described in this report has been broken down into chapters for ease of reference. The chapters are as follows:

- Chapter 1 describes the research background and context for the study. In addition it details the overall research aims and describes the specific objectives to be achieved.
- Chapter 2 describes the results of carrying out a literature review. The literature review provides an overview of the subject area giving both clarity and focus to the research from the analysis of findings of other experts in the field.
- Chapter 3 outlines the methodology that was used to conduct this research project. The research followed a mixed methods approach using both quantitative and qualitative techniques. In order to answer the research question the project focuses on two research instruments; a large scale questionnaire and a task based user study.

- Chapter 4 describes the results of each of the research instruments employed during this research. This chapter describes the results of both the detailed online questionnaire and the task based user study conducted during this research.

- Chapter 5 explores the research results in detail by conducting in-depth analysis and subsequent discussion. The findings and emerging themes from the research are further explored using statistical analysis in order to provide meaningful results to discuss within the overall context of the research.

- Chapter 6 describes the conclusions and recommendations made from reviewing the research in order to further understand the future of paper maps in the digital age. It also describes the limitations of the study and defines possible future research opportunities within the subject area.

Chapter 2 - Literature Review

Introduction

The development of the Internet along with advances in wireless and digital technologies have changed how we interact with each other and the world around us. All traditional modes of communication are now being transformed and in some cases totally replaced. Map making and the presentation of geographic information is an area concerned with communicating spatial information about the world around us. The creation of maps and map products has historically been the preserve of cartographers and map enthusiasts, but this dependence on subject matter experts is changing. Technology advancement has now brought the ability to create maps into every home and digital map products are now challenging the traditional and established modes of map delivery, such as paper. This literature review aims to investigate the effectiveness of this new mode of map communication and also identify the key issues surrounding map use across both paper and digital formats. The literature review will conclude with an overview of expected and likely future developments in both map production and dissemination across both map formats.

The Digital Divide

As the Internet revolution gathers pace it is often assumed that traditional information sharing methods will be replaced by digital means. However, due to the global digital divide between those with access to the Internet and those without many countries still remain digitally disadvantaged (Castells, 2001). Even in web-enabled western countries such as the United Kingdom (UK) the ability to access and consume digital map products requiring high bandwidths is often difficult and sometimes impossible. Currently in the UK high speed Internet is accessible in only 66% of homes (Dutton and Helsper, 2009) leaving many UK residents with insufficient bandwidth to manipulate digital maps effectively. Even with the majority of UK residents being able to access high speed Internet there is a notable difference between Internet access and the level of Internet skills/literacy of users with only 51% of users rating their competency as ‘good’ (Dutton and Helsper, 2009). These factors combined will clearly have an adverse effect on potential digital map usage and online geographic understanding. If digital maps are ever going replace paper maps indefinitely, nationwide investment in high speed Internet access combined with initiatives to improve individual levels of Internet competency are needed. These developments would subsequently encourage and promote greater digital map usage and foster technological acceptance.

The Paper Divide

Research into the so called ‘paperless office’ has revealed that even though new technology has allowed most documents to be stored digitally, the tangibility of paper is still a major factor in its continuing presence in the workplace (Bondarenko and Janssen, 2005). Nichols and Cunningham (2009) highlight the suitability of paper for “informally sharing documents and their annotations”, whilst O’Hara and Sellen (1997) identify the “ease of paper navigation” and the use of a “flexible spatial layout” as positive contributors to persistent paper usage. These viewpoints whilst citing different reasons all highlight why paper remains dominant over its equivalent digital media. If the current rise in paper document usage continues whilst suitable digital alternatives are available (Guimbretiere, 2003), then it is predicted that digital maps will not replace or even reduce paper map use. It appears that if future paper map use is viewed analogously to current paper document use it can be assumed that paper maps will remain for many years to come.

Standard Paper Maps

For millennia paper has “served as a primary communications media” (Johnson et al, 1993) due in part to the many qualities that make it a universal and dynamic medium including its “ease of use, transportation and storage” (Johnson et al, 1993). Therefore, it became the obvious choice of medium to portray geographic information about the world effectively and efficiently. Historically “Paper maps have been designed and made by professionals” (Kraak, 2006) and in Great Britain most standard paper maps are designed and produced by Ordnance Survey (OS); the country’s national mapping agency. OS have been responsible for providing both maps and geographic data to government, business and individuals alike for many years. They have traditionally provided customers with standard scale maps printed on paper (Figure 1), but they have also kept pace with the technological and digital revolution and now provide not only paper maps, but numerous online and digital mapping products.

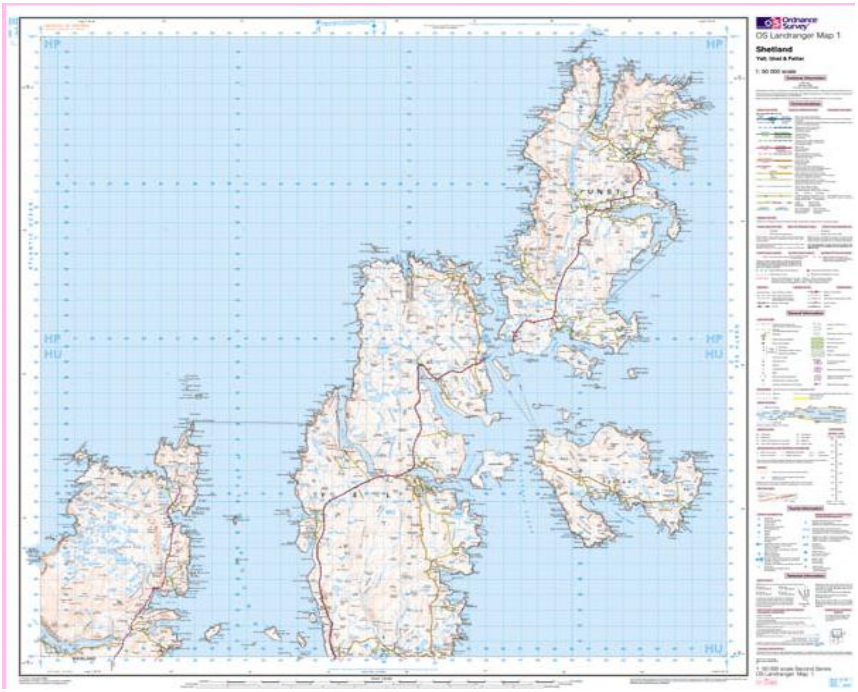


Figure 1. Screenshot of a standard 1:50,000 scale OS Landranger map sheet. (OS, 2010).

It is evident that there is still a legacy requirement for supplying standard paper mapping, but the demand is certainly not what it was before the digital revolution or the arrival of the Internet. There are a number of potential reasons for its continuing existence including the obvious tangibility of paper that offers those that purchase maps the ability to collect and refer to them with ease, thus providing a degree of value to their ownership. The flexibility and structure of paper mapping also supports collaborative working and facilitates effective information sharing; an attribute that is important for "applying local area knowledge in relation to map information, and for relating map and landscape" (Bouvin, et al, 2006). To their detriment, current digital and mobile mapping formats make collaborative working difficult and the electronic nature of digital maps make product tangibility almost non-existent. Unfortunately, paper maps continue to be relatively expensive and often provide more information than the user requires for the task (Parry, 1999) making simple digital map products an increasingly attractive, cheaper and more suitable alternative.

GIS and Digital Maps

Modern maps are now "no longer restricted to paper, maps are now transmitted from place to place over computer networks" (Peterson, 1997). As discussed by Goodchild (2000) even as early as the 1970's map users began requesting mapping information on magnetic medium instead of traditional paper. Although in the early days this content was often simply a digital form of the paper map it still signalled a significant change in map format requirements. Nowadays a large proportion of

mapping content is being presented and consumed by use of a digital interface of some description (Dodge, 2009). The backbone of any digital mapping system is the spatial database; these databases are normally developed as part of a larger Geographical Information System (GIS), with a typical GIS being designed to “store, retrieve, manipulate, analyze, and map geographical data” (Church, 2002). They also provide a way to present and “display geographically referenced information using points, lines and areas” (Laudon and Laudon, 1999). These systems have traditionally been the reserve of large mapping organisations such as Ordnance Survey and a number of smaller bespoke map makers. However, the shift in computing power and proliferation of the Internet has brought GIS tools and services into every home. Analogous with the evolution of the Internet, GIS systems have undergone significant developments mostly due to the rapid progress of information technologies. This progress has seen GIS systems move from early mainframe computers through to more compact desktop systems, to the present day distributed systems that embrace both mobile and Internet platforms (Peng and Tsou, 2003). Unfortunately, a weakness of a number of contemporary commercial and web GIS tools is the steep learning curve that beginners encounter when wishing to use them which is often due to the “bewildering amount of functionality" (Camara, 1999) that they possess.

Internet Mapping

There is little doubt that the “Internet represents a new medium for cartography” (Peterson, 2005) with the seemingly limitless range of online map products currently available for consumption. The Internet has created a platform for an abundant array of mapping tools and products that have provided access to a wide range of geographic functionality from traffic information updates to locations of ancient sites of archaeological interest. It is clear that there are no limits to the information that can be made available, as long as it can be geographically or spatially positioned on a map. It seems the growth area in Internet mapping is the provision of ‘up to the minute’ information with an increasing number of Internet map consumers expecting “immediate and real-time access to data” (Kraak, 2004). Significant barriers to the growth of Internet-based geographic tools surround the users’ ability to manipulate and interpret geographic information along with software interface usability issues. As user interfaces are “notoriously clumsy” (Goodchild, 1991) there are significant benefits in finding ways that GUI’s (Graphical User interfaces) can better support human cognition based on how our brains “learn and reason about space” (Goodchild, 1991). An important attribute of Internet maps are their adaptability, especially the ease in which they can be “tailored to suit the dynamically changing

user demands" (Meng, 2003). Of all the providers of free mapping tools on the Internet it is Google that has made the most significant contribution with their 'Google Maps' (Figure 2) and 'Google Earth' viewers. Google have essentially provided a map surface on which geographic information can be layered and manipulated.

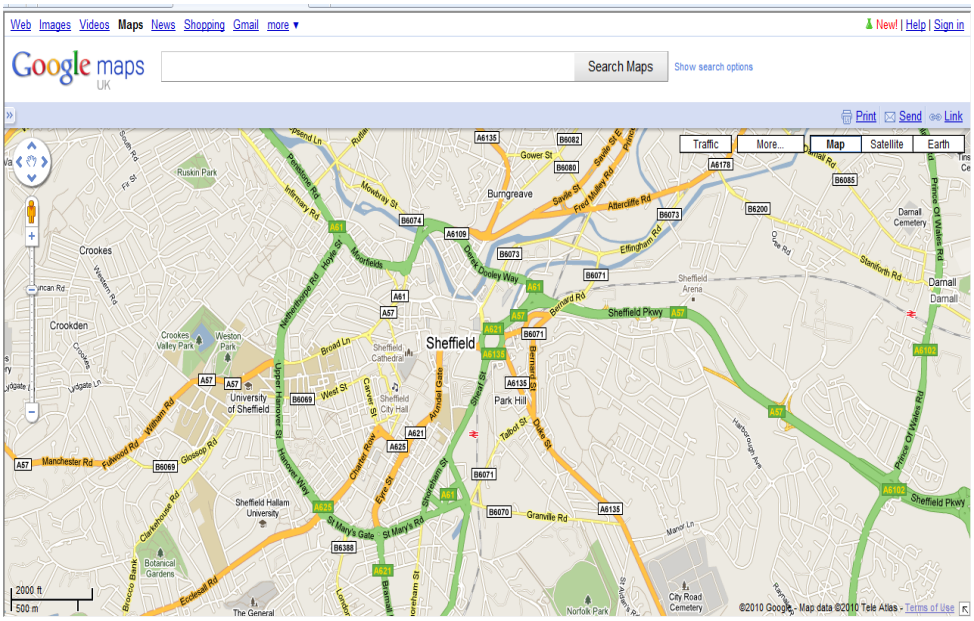


Figure 2. Screenshot from Google Maps UK centred on Sheffield. (Google, 2010).

There are a number of other successful online map tools including Multimap, Streetmap and DigiMap (OS). Each site provides a map background and a number of layers that can be manipulated allowing the user to display their desired view of a location. It is this ability to generate user defined content that is both dynamic and interactive which has made Internet mapping an important method of consuming maps and map products. Unfortunately, in some cases this user generated content portrayed on unregulated geographic map data has led to the "marginalisation of professional mapmakers" (Goodchild, 2000). Geographic information can now be created by anyone with only a mediocre amount of technological know-how. Consequently, this is causing the spread of non-standard online/digital maps that are often inaccurate in both geographic representation and content.

What makes Google and Google Maps so popular? Branding and corporate identity plays an important role in the success of any company, but with a web mapping tool it is usability that is essential in maintaining popularity and market dominance. Previous research into the suitability of Google for geographic search by Heng Lu (2006) revealed a high level of user satisfaction from all participants with the tool. More detailed research was conducted by Easingwood (2008) who compared a number of similar GeoWeb tools and found Google Maps to be the optimum by user

satisfaction. It is evident from this previous research that Google and Google Maps have evolved to satisfy the majority of users' online geographic needs. If Google have got it so right with their geographic tools what do they provide that is so important and appealing to users who have an endless choice of alternative providers and content? Erle and Gibson (2006) state the following innovations have had a great effect on the popularity and usability of Google Maps.

- Single search box - Allowing all search criteria to be entered into one location with no need for tabbing or clicking around the screen.
- Draggable maps - The ability to click, scroll, zoom, pan and move dynamically across the area of interest with ease.
- Integrated local search - You can search the visible map area on screen for local information and Google Maps will constrain the search results to that area.
- Satellite Imagery - The provision of satellite imagery and hybrid viewing methods enhance and broaden the user experience.
- Keyboard shortcuts - A simple, but powerful method of providing keyboard shortcuts for moving around the map is an effective way of speeding up common functions.

These effective features provided on top of a clear and simple interface have made Google Maps a leading authority in the provision of Internet mapping that all others try to emulate. These features aside there are also a number of important guidelines to follow when developing any effective web based GIS system as defined by Mark and Frank (1992). These guidelines are as follows:

- The look and feel must be consistent with other applications in the target environment. E.g. having similar functions and tools to Microsoft Office applications.
- All facilities should be easily accessed and executed without too many cascading menu options.
- The number of concepts in a system is related to the time it takes to learn the system; therefore effective concept design evaluation is essential.
- The GIS should cater for all levels of user, from novice to expert.

It is clear that Google have considered these guidelines when designing and implementing their Google Maps GIS tool, as its functionality achieves a reasonable level of agreement with those suggested by Mark and Frank. It is planned that this research will identify if any of these GIS guidelines or features of Google Maps are considered important by research participants. In addition, this research will also highlight any other functions or attributes that may be required to greater satisfy future users' online geographic requirements.

Mobile GIS

Recent technological advances in the communications industry has made Mobile GIS and Mobile map use a realistic possibility. The ability to make use of GIS tools and functionality through mobile and wireless devices such as PDA's, Smart Phones and Satellite Navigation Systems (SatNav's) is now universal across the developed world. With recent improvements in Global Positioning System (GPS) technology combined with developments in mobile phone and wireless technologies (Peng and Tsou, 2003) mobile GIS and access to maps on the move has become a real growth industry. The days where mobile map use was the preserve of GIS specialists and technology enthusiasts has come to an end with everyone who possesses a mobile telephone now having the capability to access mapping on the move. The portability and functionality of mobile mapping interfaces have brought a number of important benefits to ownership, including the ability to present "up to date spatial/non-spatial information in a very individual, dynamic, and flexible way" (Reichenbacher, 2001).

Whilst many perceive mobile mapping as the new medium of map distribution and consumption there are some that consider mobile map use narrower in scope causing a reduction in usability when compared to traditional paper maps (Winter and Tomko, 2004). A serious constraint of mobile map technology has been that of interface screen size as discussed by both Looije et al. (2007) and Reichenbacher (2001). A problem that could be alleviated by the use of larger tablet PC's or interfaces that afford greater resolution and provide better spatial range. However, this solution would come at the cost of portability, an issue that potentially outweighs the benefits of mobile GIS over paper mapping (Grossnicklaus et al, 2006). Meng (2003) takes a differing view on this constraint by stating that "digital functions such as zooming, panning (scrolling) and an integrated legend can compensate for the effects of display size and screen resolution". Overall it is obvious that mobile mapping tools now provide a realistic alternative to paper maps, but it is also clear that in their present state they are unlikely to replace them as they do not meet all users' contemporary mapping needs.

Paper Maps Vs Digital Maps

Lloyd and Bunch (2003) state that a map "represents real-world information as a set of abstract features". This view is a common definition of the construction requirements of both paper and digital maps. However, there is often a large disparity between the two map formats regarding their degree of feature abstraction due to differences in their creation, purpose and mode of consumption. Paper maps typically provide "high resolution, large scale information requiring zero power consumption" whereas power dependant digital maps are often displayed at a lower resolution whilst providing more "dynamic, personalised and up-to-date content" (Rohs et al, 2007). A defining attribute of a paper map is that it is portrayed at a fixed scale whereas digital maps can be viewed at multiple scale levels (Lloyd and Bunch, 2003) These differences in the two formats provide some reason for their parallel existence, but human cognitive factors such as user confidence and technology acceptance still prevent large-scale digital map consumption.

Technological innovations in interface designs may improve how we consume digital maps, but common interface issues such as glare, screen size and the cognitive demands of usage (Reilly et al, 2006) still pose a significant barrier to use, compared with the obvious "failsafe characteristics, simple use and superior resolution of paper based maps" (Paelke and Sester, 2007). Unfortunately, paper still remains "expensive, especially in large format and colour" Peterson (2005) which explains why the ability to view and manipulate map content on the web for free is prolific regardless of output print quality. Map consumers no longer have to simply accept the standard paper maps sold in shops, they are now being empowered to develop and create their own web map content that is more specific to their individual requirements. However, the need to print maps has not diminished greatly suggesting that the paper map format remains important. The way in which users interact with digital map tools is often as important as the content they are viewing in developing consumer acceptance. For example paper maps are often used collaboratively, a function afforded by its flexibility and size, whereas mobile maps are usually viewed exclusively by the user and not oriented spatially as seen in the images at Figure 3 (Winter and Tomko, 2004).

Figure 3. Paper maps can be folded, rotated and aligned, and studied collaboratively. Mobile maps are shown by devices which are held in one hand – they are not rotated and not studied collaboratively. (Winter and Tomko, 2004).

It is apparent that digital interfaces are an important catalyst in the movement away from paper maps, but new developments in interface design still need to "address a number of challenges in order to become effective" (Harding et al, 2009). Similarly, it is clear that the medium of paper does not support all ideal map requirements simultaneously either (Barkowsky and Freksa, 1997). To further understand the medium of paper Goodchild (2000) defined eight factors that have defined and constrained this traditional map medium. The factors are as follows:

- The map must appeal to the visual senses.
- It must be flat.
- An approximately uniform scale provides simple levels of detail.
- The map is static and difficult to change once printed.
- Economies of scale dictate that the map produced must satisfy as many consumers as possible.
- The detail should be exhaustive within the boundaries of the map sheet.
- The information should be precise.
- Map production is traditionally slow.

It is evident that digital mapping can and has overcome most of the constraints imposed by the medium of paper described above, however whilst many of these developments are positive and alleviate the constraints of paper maps they create a number of new issues that must be addressed such as cost, screen size and map quality.

Combining Paper and Digital

It is evident that “neither paper nor web maps possess only positive attributes” (Reichenbacher, 2001). Therefore, there are obvious benefits in combining positive attributes of both formats. GIS generated digital and paper maps are both products of the “human conceptualisation of geographic space” (Barkowsky and Freksa, 1997) and therefore share many similarities that could allow them to be integrated. As paper is interwoven into all our everyday activities it would be pragmatic to assume that the future must focus on “integrating instead of removing paper from our electronic lives” (Johnson et al, 1993). A number of experimental projects have been conducted with an aim of combining the flexibility and convenience of paper with the power and scope of digital media. The ‘Enhanced Desk’ project discussed by Kobayashi and Koike (1998) aimed to provide digital functionality to paper map content by allowing paper map features to be interrogated manually. This process provides dynamically enhanced digital information (such as route data) from users’ tracing along paper map features. The main issue with this project was the static and bulky nature of the enhanced desk framework that was in no way portable or convenient to use.

A similar project called the ‘Paper PDA’ has been discussed by Henier et al. (1999) and cited by Kraak (2004) as a way of solving digital portability issues. They describe a simple method of tagging information on notebook pages that use registration marks embedded within them for spatial referencing. These tags can then be scanned to allow the data and its associated information to be transferred to a digital PDA. Both these techniques could be suitable for combining digital devices and paper mapping, but would require significant effort to implement to ensure adequate feature abstraction and functionality. Reilly (2006) carried out analogous research using RFID (Radio Frequency Identification) tags on paper maps referencing specific routes and locations that were then scanned with a handheld digital device as shown at Figure 4.

Figure 4. Using a handheld digital device to swipe an RFID embedded paper map (Reilly, 2006).

The research discussed in this section highlights the difficulty in combining the two formats, but it also proves that where a need exists a technological solution can be engineered to suit the specific requirements. However, the real issue is being able to create a device that suits all potential mapping requirements effectively and efficiently. It is evident that any success in geographic information delivery and consumption is intrinsically linked to the medium on which it is created and displayed. Peterson (2005) describes a medium as the "carrier of information that is used to transmit knowledge and ideas between people". Therefore, if geographic knowledge is to be transmitted and used more effectively more focus on developing and improving the medium (carrier of information) is required.

Previous Related Research

This literary research into this topic has revealed a distinct lack of focussed research involving digital and paper map usage and their future requirements. However, research by Pederson et al. (2005) into the integration of digital technology into college pedagogy investigated the effect of using paper and digital maps on student learning in a number of classroom based Geography assessments. The research found there was no apparent difference between a student's perceptions of use and actual usage in either map format even though the students claimed to prefer working with paper maps. In support of Pederson's findings Verdi et al. (2003) conducted a similar experiment concluding that student ability to recall information from both paper and digital maps were comparable. However, Verdi's results did reveal a slight bias towards digital map use due to map tool interface support for spatial feature recognition (e.g. Tool Tips). The research conducted by Pederson et al. (2005) will provide the context for various aspects of this research project. This research will

use a similar methodology to Pederson to enable comparison of results, but it will also address a number of limitations described and identified in his research. Further general map related research was carried out by Harrower et al. (1997) who investigated whether professional geographers judged Internet maps differently from non-geographers, the results of which concluded that both groups of participants judged the maps similarly even though they had very different map experience and knowledge. To investigate this aspect of Harrower's research further similar population clusters of professional geographers and non-geographers will form the sample for analysis. As outlined by Sneiderman (1998) the two groups will be classed as either expert or non-expert (novice) geographic users for the context of this research. These population groupings will allow comparison with Harrower's research to take place in relation to Internet maps (online/digital maps), but will also add to his research by revealing if each sample group judged paper maps similarly.

Future of Paper Maps

It is clear that in the past map provision and development was driven and controlled by cartographers who portrayed the perceived geographic needs of potential users with a degree of cartographic license (Kraak, 2004). Nowadays, they must consider contemporary issues such as speed of delivery and temporal accuracy. Therefore, facilitating user specific map content that can be accessed digitally and then output locally by customers is becoming an essential capability. A function similar to the development of digital photography, whereby users visit 'print kiosks' to output their digital content onto the paper medium would allow consumers to generate and reproduce their required map products. Kraak (2006) discusses this change in traditional paper map production and states that contemporary mapping agencies must "step away from their century-long map sheet production thinking" due to changes in emerging consumer requirements; Consumers who are now requesting access to "Digital GeoData that they can process with their own GIS software" (Kraak, 2006). This shift in the mapping requirements of consumers is profound and is changing how all maps are consumed and sold. It is true that the optimum content of a contemporary paper map is extremely subjective and often very specific to individual user requirements, however there are often a number of expected features of any map product. Consequently, part of this research will ascertain what paper map features are considered essential by the majority of the research participants in order to provide a basic requirements framework for future paper map products.

Future of Digital Maps

It is likely that current technological developments in handheld devices such as those integrated into the new Apple I-Phone or I-Pad (See Figure 5) will continue to push the boundaries of digital map portability and challenge the benefits that paper maps provide. There is already a dearth of mobile mapping applications available on numerous platforms and interfaces that make mobile mapping solutions an attractive alternative to static paper map content.

Figure 5. Screenshot showing mapping on Apple's I-Pad (Apple Inc, 2010).

It is clear that the future of maps will inevitably include the use of digital technology with the popularity of digital mapping unlikely to diminish. However, simple reliance on technological solutions to solve problems is foolish especially with the many human interaction issues that can arise with digital and computer interfaces. It is evident in all areas of Human Computer Interaction (HCI) that there is always scope for improvements with regards interface usability, content and in terms of overall user satisfaction. As with paper maps the optimum content of a contemporary digital map is extremely subjective; however there are often a number of expected features of any digital map product. Again part of this research aims to ascertain what features are considered essential by the large majority of the participants in order to create a basic requirements framework.

Conclusion

There has been significant research into the future of mapping in the digital age as described in this review, but a suitable replacement for paper maps for all situations does not appear to be forthcoming. There are often situations where paper maps are preferential to digital maps such as collaborative working or navigation on foot.

Whether it is simply an issue that technology alone can solve or whether a shift in cognitive perceptions of maps and geographic knowledge is required remains to be seen. It is hoped that this research will go some way towards ascertaining what map consumers believe are important attributes of both formats and whether either format can exist in isolation to cover all mapping requirements.

In general, this literature review has highlighted a lack of focussed research into the role of paper mapping in the digital age. Therefore, this research aims to fill the gap in that knowledge. This research will aim to uncover and assess both digital and paper map use by analysing the thoughts and opinions of both expert and non-expert geographic users Sneiderman (1998). Secondly, this project will follow a number of research themes and suggestions outlined by Pederson et al. (2005), Verdi et al. (2003) and Harrower et al. (1997). This will ensure that the research is conducted within context and can be assessed analogously with the work of other experts in the field. It is expected that this research will either support their findings or further add to their research and increase the overall knowledge within the mapping field. Ultimately, this research aims to answer the research question and to discover whether it really is the end of the road for paper maps.

Chapter 3 - Methodology

Outline Methodology

The overall research project was conducted by triangulation and followed an inductive mixed methods approach (Bryman, 2008). The use of triangulated research methods meant data was gathered using a number of different research instruments. Pursuing this method allowed clarity and depth to be added to the findings at each stage, according to the varying strengths and qualities of the techniques employed. Using an inductive process enabled theories to be generated directly from the research data without any predefined hypothesis affecting the analysis. This unbiased data driven approach led to the selection and use of each subsequent research instrument throughout the project. Finally, the decision to follow a mixed methods approach enabled the combination of both quantitative and qualitative research data. This research initially used quantitative data analysis techniques to provide statistical significance to the dataset from which initial theories could be generated. The resulting theories were then supported by analysing and assessing the associated qualitative data. The use of both quantitative and qualitative data gives the emerging ideas and theories clarity, reasoning and context making any argument or discussion made using them valid and robust.

Ethical Consideration

The research was conducted using a mixture of anonymous online surveys, face to face interviews and task based user studies. Therefore, due to the human involvement a request for ethical approval was submitted and subsequently approved. All potential participants received an information sheet before taking part informing them that completion of any survey, interview or task was considered provision of their consent to use the information collected for the project. Additionally, participants were informed that they were not obliged to take part in the project and could terminate their involvement at any time. Copies of the participant briefs for each research instrument can be seen at Appendix 1 and 2.

Initial Research Limitations

This project was organised and planned to make use of available University facilities to limit the requirement for any external resources. Any requirement beyond those provided by the University were discussed and sourced from either OS or RSMS. The research period was limited to twelve weeks, therefore the scope of the study was constrained to ensure the research question and objectives could be completed

within the allocated time. To ensure the timely collection of data the initial online questionnaire was deployed before the official commencement of the research project period to enable adequate diffusion across the defined population clusters. This research was conducted in conjunction with two external agencies both located outside of Sheffield, therefore there were occasions where travel was required; an expense that RSMS agreed to pay for. The requirement for IT equipment and software was limited to a personal computer and standard Microsoft Office packages already owned by the researcher. However, to enable effective data collection and analysis during the project a copy of SPSS (Statistical Package for the Social Sciences) software was acquired and a subscription to 'SurveyMonkey' online software was paid. RSMS were approached about potential funding for these additional requirements and they agreed to reimburse the cost of the software retrospectively.

Pilot Surveys

A pilot survey for both the initial online questionnaire and the task based user satisfaction questionnaire were conducted using the online 'SurveyMonkey' software. These pilots were run to ensure question and task suitability before any full scale usage took place (Balnaves and Caputi, 2001). The constructive feedback received from the pilots either confirmed question/task suitability or highlighted areas that needed adjusting. This strategy ensured that the research tools to be used were valid and that the task and questioning strategies employed would be effective.

Population Samples

UK residents provide the overall sampling frame for the research from which the focus will be on two distinct cluster/stratified population samples (Moore, 2006). The initial aim was to survey approximately two hundred people by online questionnaire and approximately eight to fourteen people using interviews/tasks. The criteria for acceptance into either cluster would be defined by results from the online questionnaire. Upon analysis of the initial questionnaire all participants were to be grouped into one of the following population clusters as discussed by Sneiderman (1998):

- **Non-expert Users (Novices).** This cluster is representative of individuals from a variety of professional backgrounds having no formal experience of paper and digital map creation and development, but who may have had some degree of exposure to geographic information during the course of their domestic lives.

- **Expert Users.** This cluster is representative of those with substantial professional experience of paper and digital map use or map creation. The group is likely to include military students and staff from RSMS, civilian staff from OS and a number of other expert users of geographic information.

Detailed Methodology

The process of data collection and analysis followed aspects of grounded theory (Flick, 2006), whereby the data analysis at every stage provided the focus for each subsequent stage. This enabled the researcher to follow an emerging concept or theme (Preece et al, 2007). These emergent concepts and themes were then assessed and analysed to develop a holistic view of all the findings in order to answer the overall research question. These findings were then used to generate a set of conclusions and recommendations to help define and describe the likely future of paper mapping in the digital age. In addition, the research also revealed a number of areas for potential further research that could be pursued at a later date.

The research aim and associated objectives defined within this project were met by progressing through the following defined stages:

Stage 1 - Desk Research

This stage provided context and rationale for the research project by the investigation and analysis of existing information across the subject area. The desk research culminated in the creation of an in depth literature review (see Chapter 2) that formed a “conceptual bridge” between the current state of knowledge around the topic and my independent research findings (Pickard, 2007). The research initially considered the wider topics of the digital divide and technological acceptance. This was followed by more detailed research into issues surrounding both the functionality and development of paper and digital maps. Apart from creating the framework for study the literary review also highlighted a number of analogous and related research studies that were critically analysed to provide clarity and focus for the research to follow. This stage also revealed a number of gaps in current knowledge surrounding the future of paper maps that could be exploited and explored in order to create this piece of original research.

Stage 2 - Large Scale Online Survey

This research technique was selected to generate a quantitative frame of reference for the study and provide initial results to focus the research in the subsequent stages. This stage was conducted in three phases as follows:

- **Data Collection** The survey data was collected by means of an online questionnaire generated and deployed using 'SurveyMonkey' software. The survey consisted of a mixture of nominal-level; interval-level and likert-scale based summative questions (Bryman, 2008). The questionnaire included both open and closed questions in order to provide response data that could be analysed quantitatively and qualitatively. The preliminary questions included controlled variables such as age, profession and gender. These questions meant profiles of each participant could be created and subsequently split or sliced allowing more specific analysis. The following questions included more specific experimental variables relating to the current use and future development of paper and digital maps. A copy of the questionnaire can be seen at Appendix 1. The survey was deployed using two means of delivery; Internet and Paper. This was done to avoid any bias in the results towards those with Internet access, unfortunately the response rate from paper was low due to dissemination restrictions. Overall, it was expected that in excess of two hundred participants would take part due to the early deployment of the survey. This number was exceeded dramatically with over seven hundred complete responses being collected.

- **Data Preparation** The survey remained available online for five weeks and once sufficient data had been gathered the survey collector was closed and the spoilt results were filtered out. Although the incomplete responses may have held some value it was decided that to produce a cleaner dataset the spoilt results would be removed. The decision to exclude spoilt responses was taken carefully to avoid creating a biased or distorted sample (De Vaus, 2002). At this point the complete dataset was exported to Microsoft Excel in order to verify and accurately format the data. Finally the dataset was imported into SPSS (Version 16) in preparation for thorough statistical analysis. In SPSS each variable was coded into a representative data measure of ordinal, nominal or scale (Bryman, 2005).

- **Data Analysis** Once coded in SPSS each independent variable was analysed using "univariate statistics" (Fielding and Gilbert, 2006). This analysis allowed each unique variable to be considered separately in order to identify any significant results or highlight any trends that could be used to focus the inductive

research process. Initially, frequency distribution statistics were created followed by the creation of bar graphs. This allowed the data to be visualised both graphically and analysed proportionally. Secondary analysis was then carried out by running "bivariate statistics" on the data (Fielding and Gilbert, 2006). This allowed any correlations or statistical differences between groups of variables to be analysed and researched. The results of the data analysis process were then used to generate a set of assumptions and findings that could be investigated and developed in the subsequent stages, using the proposed alternative techniques and research instruments.

Stage 3 - Task Based User Study

This second research instrument was used to assess the ability of participants to manipulate both paper and digital mapping by completing a set of map related tasks. The participants for the study were selected from participants that took part in the initial questionnaire. The participants were selected based on their level of geographic experience being either experts or non-experts. The study tasks involved finding, investigating, planning and identifying a series of locations/routes using both map formats. The results of the initial questionnaire suggested a link between map preference and context of use. Therefore, the task study aimed to investigate whether participants were competent using both map formats and whether their perceptions of use matched their abilities. The map areas chosen for the study were selected to be deliberately unfamiliar to the user to ensure local/previous knowledge did not affect the task execution and results. The user tasks chosen for use within the study were based on the results of the initial questionnaire which found that the majority of participants used maps for travel and route planning. The final stage of the research involved participants completing a user satisfaction survey and a general questionnaire. The structure and content of the satisfaction survey was based on suggestions by both Goto and Cotler (2004) for use in web redesigns and Preece et al. (2007) for use in Questionnaires for User Interaction Satisfaction (QUIS). The task survey initially constructed a basic 'user profile' of each participant to allow the assessor to ensure that experimental bias in participants is avoided where possible (Benyon et al, 1994). The questions that followed this profile assessed factors of usability that applied to both paper and digital map media as suggested by Easingwood (2008) and Seffah et al. (2006). These usability questions enabled comparative analysis between the results of each map format questionnaire. In addition, each participant was timed during task execution to provide a temporal frame of reference for the study.

Data Collection The usability test was developed and conducted using two general scenarios that were based around medium/long distance travelling and short range navigation. Each participant followed the two scenarios using either the web map tool (Google Maps) or a set of paper maps and then vice versa. Both scenarios consisted of three similar individual tasks to enable simple task comparison; however the tasks were based in separate areas geographically to avoid 'learnability' bias. The usability test was conducted and completed by twelve participants for two reasons:

- There are two scenarios and two map mediums to assess. Therefore using twelve participants produced an even and symmetric group. The participants were split equally by geographic skill, with six experts and six non-experts.

- Conducting experiments with between five and ten participants should reveal eighty to ninety percent of all usability problems (Dumas and Redish, 1999).

The testing process was planned and conducted using a 'latin square' formation to ensure that map location learning bias was adequately counterbalanced. The sequence of participants and scenarios are shown in Figure 6 below.

User 1	User 2	User 3	User 4	User 5	User 6
MedA -Sc1	MedA –Sc2	MedA -Sc1	MedA –Sc2	MedA -Sc1	MedA –Sc2
MedB–Sc2	MedB –Sc1	MedB -Sc2	MedB –Sc1	MedB –Sc2	MedB –Sc1

KEY - Medium A (MedA) = Digital, Medium B (MedB) = Paper. Sc1 = Scenario 1, Sc2 = Scenario 2.

User 7	User 8	User 9	User 10	User 11	User 12
MedA -Sc1	MedA –Sc2	MedA -Sc1	MedA –Sc2	MedA -Sc1	MedA –Sc2
MedB–Sc2	MedB –Sc1	MedB -Sc2	MedB –Sc1	MedB –Sc2	MedB –Sc1

Figure 6. Latin square grid used for the task based user study.

Each of the usability tests were conducted individually so that user-tester interaction and observation could take place and also to prevent participants from biasing the actions of others. Each participant was requested to follow a 'think aloud' protocol (Loranger and Nielsen, 2006) so that their thought process could be recorded and analysed. Each scenario included the following 3 components:

- Long distance travel planning. e.g. Sheffield to Salisbury.

- Medium distance travel planning. e.g. Salisbury to Shrewton.

- Short distance travel planning. e.g. walking route around Shrewton.

Each task was conducted using either Google Maps or a set of paper maps that included Ordnance Survey 1:50k map sheets, road atlases and other maps at various scales. Each participant was informed that at the end of the task planning exercise they would be expected (in theory) to use their map product to actually carry out the route/journey. Each participant was then shown a copy of the output and asked to comment on its task suitability. Upon completion of the tasks the participants completed a short questionnaire and user satisfaction survey. All the documentation for the user study including the questionnaires can be seen at Appendix 2.

Data Preparation Upon completion of the user study the dataset was collected and the results were collated and formatted. Again the use of 'SurveyMonkey' software for collecting responses allowed the data to be easily verified and exported to SPSS for further detailed analysis. Similarly, once loaded into SPSS each variable was coded into a representative data measure of ordinal, nominal or scale.

Data Analysis The aim of the satisfaction survey was to determine user perceptions of map use from the tasks carried out in the study and was used to identify which map format they preferred and why. By analysing the post-test feedback, a framework for understanding users' perceptions and thoughts of each map medium was created (Goto and Cotler, 2004). The data gathered during the task study was then combined with the results of the satisfaction survey to highlight any correlation between participants map preference and their ability to use each map format.

Stage 4 - Research Completion

After all the research stages were complete the findings from each research instrument were analysed and assessed together to develop a set of defined and reasonable conclusions in order to answer the overall research question and address some of the wider issues that the research identified. To conclude the research a number of limiting factors were outlined and areas that would be suitable for further research were identified.

Chapter 4 - Results

Results Overview

This chapter describes all the results from this research and has been structured to follow a logical sequence to enable simple cross reference. The results have been separated into two distinct parts representing the two research instruments employed. Part one describes the results of the online questionnaire and part two describes the results of the task based user study.

Part 1 - Online Questionnaire

The results from conducting the online questionnaire have been broken into the subject areas of participant profiles, digital map data, paper map data and combined map data to allow simple cross referencing. A copy of the questionnaire can be seen at Appendix 1.

Participant Profiles

Overall the online questionnaire generated 931 attempted responses from which 766 were complete responses providing an overall response rate of 82.3%. It was decided that the incomplete responses would be filtered out and excluded from the analysis due to the high completed survey response rate and the potential unreliability of the incomplete responses. The questionnaire consisted of 62 questions that required a mixture of both quantitative and qualitative responses. Overall, the questionnaire produced 47,492 individual data items that could be used for analysis. Initially, the participant profile data was extracted to reveal information about the respondents that could be subsequently used to categorise and group participants for closer analysis. The participant profile data has been presented as bar charts in Figures 7-13 to enable simple comparison between the proportions in each category (Fielding and Gilbert, 2006).

Question 1&2 – What is your Age and Gender?

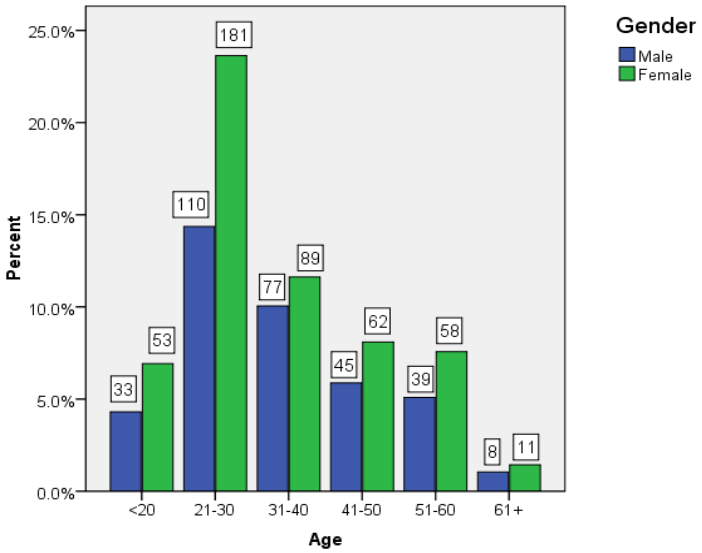


Figure 7 – Bar graph showing participants by age group and gender.

The participant profile data (see Figure 7) revealed a relatively even spread of age ranges; with a predominant age range between 21 and 30 (38.0%). This age range is indicative of the high volume of university student respondents in the sample. Similarly there was a fairly even split between genders with 454 (59.3%) being female and 312 (40.7%) male. This even gender split was not planned, but meant analysis across the gender gap could take place if required. Participant breakdown by profession again reveals a high volume of student responders with the academic field accounting for 61.9% of the total, but due to targeted survey deployment the remaining 38.1% are spread across the range of other categories as described at Figure 8.

Question 3 – Which of the following best describes your profession?

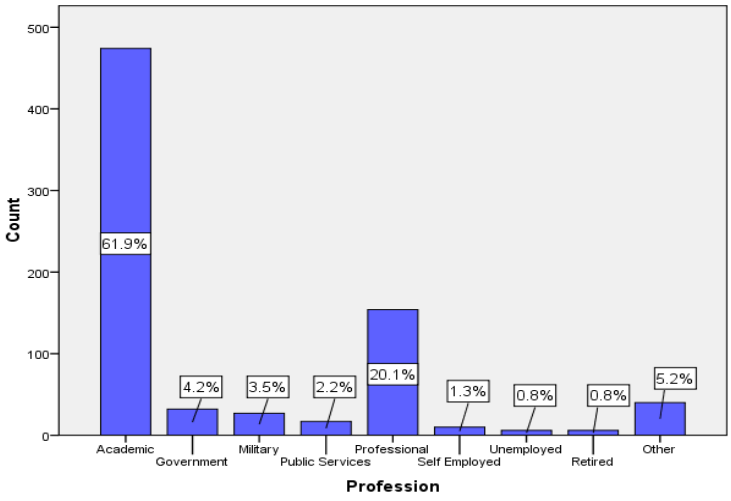


Figure 8 – Bar graph showing participants by profession.

Question 4 – What is your level of computer/Internet skills?

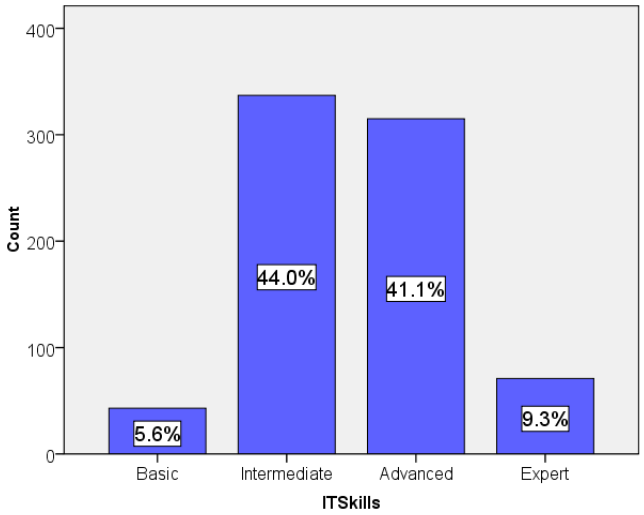


Figure 9 – Bar graph showing participants by IT skill.

Question 5 – How often do you use the Internet?

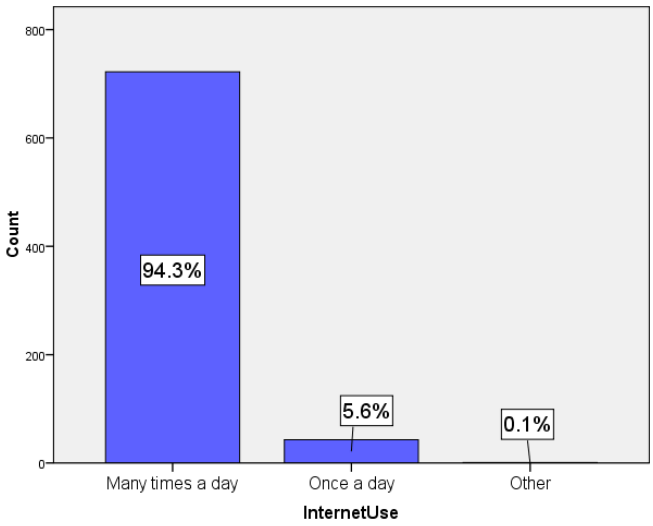


Figure 10 – Bar graph showing participants Internet usage.

The subsequent questions gathered information about participants IT skills and Internet usage. It was found that the majority of participants perceived their IT skills to be 'Intermediate' (44.0%) or 'Advanced' (41.1%) with an overwhelming 94.3% using the Internet 'Many times a day' as shown in Figures 9 and 10 respectively. Predictably 97.1% of participants chose Google as their preferred search engine with only Yahoo reaching any notable recognition with 1.7%. The remaining four search engines combined only accounted for 1.2% as seen at Figure 11.

Question 6 – Which search engine do you use most frequently?

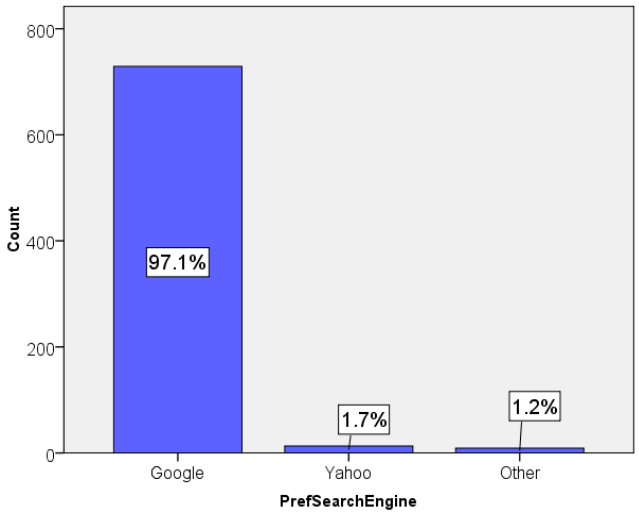


Figure 11 – Bar graph showing participants preferred search engine.

Question 7 – What is your level of geographic knowledge?

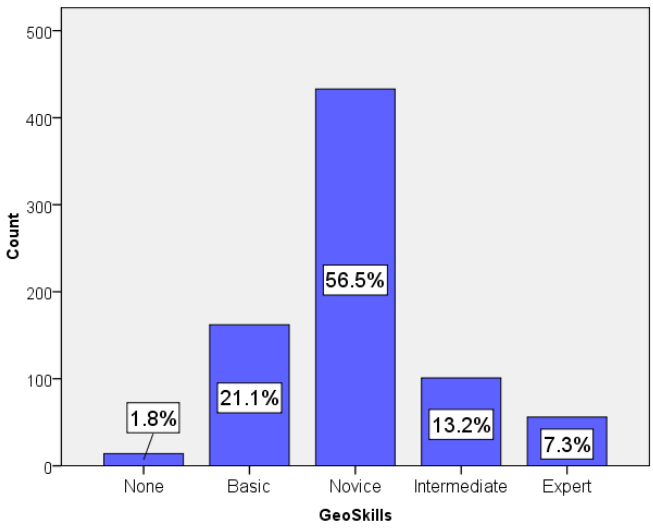


Figure 12 – Bar graph showing participants by geographic skills.

The final element of the profile gathered information about perceived levels of geographic knowledge (see Figure 12). It revealed that the majority of responders (56.5%) class themselves as novices who regularly use online and paper maps. An important aim of this research was to gather data from geographic experts, therefore targeted responses were gathered from a number of both military and civilian professional geographers, resulting in 20.5% of the responders rating themselves as either Intermediate or expert in using/creating maps and geographic information.

Reclassified participants by Geographic experience

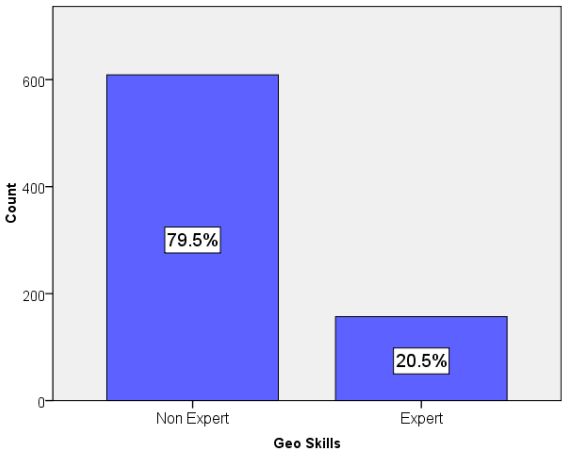


Figure 13 – Bar graph showing participants reclassified according to geographic knowledge into Experts or Non-experts (novices).

At this stage the data was reclassified across participant's perceived geographic knowledge to create two discrete categories of non-experts (79.5%) and experts (20.5%) as shown at Figure 13. To achieve this, the variable values of 'None', 'Basic' and 'Novice' were combined to define 'Non-experts' and the variable values of 'Intermediate' and 'Expert' were combined to define geographic 'Experts'. This split was believed appropriate based on the prescriptive question wording and analysis of the profession of the respondent extracted from the qualitative job data provided. This decision to reclassify the data in this way was made to bring the data into a more defined and descriptive format (Sneiderman, 1998) and would allow the results to be compared to analogous research conducted by Harrower et al (1997).

Online/Digital Map Question Results

The following section describes the results of the digital map format questions from the online questionnaire.

Question 1 – How often do you use online map services/tools

Question 1 was used to identify how often participants used online map services or tools. From the results of Question 1 (see Figure 14) it is clear to see that both experts and non-experts frequently use online maps. The majority of non-experts use online maps at least 'once a week' whilst unsurprisingly over 75% of experts use them more frequently, answering either 'once a week' or 'once a day'.

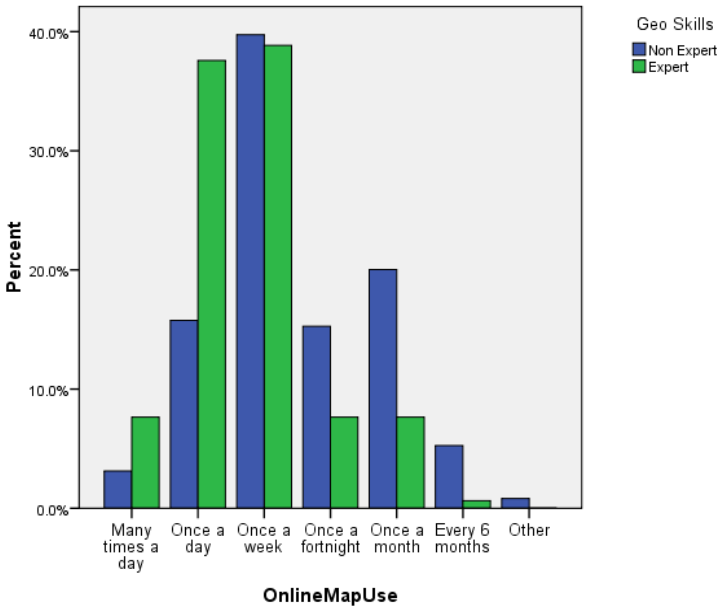


Figure 14 – Bar graph showing how often participants use online map tools.

Question 2 – Which of the following online map services/tools have you used

Service/Tool	Quantity	Percentage
Google Maps	**729**	**95.2%**
AA Routeplanner	423	55.2%
MultiMap	423	55.2%
StreetMap	333	43.5%
RAC Routeplanner	196	25.6%
MapQuest	143	18.7%
Getamap OS	87	11.4%
Yahoo Maps	71	9.3%
Michelin Maps	59	7.7%

Figure 15 – Table describing what type of online map services/tools participants regularly use.

Question 2 was a multiple choice question that allowed participants to select all types of online map that they had used, thus providing an overview of usage and preference for each tool. Figure 15 depicts the service/tools chosen by participants and the cumulative response counts for each choice. As expected the most frequently selected tool was Google Maps with 95.2% of responders stating they had used it. More than half of all responders also stated they use AA Routeplanner and MultiMap which may be related to usage, especially in the case of AA Routeplanner which is predominantly a route finding tool.

Question 3 – Which online map services/tools do you prefer

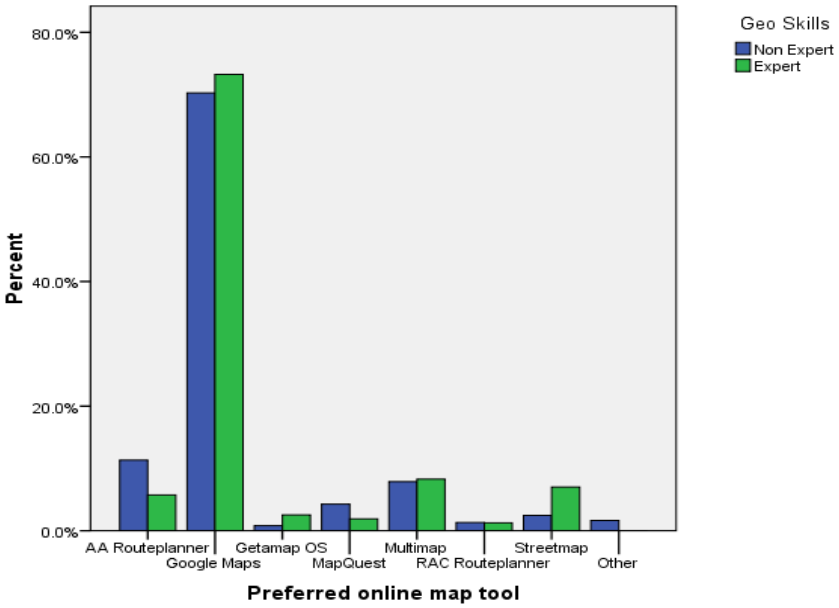


Figure 16 – Bar graph showing which online map service/tool participants prefer.

The aim of question 3 was to discover which online map tool participants preferred overall. Once again an overwhelming majority of participants across all geo skill levels preferred Google Maps to any of the other available map tools as shown at Figure 16.

Question 4 – When looking for maps/routes online which search terms would you use

Question 4 was designed to gauge what search terms individuals entered when attempting to find out geographic information using the Internet. The table at Figure 17 describes the most frequent search terms used extracted from the qualitative data.

Rank	Search Terms
1	Address (e.g Regents Court, Sheffield)
2	Postcode of location (e.g S10 1GG)
3	Typing ‘Map’ or ‘Maps’
4	Typing a destination (e.g Sheffield)
5	Typing ‘Directions’ to and from (e.g Sheffield to Leeds)

Figure 17 – Table describing most common geographic search terms.

Question 5 - What type of online/digital maps do you commonly use

Question 5 was a multiple choice question that enabled participants to select all the types of map that they frequently use. The table at Figure 18 lists the map types and

the cumulative participant response counts for each. It is evident from the data that the majority of participants use online/digital map tools to obtain route information. The results shown at Figures 17 and 18 both support the findings of Easingwood (2008) who found that the majority of users of online/digital map tools do so to acquire route information.

Map Type	Quantity	Percentage
Route map/Atlas	**622**	**81.2%**
Guide book/city maps	497	64.9%
Aerial Imagery maps	342	44.6%
Walking/cycling map	270	35.2%
Geology/Archaeology map	45	5.9%

Figure 18 – Table describing what type of digital/online maps participants regularly use.

Question 6 - Indicate the importance of the following features of online map services/tools

Question 6 asked participants to rate the importance of a number of features of online/digital map services using likert based satisfaction scales (Bryman, 2008). The responses to each sub-question have been broken down by geographic skill to enable analysis between the skill groups. Bar graphs displaying these results can be seen in Figures 19 to 28.

Question 6.1/6.2 – How important is bookmarking and feature positional accuracy on digital/online maps

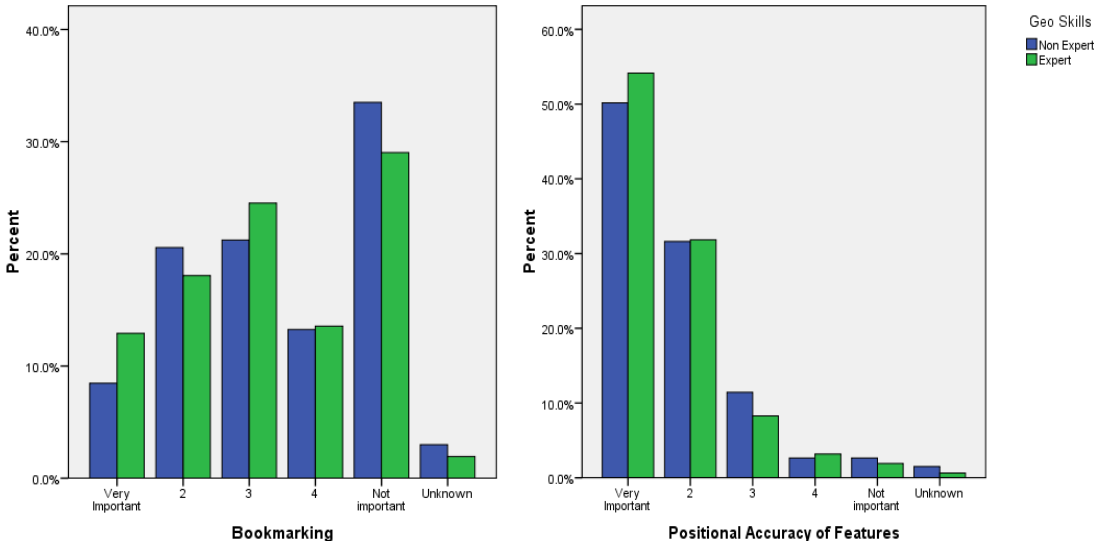


Figure 19 – Bar graphs showing the importance of bookmarking and feature positional accuracy of digital/online maps.

Looking at the spread of responses at Figure 19 it is clear that bookmarking is not a feature that is considered essential for either skill group. On the other hand over 50% of respondents considered that positional accuracy of features as 'Very important'.

Question 6.3/6.4 – How important is aerial imagery and the ability to locate local amenities on digital/online maps

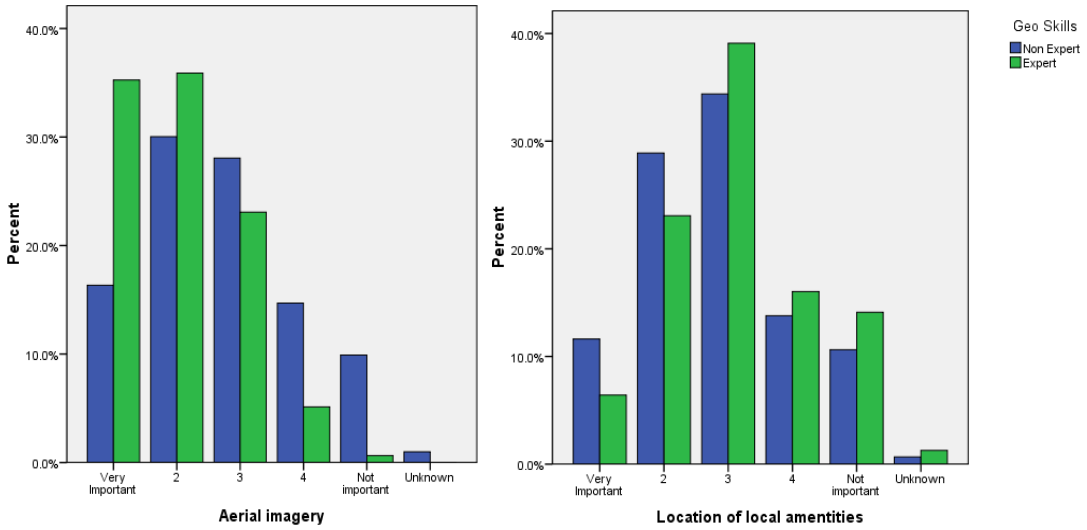


Figure 20 – Bar graphs showing the importance of aerial imagery and the ability to locate local amenities on online/digital maps.

Figure 20 displays the general importance of being able to access aerial imagery, especially for expert users. While both skill groups show indifference about the importance of being able to locate local amenities on digital/online maps.

Question 6.5/6.6 - How important are currency of map information and advanced tools on online/digital maps

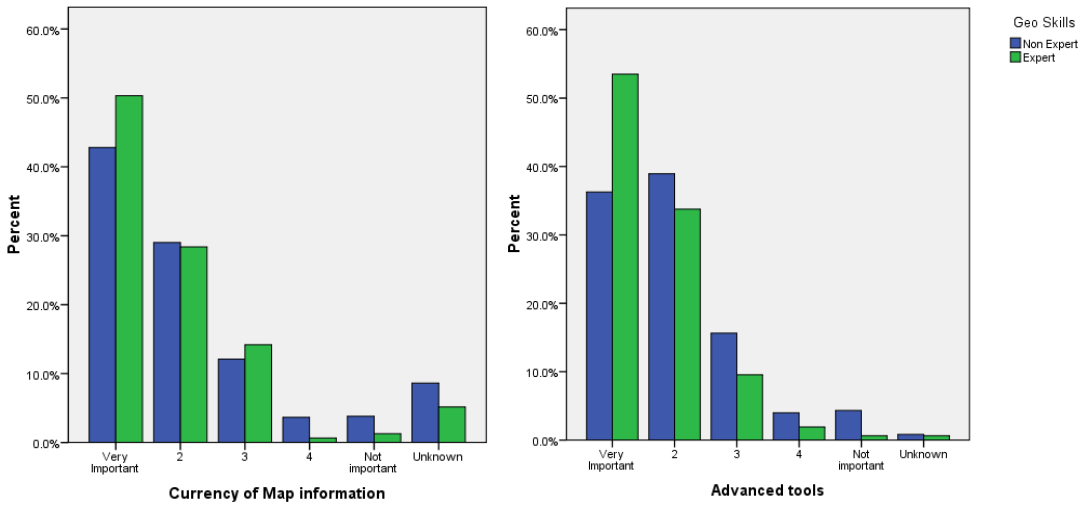


Figure 21 – Bar graphs showing the importance of map information currency and advanced tools on online/digital maps.

Both geo skill groups consider access to advanced tools and the currency of the map information as ‘Very important’ features of online/digital maps as shown at Figure 21.

Question 6.7/6.8 – How important are the ease of screen navigation and the ability to add your own data to digital/online maps

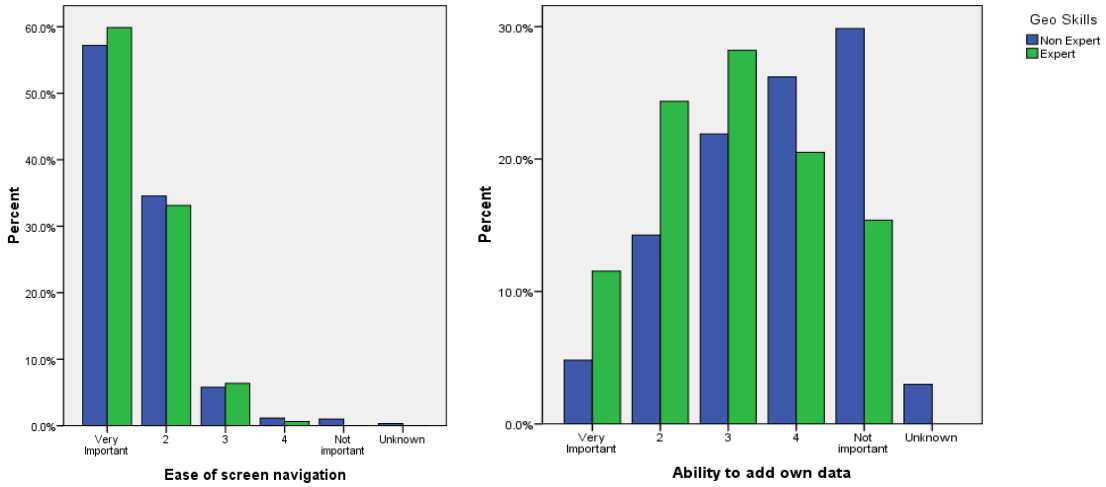


Figure 22 – Bar graphs showing importance of ease of screen navigation and the ability to add your own data using online/digital maps.

There is an overwhelming majority of respondents that consider the ease of navigating around the screen using a map tool as ‘Very important’. This is certainly not the case for the ability to add user defined content which displays a general trend towards unimportance especially by non-experts as seen at Figure 22.

Question 6.9/6.10 – How important is the efficiency and speed of search results and grid referencing on digital/online maps

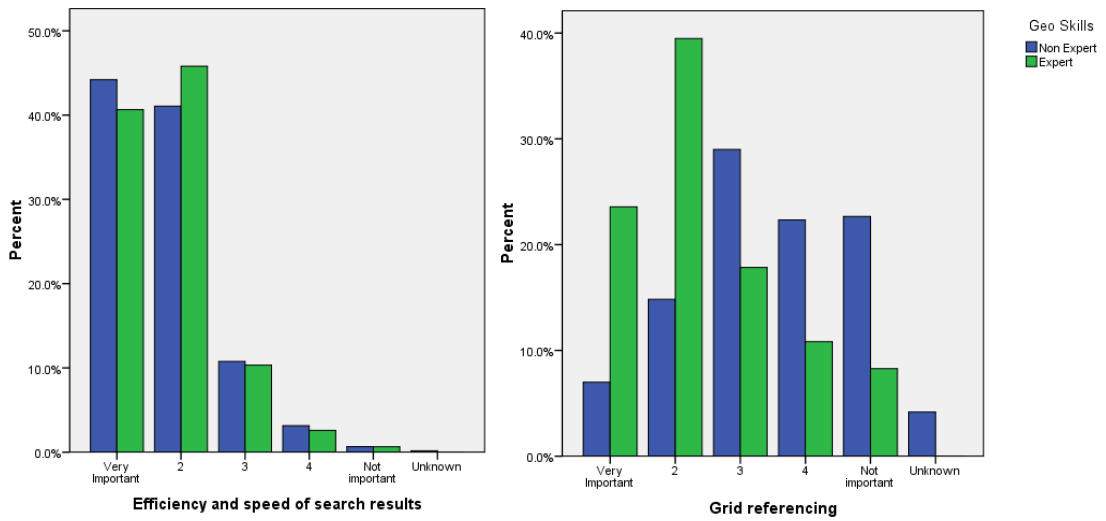


Figure 23 – Bar graphs showing the importance of efficiency and speed of search results and grid referencing on digital/online maps.

Responders predictably rated the efficiency and speed of search results as an important feature of online/digital map tools as with any online tool. However, when it comes to displaying grid references non-experts are not convinced of its importance whereas over 60% of experts believe it is either 'Important' or 'Very important' with less than 10% rating it as 'Not important' (see Figure 23).

Question 6.11/6.12– How important are print functionality/quality and the readability of digital/online map features

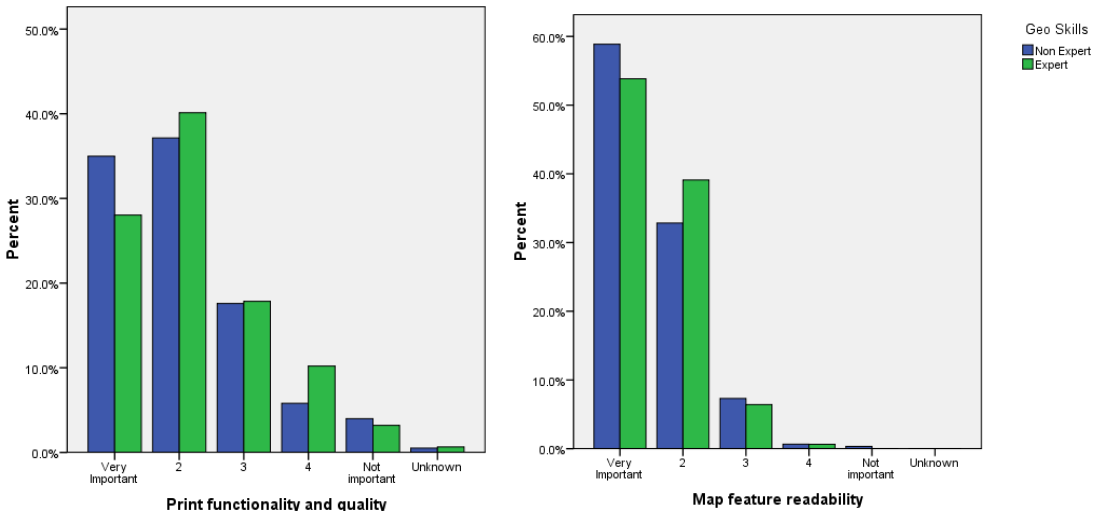


Figure 24 - Bar graphs showing the importance of print function/quality and readability of digital/online maps.

Figure 24 shows that both skill groups equally consider print functionality and the readability of map features as important aspects of digital/online maps.

Question 6.13/6.14 – How important are availability of map scales and usability of digital/online maps

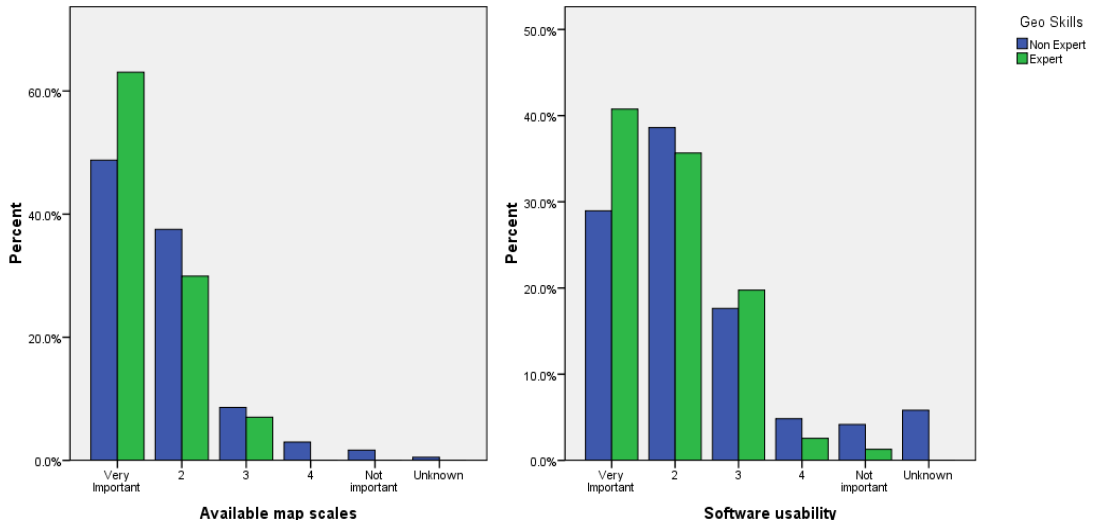


Figure 25 – Bar graphs showing the importance of map scalability and usability of online/digital map.

It is evident that being able to access a range of map scales and the overall usability of map tools are both rated important by both geo skill groups as shown at Figure 25.

Question 6.15/6.16 – How important is a low map purchase price and relief information on online/digital maps

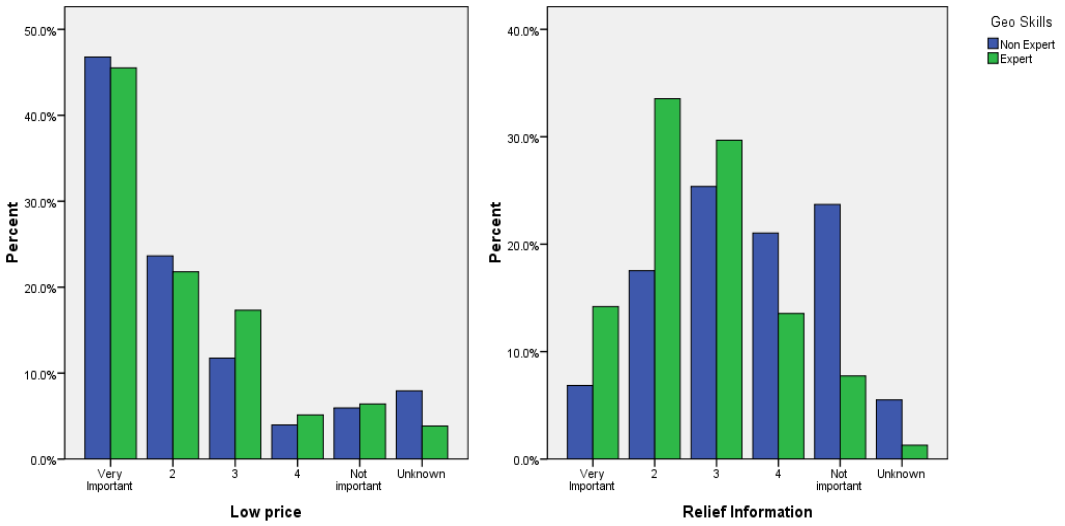


Figure 26 – Bar graphs showing the importance of purchase price and relief information for digital/online maps.

An important attribute of online/digital maps is low price (people generally do not expect to pay for their online maps). Conversely more than 45% of experts rate relief information as important as opposed to only about 25% of non-experts. There are also a significant number of non-experts who did not know what relief (or contour) information was (see Figure 26).

Question 6.17/6.18 – How important are simple map symbols and access to route information on digital/online maps

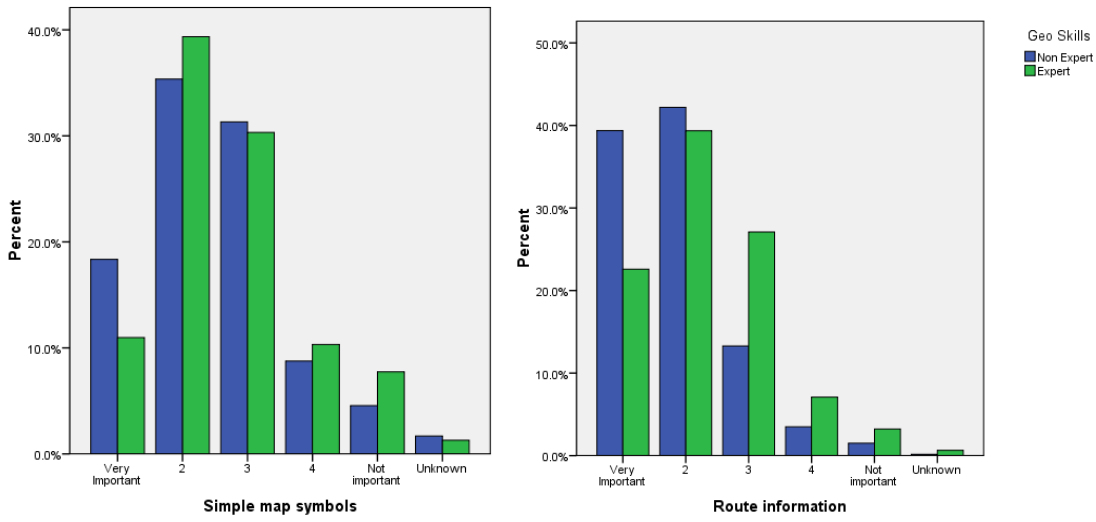


Figure 27 - Bar Graphs showing the importance of map symbols and route information on online/digital maps.

Figure 27 shows that having simple map symbols is an important aspect of online/digital maps whilst, there is significant disagreement over the importance of having access to route information between the geo skill groups. It is likely that this difference is linked to how and what digital/online maps are used for across the skill groups.

Question 6.19/6.20 – How important is the ability to locate manmade or natural points of interest on digital/online maps

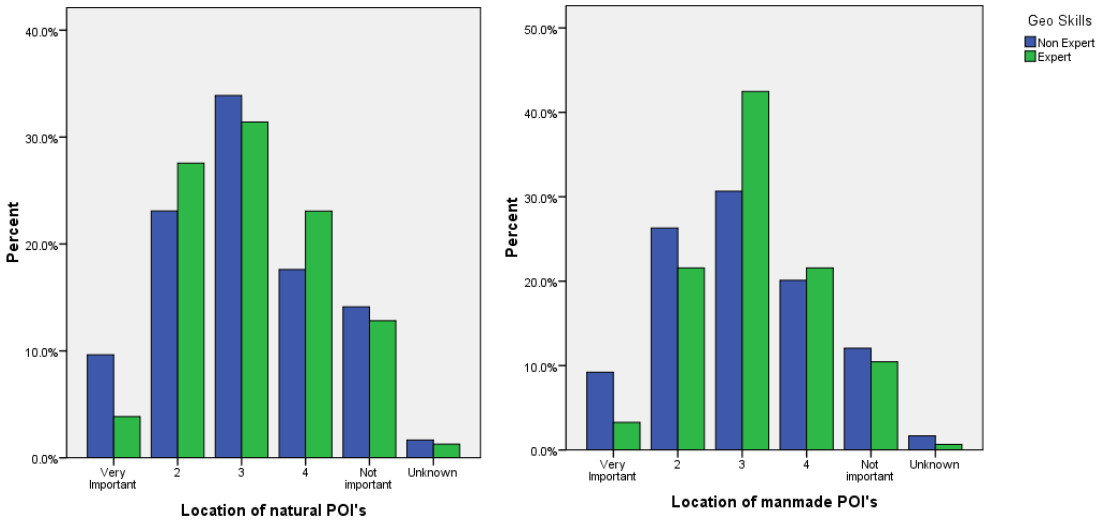


Figure 28 – Bar graphs showing the importance being able to locate manmade or natural points of interest using online/digital maps.

Both skill groups are relatively indifferent about being able to locate manmade and natural points of interest on digital/online maps as shown at Figure 28.

Question 7 - What do you think your preferred map tool should include to improve your user experience

This question aimed to gather data on what participants believed would be useful features that would improve current digital/online map functionality and usability. Overall, participants cited print capabilities as the main area for improving current map tools with over 16% commenting on the topic. With respondents giving comments like “Printing is definitely the weak point of most map provision services” and why can’t I “print a true representation of what is seen on the screen”. An overriding requirement was to be able to print at an A3 scale. Across the rest of the responses suggestions ranged from “Contours would be useful when planning cycling or walking routes” to comments about “Better integration with OS grids and more pinpointed, precise coordinate views”. The results of this question produced a vast range of responses that would be too detailed to investigate for the purposes of this research.

Paper Map Question Results

The following section describes the results of the paper map questions asked within the online questionnaire.

Question 1 – How often do you use paper maps or atlases

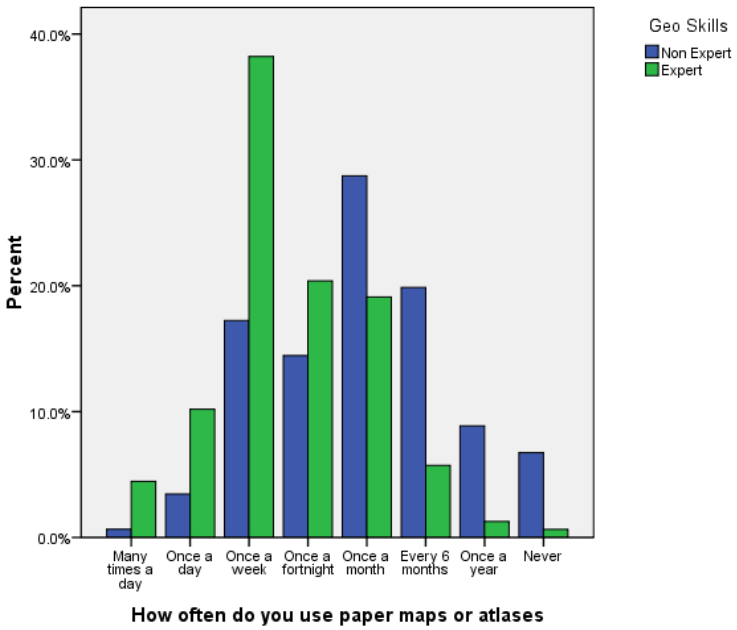


Figure 29 – Bar graph showing how often participants use paper maps.

It is evident from the bar graph at Figure 29 that there is a full range of timescales over which participants use paper maps from 'many times a day' to 'never'. There is a notable difference between non-experts and experts, with the majority of experts using paper maps 'once a week' and Non-experts using them less frequently.

Question 2 – What type of paper maps do you commonly use

This question was a multiple choice question that enabled participants to select all relevant map types they have used from those defined. The table at Figure 30 lists the map types and the cumulative response counts for each. Once again (as for digital/online maps) most participants used paper maps to acquire route information.

Map Type	Quantity	Percentage
Route map/atlas	**537**	**70.1%**
Street map	464	60.6%
Guide book/travel map	387	50.5%

Walking/cycling map	287	37.5%
Hobby map (e.g. orienteering)	79	10.3%
Geology/Archaeology map	52	6.8%
None	41	5.4%

Figure 30 – Table describing what type of paper maps participants regularly use.

Question 3 – How do you acquire your paper maps

This question was a multiple choice question that enabled participants to select all relevant map types from those defined. The table at Figure 31 lists the acquisition methods and the cumulative response counts for each. It highlights that most paper map users (77.9%) purchase their maps from shops with 39.6% acquiring them for free by downloading from the web.

Map Type	**Quantity**	**Percentage**
Purchase from a shop	**597**	**77.9%**
Download Free from website	303	39.6%
Borrow from a friend	190	24.8%
Purchase from a website	132	17.2%
Borrow from a library	68	8.9%
Never use paper maps	39	5.1%

Figure 31 – Table describing how participants acquire paper maps.

Question 4 - Indicate the importance of the following features of paper maps/atlases

This question aimed to identify the level of importance that participants gave to a number of paper map features. The question was broken into thirteen sub questions and split by geo skill group to allow comparison. Bar graphs showing these results can be seen in Figures 32 to 38.

Question 4.1/4.2 – How important is durability and a low price for paper maps

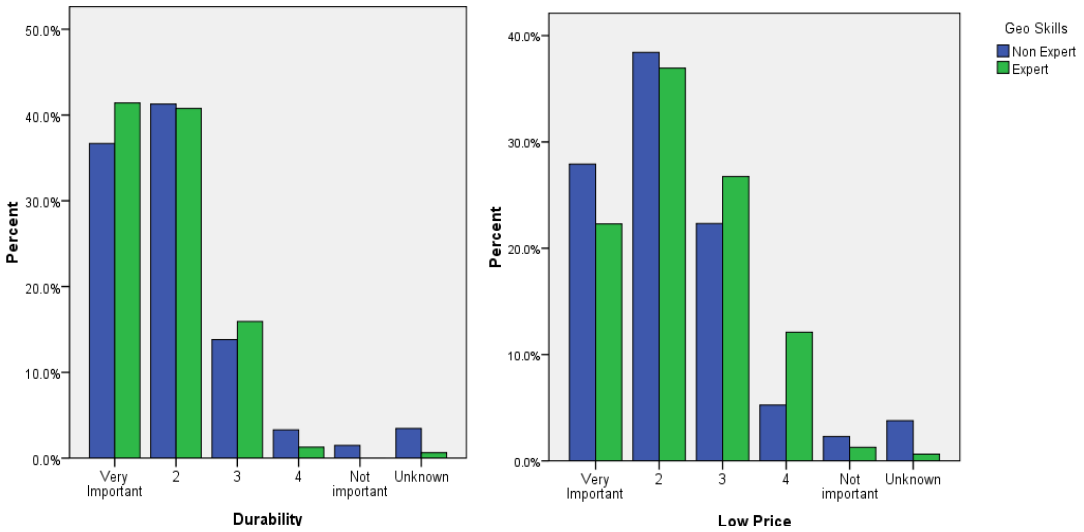


Figure 32 – Bar graph showing importance of durability and a low price for paper maps.

In terms of durability the majority of respondents across both skill levels agree it is an essential paper map attribute. As for low price there is a spread of values across the range with a general trend towards relative importance, but the value varies across the geo skills groups as shown at Figure 32.

Question 4.3/4.4 – How important is usability and map feature readability on paper maps

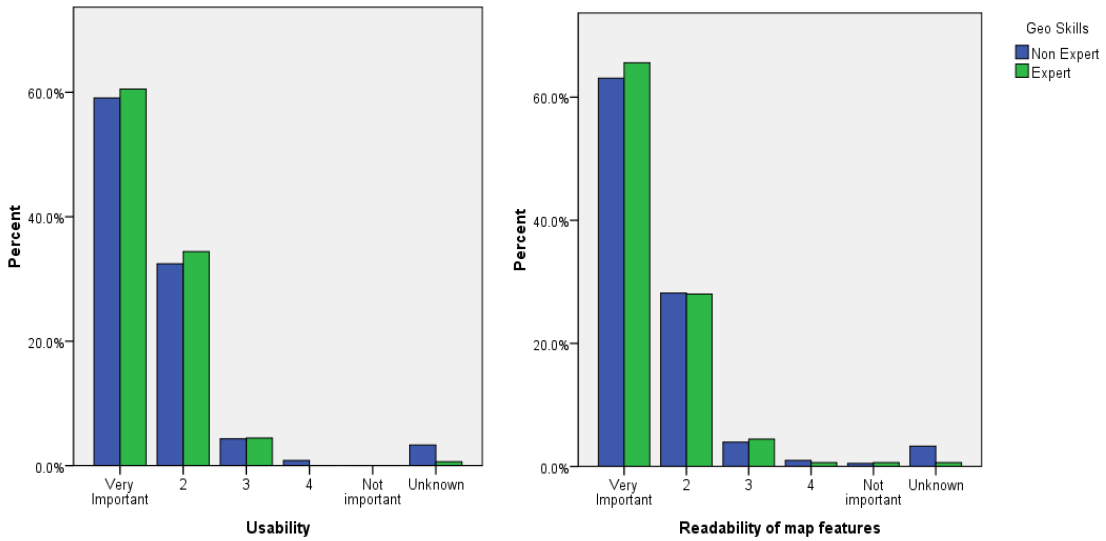


Figure 33 – Bar graphs showing importance of usability and map feature readability on paper maps.

Across both usability and map feature readability results there is a general consensus that both features are of significant importance with very few respondents selecting low importance. Additionally there is a visible degree of correlation between experts and non-experts on the importance of both these features as shown at Figure 33.

Question 4.5 – How important is relief information on paper maps

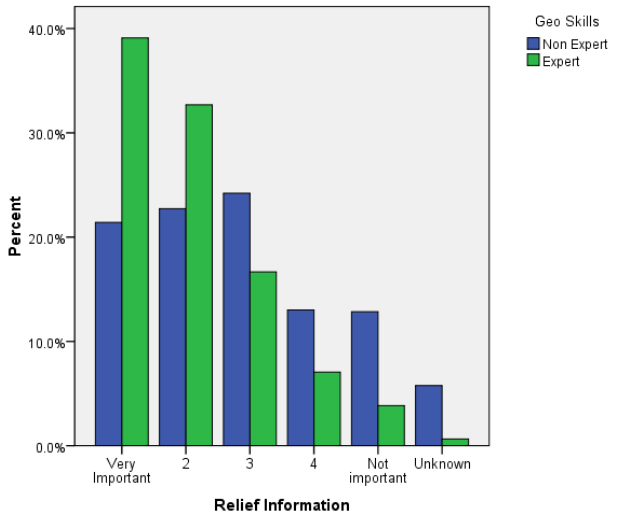


Figure 34 – Bar graph showing importance of relief information on paper maps.

The bar graph at Figure 34 shows a significant difference in the importance of the depiction of relief information on paper maps between non-experts and experts with the latter regarding it as 'Very important' in the majority of cases whilst non-experts regard it as only relatively important.

Question 4.6/4.7 – How important are simple map symbols and route information on paper maps

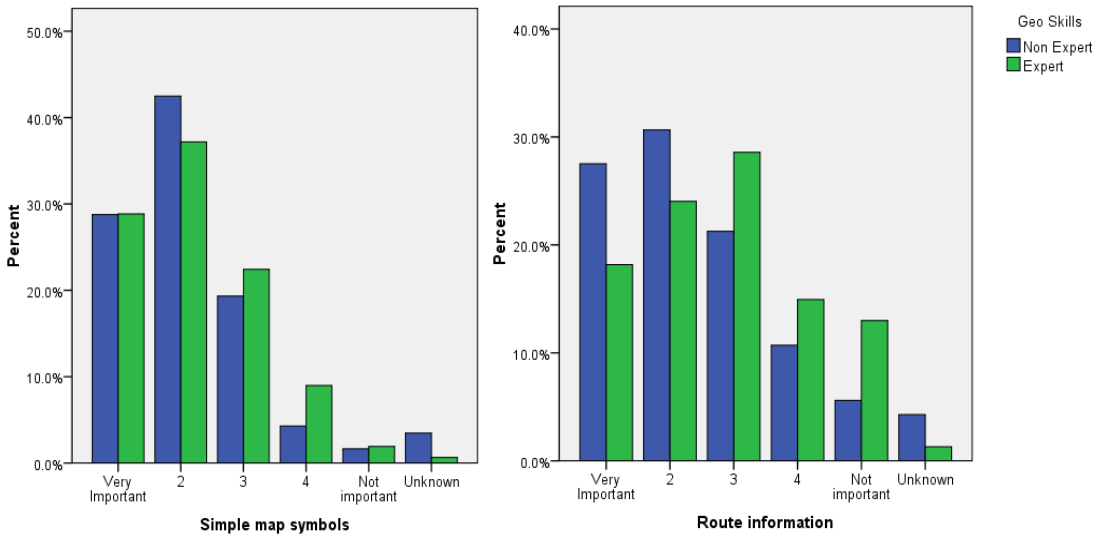


Figure 35 – Bar graphs showing importance of simple map symbols and route information on paper maps.

The importance of simple map symbols on paper maps shows a general positive trend in importance across both geo skill levels. The importance of route information on paper maps also shows a general trend towards greater importance, however

there is a greater degree of apathy between expert users as to its importance as seen at Figure 35.

Question 4.8/4.9 - Indicate the importance of the ability to locate manmade or natural places of interest using paper maps/atlases

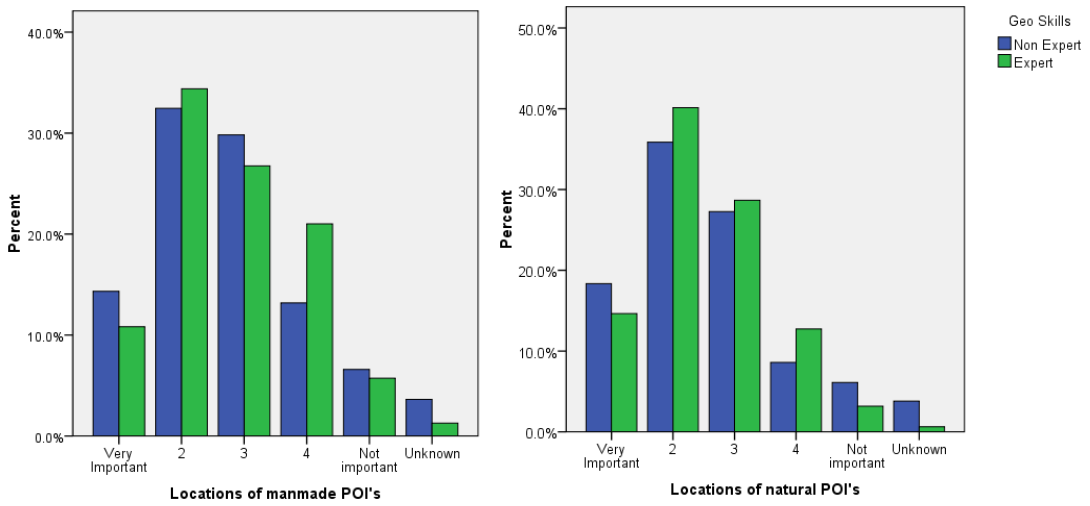


Figure 36 – Bar graphs showing importance of being able to locate natural or manmade POI's on paper maps.

With regards to the importance of depicting manmade or natural places of interest on paper maps there is a common apathy between geo skill groups over their relative importance, as shown in the bar graphs at Figure 36.

Question 4.10/4.11– Indicate the importance of the currency of map information and the positional accuracy of map features of paper maps/atlases

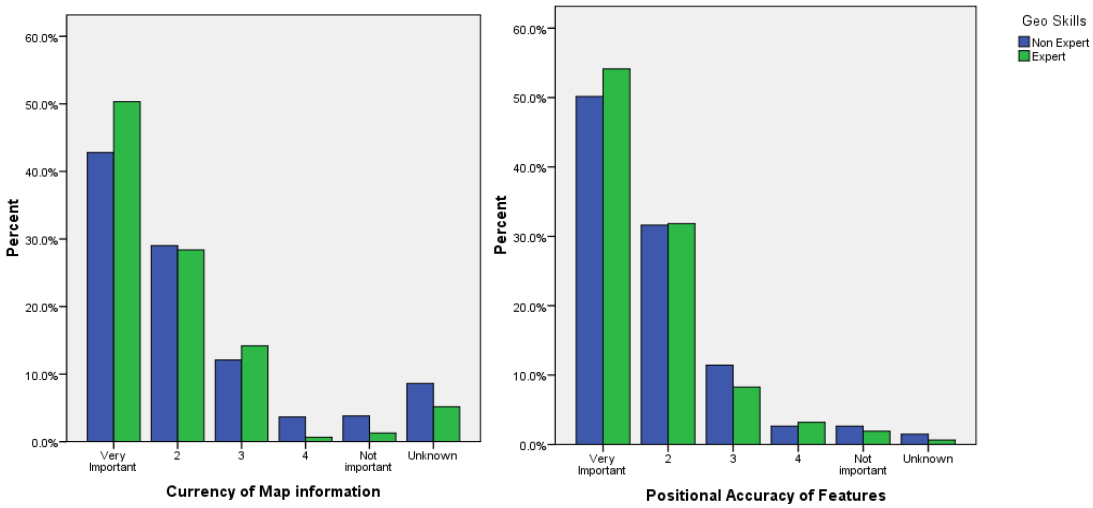


Figure 37 – Bar graphs showing the importance of map information currency and positional accuracy of paper maps.

In the case of map feature readability and the currency of map information there is a similar high importance rating across all participants, a result that is congruent across the geo skills gap as seen at Figure 37.

Question 4.12/4.13 – Indicate the importance of grid reference availability and print quality of paper maps/atlases

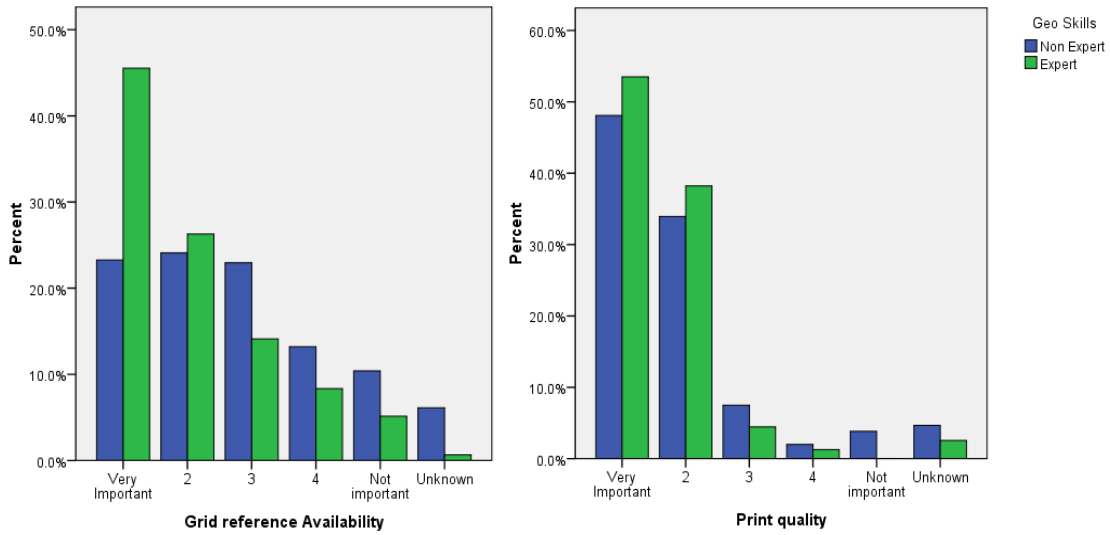


Figure 38 – Bar graphs showing importance of grid references and print quality of paper maps.

Figure 38 displays a trend in agreement that both grid referencing and print quality are important attributes of paper maps. This fact is consistent across the geo skills gap albeit there is a notable strength of importance by response in experts with regards to grid referencing. Similar to relief Information a relatively high proportion of Non-experts did not know what grid referencing was useful for.

Question 5 – What additional features would you find useful on a paper map

This question aimed to gather data on what participants believed would be useful features that could improve current paper map functionality and usability. Overall, participants cited locations of fuel stations as the main area for improving current paper maps with over 25% commenting on the topic. With respondents giving comments like “Fuel station locations would definitely be advantageous”. Across the rest of the responses suggestions ranged from “Present OS maps contain most of the information I require” to comments about having “All local amenities listed so walkers can find them quickly and easily”. Overall there was a resounding contentment with current paper mapping with a plethora of comments like “I find OS maps (1:25K and 1:50K) to be of outstanding quality”. The results of this question produced a vast range of responses that would be too detailed to investigate for the purposes of this research.

Combined Map Question Results

The following section describes the results of questions that were designed to compare aspects of both paper and digital/online maps directly.

Question 6 – In general do you prefer paper or digital/online maps

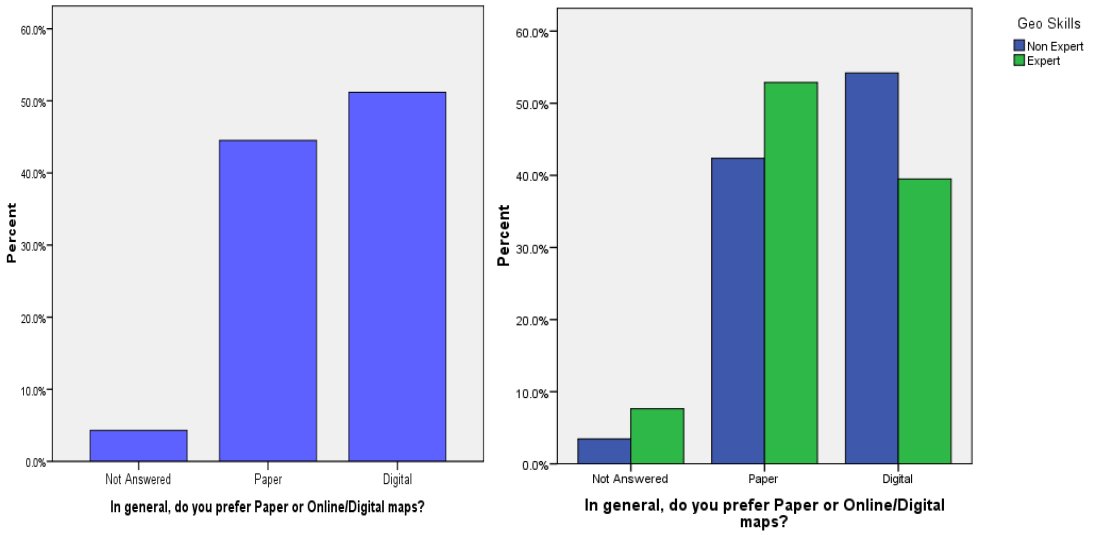


Figure 39 – Bar graphs representing overall map preference and map preference by skill group.

It is clear that overall participants generally preferred digital maps, but only by a small margin. When divided by Geo skill level the preference for paper maps over digital by experts and vice versa is more pronounced as shown in the bar graphs at Figure 39.

Question 7 – Are there situations when you would prefer one over the other

This question aimed to put the overall map preference question into qualitative context. The five main reasons for the preference for both paper and digital maps are reported in the table at Figure 40.

Rank	Paper Map Preference	Digital Map Preference
1	For walking and cycling	For travel directions
2	For navigation outdoors	Finding information about a new location
3	Detailed navigation	For journeys by car
4	Useful as a backup to digital	Planning all journeys
5	Ability to see large area & review map	Easy to use & always available

Figure 40 – Table representing the main reasons for paper/digital map preference.

Some interesting comments from this question included “digital is too slow on mobile phone so I use paper” and “paper maps would be useful if I couldn't charge my phone” highlighting a technological reason for not using digital maps on portable devices. With some commenting that they prefer paper maps because they are likely to be more accurate. The results of this question produced a vast range of responses that would be too detailed to investigate for the purposes of this research.

Question 8 – Indicate your preference for paper or online/digital maps for the following tasks

Question 8 aimed to put the preference for map use into context to enable investigation into potential trends surrounding overall map selection process. The question was broken into five sub questions with bar graphs showing the results shown in Figure 41 to Figure 45.

Question 8.1 - Finding location information

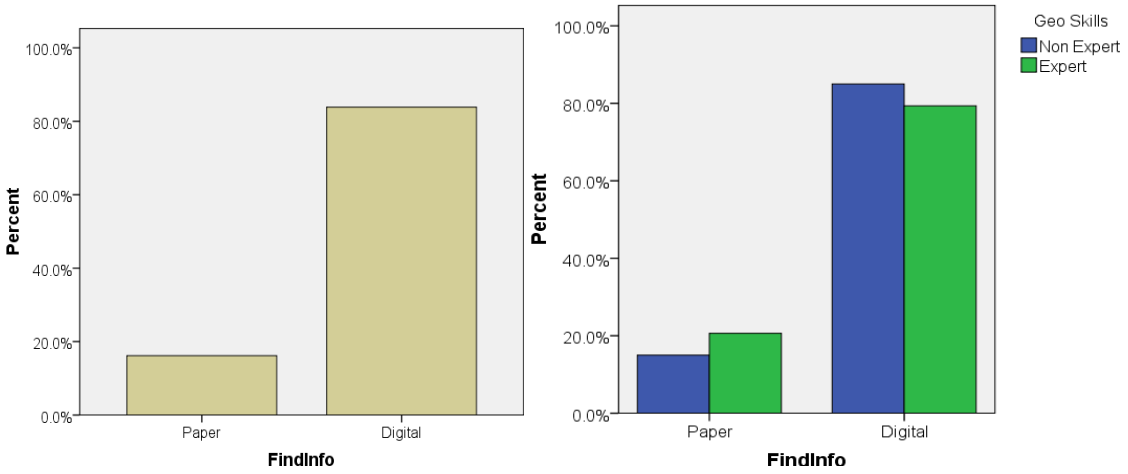


Figure 41 – Bar graphs showing overall preference and preference by skill level for finding location information

It is clear from the graphs at Figure 41 that both geo skill groups would use digital/online maps to find information about locations they wished to visit with over 80% stating that they preferred digital/online tools for conducting the task.

Question 8.2 - Navigation on foot

The bar graphs at Figure 42 display an overall preference for paper maps by all participants when navigating on foot with a higher proportion of experts choosing paper over digital maps. This result clearly highlights the role that ‘context of use’ is an important factor to consider when considering map format suitability and preference.

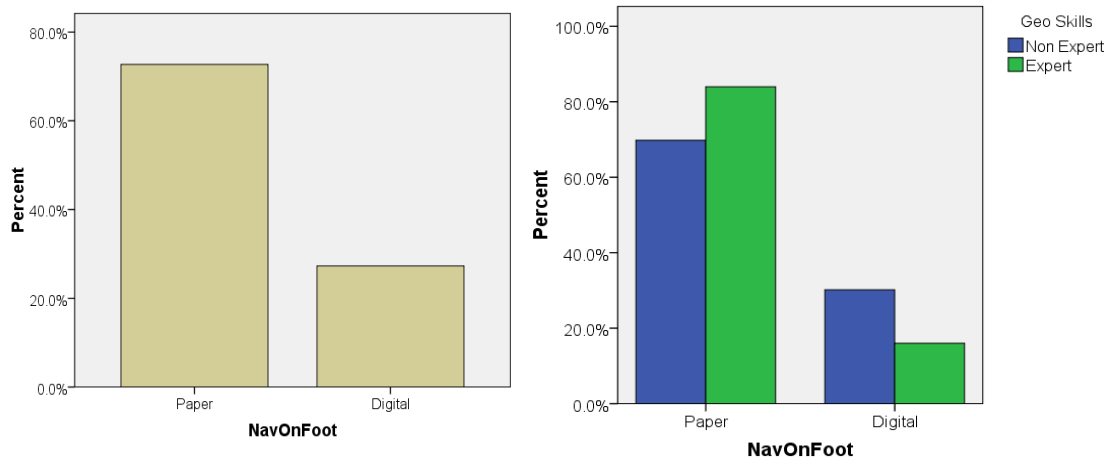


Figure 42 – Bar graphs showing overall preference and preference by skill level for navigating on foot.

Question 8.3 - Navigation by car

When it comes to navigating by car not surprisingly most participants expressed a preference for digital maps. However, what is surprising is the narrow margin by which it leads. Also of interest is the slight overall preference for paper maps by experts for car navigation as shown at Figure 43.

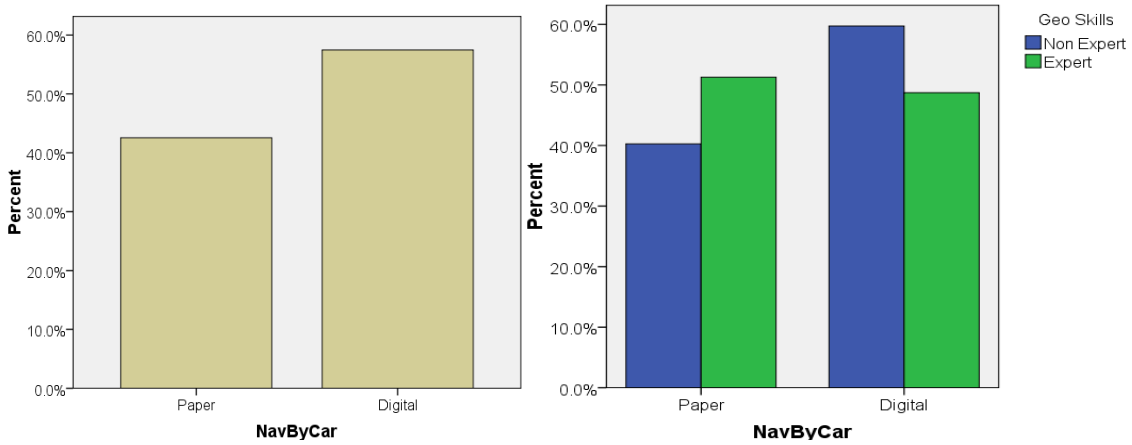


Figure 43 – Bar graphs showing overall preference and preference by skill level for navigating by car.

Question 8.4 - Short distance route planning

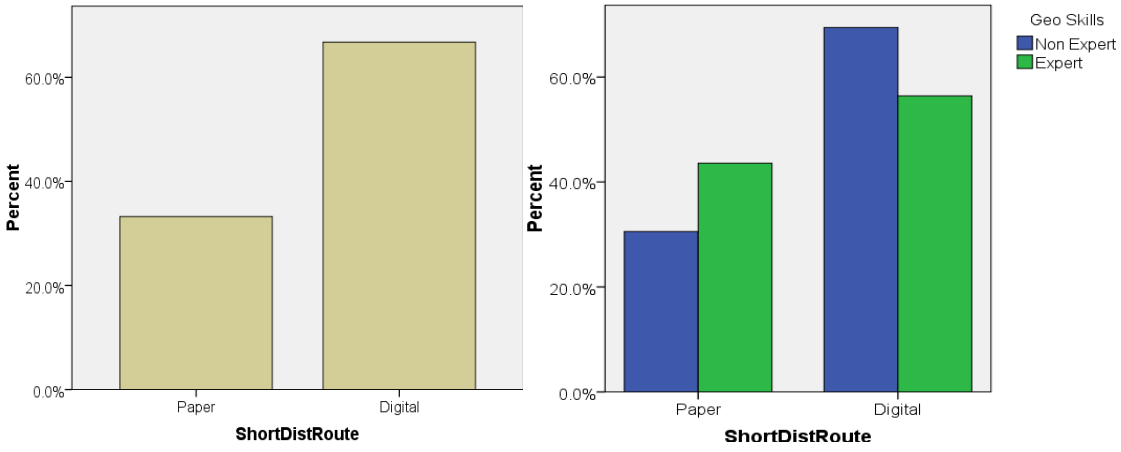


Figure 44 – Bar graphs showing overall preference and preference by skill level for short distance route planning.

The bar graphs at Figure 44 show a preference for digital maps when planning a short distance route. However, there is a significant difference between experts and non-experts with a preference for paper by experts being proportionally higher than non-experts.

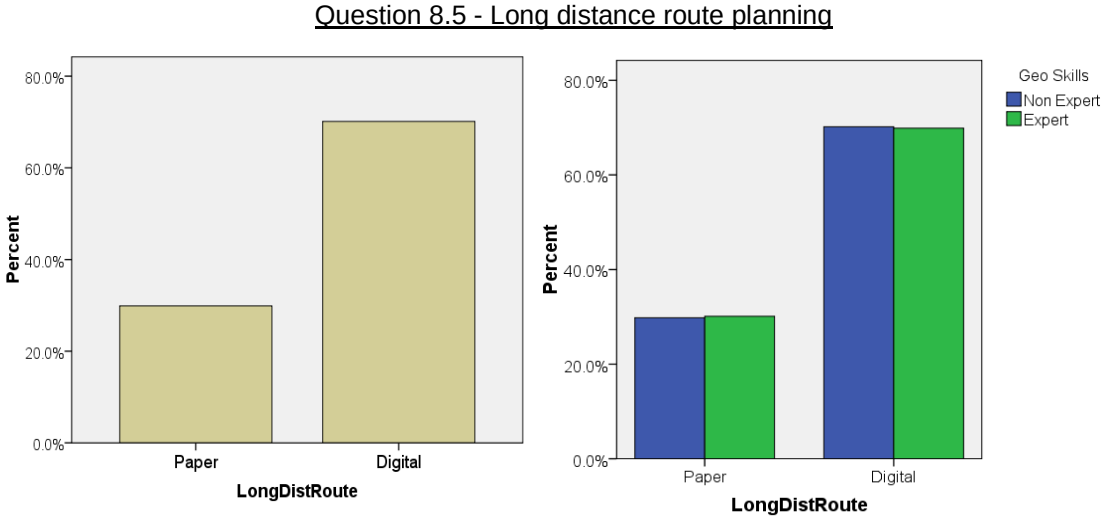


Figure 45 – Bar graphs showing overall preference and preference by skill level for long distance route planning.

With regards to preference for paper or digital maps for long distance route planning the majority of participants displayed a preference for digital maps with no significant difference across the geo skills gap as shown in the bar graphs at Figure 45

Part 2 - Task Based User Study

The results of conducting a task based user study have been broken down into subject areas to allow easy cross referencing. These subject areas are participant profiles, general questions, digital map satisfaction, paper map satisfaction and combined map responses. The scenarios and satisfaction questionnaire can be seen at Appendix 2.

Participant Profiles

The twelve participants that took part in the study were selected from individuals that answered in the initial online questionnaire and were grouped as experts or non-expert geographic users. Using these sample groups would allow direct comparison of results between the two skill levels. The initial questions (1-6) were used to gather information on the participants to ensure the analysis framework was relevant to the research and with the results of the previous online questionnaire. All participants were asked whether they had experience of online maps, paper maps and portable map interfaces (which they all had). This question ensured that there was no bias towards those with prior knowledge of one format over the other. The subsequent

questions were related to the tasks, the results of which are described in the following section:

General Questions

Question 7 – What map format would you choose in the following situations

This question was used to further investigate map medium preference. A set of potential situations were provided and the participants had to choose from the following list of options.

- Online/Digital map.
- Paper printout of an Online/Digital map.
- Mobile GIS (Mobile phone, SatNav etc).
- Export digital map to mobile device.
- Paper maps/atlases.

The table at Figure 46 details the answers to Question 7 broken down by skill level.

Situation	Non-expert	Expert
Planning Navigation by car	Online/Digital Map	Online/Digital Map
Executing Navigation by car	Mobile GIS	Mobile GIS
Planning Navigation on foot	Online/Digital Map	Paper Map/Atlas
Executing Navigation on foot	Paper Map/Atlas	Paper Map/Atlas
Planning to travel a short distance (up to 10 miles)	Mobile GIS	Mobile GIS
Executing a short distance journey(up to 10 miles)	Mobile GIS	Mobile GIS
Planning to travel a long distance (over 100 miles)	Online/Digital Map	Online/Digital Map
Executing a long distance journey (over 100 miles)	Mobile GIS	Mobile GIS

Figure 46 – Table showing preference for map formats for a selection of likely requirements

Both skill groups show a high level of agreement in what map medium they would use to approach each situation. With ‘planning navigation by foot’ being the only situation where they disagree with non-experts preferring online/digital maps and experts paper maps/atlases.

Question 8 – What are the positive/negative aspects of using a portable digital map interface

Positive Attributes	Negative Attributes
Simple to use (3)	Expensive (5)
Portable (3)	Power dependent (4)
Up to date information (2)	Easy to damage (3)
Map scales (2)	Small screen size (3)

Figure 47 – Table showing positive/negative attributes of digital maps/atlases.

The twelve participants gave a range of responses to question 8, but there were a number of common themes across the main positive and negative aspects. It is clear that screen size is a concern to potential users of portable map interfaces as highlighted at Figure 47 and in research by Looije et al. (2007), Reilly et al. (2006) and Reichenbacher (2001). The table at Figure 47 displays a concise list of their comments and a response count (n):

Question 9 – What are the positive/negative aspects of using paper maps/atlases.

Positive Attributes	Negative Attributes
Relatively cheap (4)	Weather damage (3)
No power required (2)	Map too large (3)
Portable (2)	Easy to damage (2)
Easy storage (2)	Fixed scale (2)
Grid refs and contours (2)	Too much detail (1)
Print quality (1)	No route information (1)

Figure 48 – Table showing positive/negative attributes of paper maps/atlases.

This question allowed participants to provide short qualitative positive/negative aspects of paper maps/atlases as shown at Figure 48. Interestingly participants in this study stated that paper maps are relatively cheap, whereas research by Parry (1999) found that users thought they were expensive. This difference may be due to participants in this survey comparing the cost of paper maps to the cost of actually purchasing digital maps that are often expensive. One comment in this research stated that paper maps showed too much detail. A comment that did agree with Parry's research as he found that users believed paper maps provided too much information. The results of question 9 also showed similarity with work by Johnson et al (1993) who found paper maps displayed positive attributes such as easy storage and portability.

User Satisfaction – Digital Maps

Question 1 – Please rate the following digital map features

This question was asked immediately after participants had conducted the tasks with Google Maps. The average results of non-experts and experts were used to smooth out any anomalies. The results can be seen at Figure 49 (agreement levels rise from one to five. For example 1.7 = agree & 4.3 = disagree).

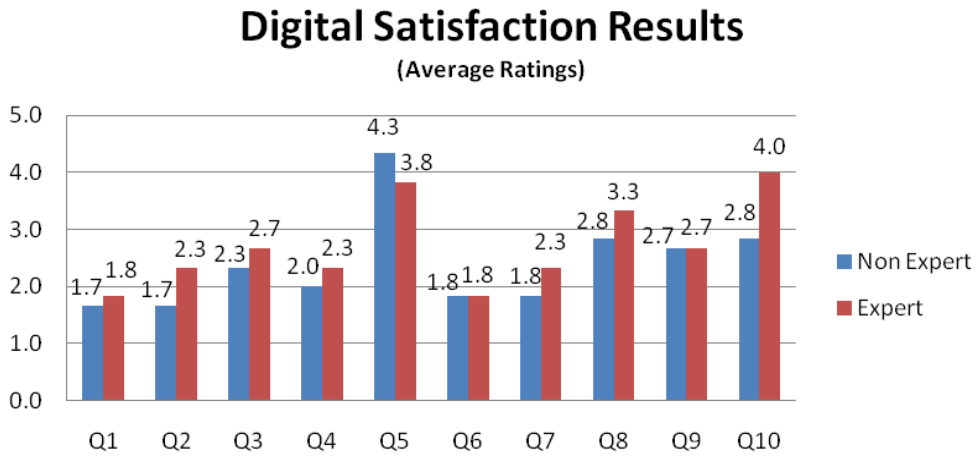


Figure 49 – Bar graph showing average digital map ratings

The following list is the key to the questions:

- Q1 – The format enabled easy task completion.
- Q2 – The task results were relevant and accurate.
- Q3 – Information on the map is easy to find.
- Q4 – The map presents information in a visually pleasing manner.
- Q5 – The map is confusing and difficult to read.
- Q6 – The map is easy to use.
- Q7 – The map is well structured and easy to navigate.
- Q8 – The quality of the maps are high.
- Q9 – The map is too small.
- Q10 – I would be happy to purchase the map.

In general both skill groups are satisfied with the results of using the digital map tool. The main disagreements between skill levels are on Q2 and Q10. Non-experts think that the results of the digital map tool were more relevant and accurate, yet they would be more likely to purchase the digital map than the experts. Not surprisingly users' rate most aspects of Google Maps well above average, results that were analogous with satisfaction ratings reported by Heng Lu (2006) and Easingwood (2008).

Question 2 – What do you like and dislike about the digital map format

This question allowed participants to provide short qualitative reasons why they like/dislike the format they had just used. The following table (Figure 50) is a concise list of their comments and a response count (n):

Positive Attributes	Negative Attributes
Quick route finding (7)	No walking route information (4)
Easy to plan journeys (5)	Internet connection required (2)
Various map scales (3)	Poor level of detail (2)
Good quality maps (2)	Poor print functionality (1)
Effective search function (2)	No relief information (1)
Free to use (1)	Requires power (1)

Figure 50 – Table showing positive/negative attributes of digital maps/atlases.

User Satisfaction – Paper Maps

Question 1 – Please rate the following paper map features

This question was asked immediately after participants had conducted the tasks with the paper maps. The mean results of non-experts and experts were used to smooth out any anomalies. The results can be seen at Figure 51 (agreement levels rise from one to five. For example 1.8 = agree & 4.7 = disagree). The questions are the same as the digital satisfaction questions described in the last section:

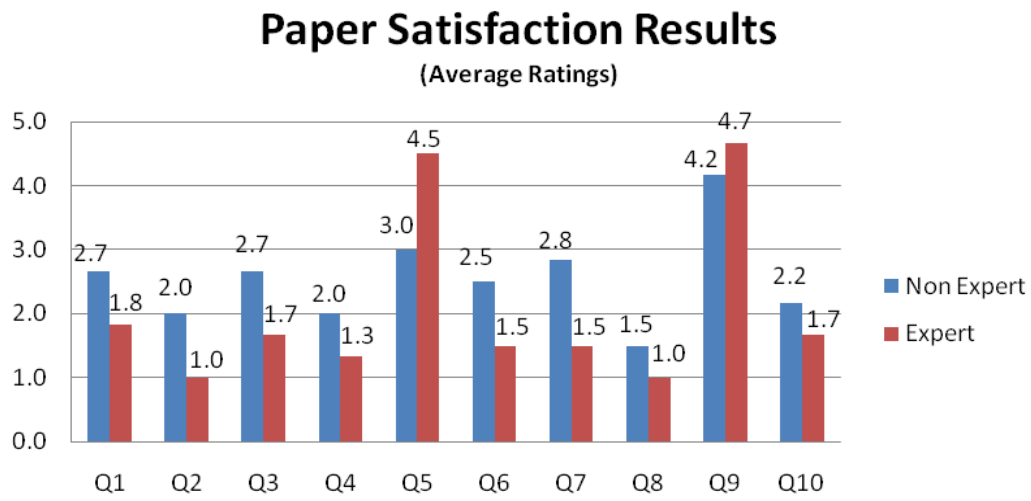


Figure 51 – Bar graph showing paper map ratings.

In general there is a significant difference in paper map satisfaction between the skill groups. The main areas of general consensus between skill levels are on Q8, Q9 and Q10. Therefore they agree that map quality is high, the map is not too small and that they would be happy to purchase the paper maps. However, across the remaining seven questions there is substantial disagreement, with most expert's generally showing high satisfaction whilst non-experts display more apathy towards the format.

Question 2 – What do you like and dislike about the paper map format

This question allowed participants to provide short qualitative reasons as to why they like/dislike the format they had just used, the following table (Figure 52) is a concise list of their comments and a response count (n):

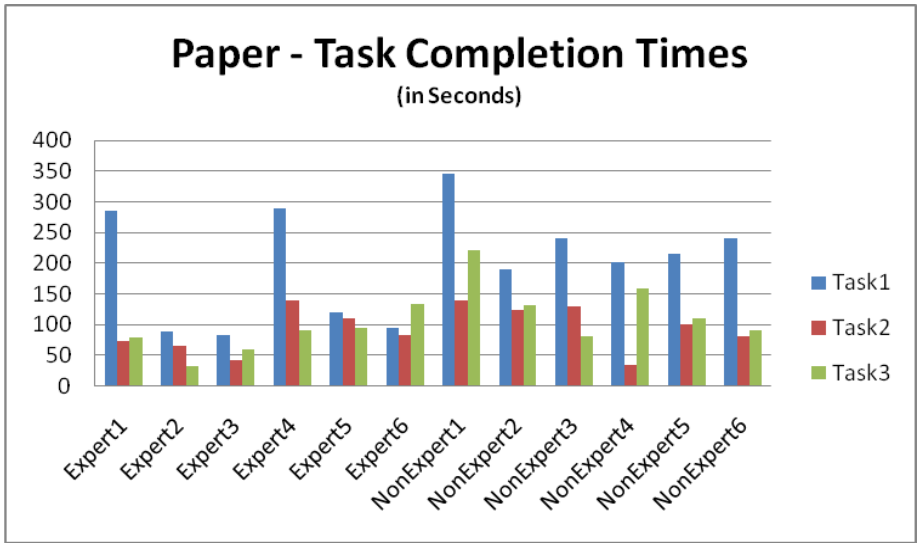
Positive Attributes	Negative Attributes
Level of detail (4)	Locating places takes too long (5)
Map size (2)	Map size is too large and cumbersome (2)
Detailed walking routes (2)	Difficult to learn (1)
Grid references (2)	Expensive to buy (1)
Index of locations (Atlas) (2)	Difficult to read (1)
Contours (1)	Too much detail (1)
Accuracy (1)	
Portable (1)	

Figure 52 – Table showing positive/negative attributes of paper maps/atlases.

Combined Map Results

Whilst the user study was being conducted the time it took participants to complete each task in both formats was being logged to allow simple task duration comparison as described below

Overall Task Completion Times



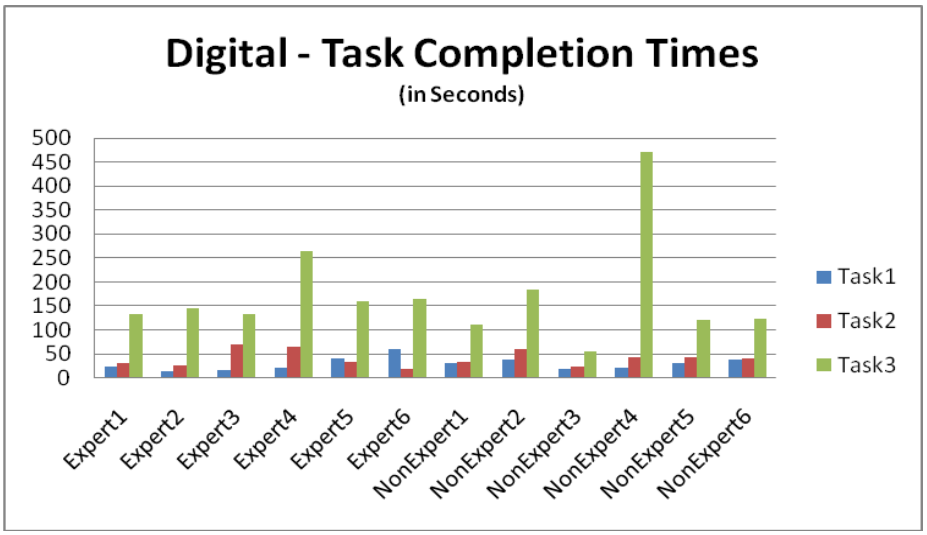


Figure 53 – Bar graphs showing task completion times for both paper and digital maps.

The time it took participants to complete each task was logged (in seconds) to enable simple comparison between formats and skill groups. From observing the graphs at Figure 53 it is clear that Task 1 proved the most difficult to complete with paper maps and Task 3 most difficult with digital maps. In general the results show that task 1 takes over six times longer to achieve with paper. Task 2 takes over twice as long to achieve with paper. Whereas in Task 3 paper proved to be a third more efficient than digital.

Question 1 – Which map format did you prefer overall

This question asked the participant to choose their overall preference for paper or digital maps after completing the tasks. The graph at Figure 54 shows that the majority of experts prefer paper whilst non-experts prefer digital. These results are coincident with those from the online questionnaire.

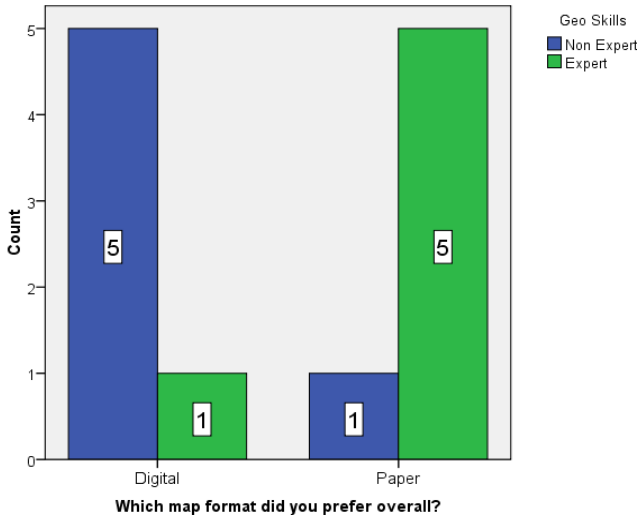


Figure 54 – Bar graphs showing overall post-task preference for paper or digital maps.

Question 2 – Which map format did you prefer for the following tasks

The participants were asked to be more detailed in their preference for the map formats by selecting which format suited which task. The results are shown in the table at Figure 55. It is clear that digital maps were more suited to Task 1 and paper for Task 3 however, there is disagreement between skill levels over format suitability for Task 2.

Task	Non-expert	Expert
Task 1 (Long distance route)	Digital	Digital
Task 2 (Short distance route)	Digital	Paper
Task 3 (Short walking route)	Paper	Paper

Figure 55 – Table showing preference for paper or digital maps for a number of tasks.

Question 3 – Rate your overall map format preference based on the following usability factors

This final question was used to gather users' perceptions of the map formats in terms of a number of usability factors. The factors used were Usability, Learnability, Efficiency, Reliability, Appearance, Presentation and Accuracy. These factors were selected based on previous research by both Easingwood (2008) and Seffah et al. (2006). Participants were asked to select which format best represented the factor, the results and a response count (n) are shown at Figure 56.

Factors	Non-expert	Expert	Overall
Usability	Digital (5)	Digital (5)	Digital (10)
Learnability	Digital (5)	Digital (5)	Digital (10)
Efficiency	Digital (6)	Digital (6)	Digital (12)
Reliability	Paper (4)	Paper (6)	Paper (10)
Appearance	Paper (5)	Paper (5)	Paper (10)
Presentation	Digital (3)	Paper (4)	Paper (7)
Accuracy	Digital (4)	Paper (4)	Paper (8)

Figure 56 – Table showing preference for paper or digital maps by usability factor.

From observing the results at Figure 56 it is clear that there is a common view that digital maps are more usable, efficient and easier to learn with paper maps being perceived more reliable and better by appearance. There is a disagreement between geo skill groups over presentation and accuracy with non-experts regarding digital maps as more accurate and better presented while experts perceive the contrary. Easingwood (2008) found that reliability was considered as the most important feature of a digital/online map by the majority of participants (32%) this research highlights all participants perceive paper maps are more reliable than digital maps, therefore there is a strong argument for the perceived benefits of paper maps.

Summary

It is clear from the results that there is an emerging theme that suggests that paper is still a relevant map format, but the decision to use paper is highly contextualised. The results of both the online survey and the task based user study discussed in this chapter have identified areas that would benefit from further in-depth analysis. These areas included:

- What are the most/least important features of both digital/online and paper maps and are there any differences between geo skill levels.
- Is there any correlation between the level of geographic skill level and paper or digital/online map usage.
- In what situations are paper maps preferred over digital/online maps and is the preference related to geographic skill level.
- Do non-experts and experts perform basic tasks with both formats equally and how do they perceive both formats.

These topics along with other interesting and relevant data from the results will be discussed and analysed in detail in Chapter 5.

Chapter 5 - Analysis & Discussion

Introduction

This chapter will focus on analysing the results of both the online questionnaire and the task based user study in order to answer the research question. The analysis in this chapter has been broken down by research instrument. Each research instrument is discussed in turn with the final section combining the findings of both.

Part 1 - Online Questionnaire

The online questionnaire produced a large amount of information about participant's opinions of a number of both paper and digital map features. The most significant and relevant data has been selected for further statistical analysis and will be discussed in the following section.

Digital Map Analysis

As an initial analysis into the requirements of digital maps the features of digital map products were assessed as most and least important respectively as rated by geo skill level (see Figure 57).

Results in order of most importance by mean values

Rank	Experts	Non-experts
1	*Available map scales*	*Map feature readability*
2	*Ease of screen navigation*	*Ease of screen navigation*
3	*Map feature readability*	*Available map scales*
4	Advanced Tools (Pan/zoom etc)	Efficiency and speed of search results
5	*Positional Accuracy of features*	*Positional Accuracy of features*

Results in order of least importance by mean values

Rank	Experts	Non-experts
1	*Bookmarking*	*Ability to add own data*
2	*Location of Natural POIs*	Relief Information
3	Location of manmade POIs	*Bookmarking*
4	Location of local amenities	Grid referencing
5	*Ability to add own data*	*Location of Natural POIs*

NB - Data annotated in italics denotes similarities across results from both non-expert and expert groupings.

Figure 57 – Tables showing most/least important digital map features by geo skill.

The basic analysis of results of digital map feature preferences across geo skills highlighted a number of significant differences. Therefore, it was decided that independent samples t-tests would be run to reveal if the differences between the opinions of experts and non-experts were statistically significant and not due to sampling errors. An independent samples t-test determines whether differences between two values are significant by analysing the means of two samples. Its principle is based on "comparing the difference in means of two samples to the expected value of this difference under a 'null hypothesis' that there is no difference; the expected value under the null hypothesis is zero" (Garner, 2005). The results of running the independent samples t-tests are shown in Figure 58.

	t-test for Equality of Means				
	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference
Bookmarking	1.367	760	.172	.175	.128
Positional Accuracy of Features	1.296	762	.195	.123	.095
Currency of Map information	2.379	763	.018	.316	.133
Location of local amenities	-2.743	762	.006	-.287	.105
Advanced tools	4.222	758	.000	.401	.095
Aerial imagery	7.100	762	.000	.753	.106
Ease of screen navigation	1.126	761	.261	.077	.068
Ability to add own data	5.983	759	.000	.669	.112
Efficiency and speed of search results	-.144	758	.886	-.011	.075
Grid referencing	9.699	757	.000	1.109	.114
Print functionality and quality	-1.431	759	.153	-.140	.098
Map feature readability	-.465	758	.642	-.029	.061
Available map scales	3.751	762	.000	.292	.078
Software usability	4.057	759	.000	.467	.115
Low price	.525	762	.600	.073	.139
Relief Information	7.008	757	.000	.827	.118
Simple map symbols	-1.560	751	.119	-.159	.102
Route information	-5.339	757	.000	-.447	.084
Location of natural POI's	-.771	758	.441	-.084	.109
Location of manmade POI's	-1.064	750	.288	-.113	.107

Figure 58 – Tables showing independent samples t-test results for digital map features by geo skill.

The important attribute in a t-test is the resulting p-value which describes the "probability of an outcome in terms of discrepancy from an expected value" (Garner, 2005). In general, p-values of 0.05 and below highlight a significant discrepancy (at a 95% confidence level). As shown in Figure 58 the following features were found to be statistically significant all having p-values of less than 0.05.

- Available map scales (p-value of .000).
- Software usability (p-value of .000).
- Relief information (high mean difference and p-value of .000).
- Route information (p-value of .000).
- Advanced tools (p-value of .000).
- Aerial imagery (p-value of .000).
- Ability to add own data. (p-value of .000)
- Grid referencing (high mean difference and p-value of .000).
- Currency of map information (p-value of .018).
- Location of local amenities (p-value of .006).

It is evident from these results that there is a close similarity between the opinions of non-experts and experts over the importance of digital map features in 10 out of the 20 features. However, there is a statistical difference between the relevance of the remaining 10 features as detailed above. This analysis also identified 'high mean differences' in opinions over the relief and grid reference features, with experts expressing their higher importance. The reason for this is likely to be related to the lack of map reading skills and experience of non-experts. Conversely, the low importance given to natural and manmade POI's by experts' highlights a likely difference in use between the geo skill groups. Non-experts are more likely to use digital maps for accessing general route and location information as seen by their high statistical preference for the route information feature. Whereas, experts are more likely to favour more professional features of geographic information such as advanced tools and access to imagery due to their context of use.

Paper Map Analysis

As an initial analysis into the requirements of paper maps the features of paper map products were assessed as most and least important respectively as shown at Figure 59.

Results in order of most importance by mean values

Rank	Experts	Non-experts
1	*Readability of map features*	*Readability of map features*
2	*Usability*	*Usability*
3	*Positional accuracy of features*	*Positional accuracy of features*
4	*Print quality*	*Print quality*
5	*Durability*	*Durability*

Results in order of least importance by mean values

Rank	Experts	Non-experts
1	*Route Information*	Relief Information
2	*Location of manmade POI's*	Grid referencing
3	*Location of natural POI's*	*Location of manmade POI's*
4	Low Price	*Location of natural POI's*
5	Simple map symbols	*Route Information*

NB - Data annotated in italics denotes similarities across results from both non-expert and expert groupings.

Figure 59 – Tables showing most/least important paper map features by geo skill.

By conducting simple analysis of the paper map feature preferences across geo skills a number of significant differences were apparent. Therefore, independent samples t-tests were run to reveal if the differences between the opinions of experts and non-experts were statistically significant. Figure 60 shows the results of the t-tests.

	t-test for Equality of Means				
	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference
Durability	2.285	763	.023	.224	.098
Low Price	-.772	764	.441	-.081	.105
Usability	1.581	759	.114	.136	.086
Readability of map features	1.445	762	.149	.129	.089
Relief Information	6.616	762	.000	.852	.129
Simple map symbols	-.120	760	.905	-.012	.102
Route information	-2.885	759	.004	-.353	.122
Locations of natural POI's	.785	761	.433	.086	.110
Locations of manmade POI's	-.327	763	.744	-.036	.110
Positional accuracy of features	1.995	762	.046	.196	.098
Currency of map information	3.572	759	.000	.492	.138

Grid reference Availability	6.074	761	.000	.790	.130
Print quality	2.710	757	.007	.305	.113

Figure 60 – Tables showing independent samples t-test results for paper map features by geo skill.

From conducting independent samples t-tests it was revealed there were significant statistical differences between experts and non-experts opinions regarding the following features:

- Relief information (high mean difference and p-value of .000).
- Grid referencing (high mean difference and p-value of .000).
- Durability (p-value of .002).
- Currency of map information (p-value of .000).
- Print quality (p-value of .007).
- Route information (p-value of .004).

It is evident from this analysis that there is close similarity between non-experts and experts over the importance of paper map features in 7 of the 13 features, but there is a statistical significance between the remaining 6 features (detailed above). In addition, there is again a notable statistical difference regarding the importance of relief and grid referencing features. As for digital maps the reason for this is likely to be related to the non-expert's lack of map reading skills and experience. Across digital and paper features it is clear that both groups believe print quality is important for paper maps, but not for digital maps, this suggests that it is not an essential feature. However, 82.8% of participants stated they print their digital maps at least sometimes, therefore one would expect print quality to be rated important, especially as the qualitative data stated improvements in print quality as an essential requirement.

An interesting comparison with previous research was discovered regarding the acquisition of paper maps by students. Parry (1999) stated that students are just as likely to acquire maps from a library than a map vendor, however this research found that now only 6.1% of academics choose to access paper maps from a library with just under half (46.9%) choosing to purchase paper maps from a shop as shown at Figure 61. It is likely that the arrival of the Internet and a rise in the availability of digital/online maps since 1999 has contributed to the demise of library accessed paper maps. This overall change in map consumption now results in 32.0% of academics acquiring their paper maps by either purchasing online or downloading and printing them for free themselves.

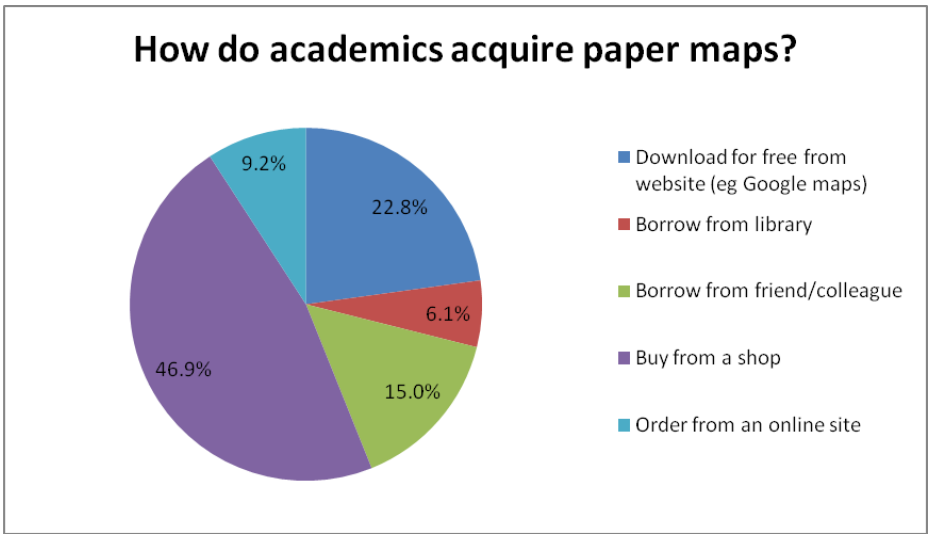


Figure 61 – Pie chart showing how academics acquire their paper maps

Combined Map Format Analysis

When analysing the features of both paper and digital maps together whilst all the features are not the same due to medium nuances there were similarities between them. The common features of 'readability of map features' and 'positional accuracy of features' both appeared in the top 5 of all participants and across both formats suggesting obvious essential user requirements for both formats that maps should be readable and accurate. More significant are the similarity between features considered unimportant across the mediums and by geo skill level. Experts consider the ability to locate either manmade or natural places of interest equally unimportant across both formats. Whilst non-experts consider location of natural points of interest, relief information and grid referencing equally unimportant across both map media. It is clear that non-experts consider both relief information and grid referencing relatively unimportant in both map formats which is likely to be related to their skill level and the context in which they would use the maps.

The relationship between frequency of online map usage and paper map usage in relation to geo skills was considered an interesting line of enquiry therefore an independent samples t-test was run to test statistical significance. Following this a Pearson's correlation analysis was conducted to identify if the values were related and followed a trend. The results of both tests are shown at Figures 62 and 63.

	t-test for Equality of Means				
	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference
How often do you use Online/digital Maps?	7.395	764	.000	.809	.109
How often do you use paper maps or atlases?	9.710	764	.000	1.309	.135

Figure 62 – t-test output showing relationship between online and paper map usage related to geo skill

Correlations

		OnlineMapUse	GeoSkills	How often do you use paper maps or atlases
OnlineMapUse	Pearson Correlation	1.000	-.414**	.362**
	Sig. (2-tailed)		.000	.000
	N	766.000	766	766
GeoSkills	Pearson Correlation	-.414**	1.000	-.454**
	Sig. (2-tailed)	.000		.000
	N	766	766.000	766
How often do you use paper maps or atlases	Pearson Correlation	.362**	-.454**	1.000
	Sig. (2-tailed)	.000	.000	
	N	766	766	766.000

**. Correlation is significant at the 0.01 level (2-tailed).

Figure 63 – Pearson's Correlation outputs showing online and paper map usage related to geo skill.

The results of the t-test proved a significant difference in expert and non-expert map use in both formats due to a p-value of .000. The subsequent correlation test provided Pearson Correlation values of .362 for paper and .414 for digital. Both results identify statistical significance and highlight a correlation between geographic skill and map usage. To further assess the hypothesis, histograms showing the normal distribution curves and scatter plots displaying the trends were produced to provide visual confirmation of data distribution (see Figure 64).

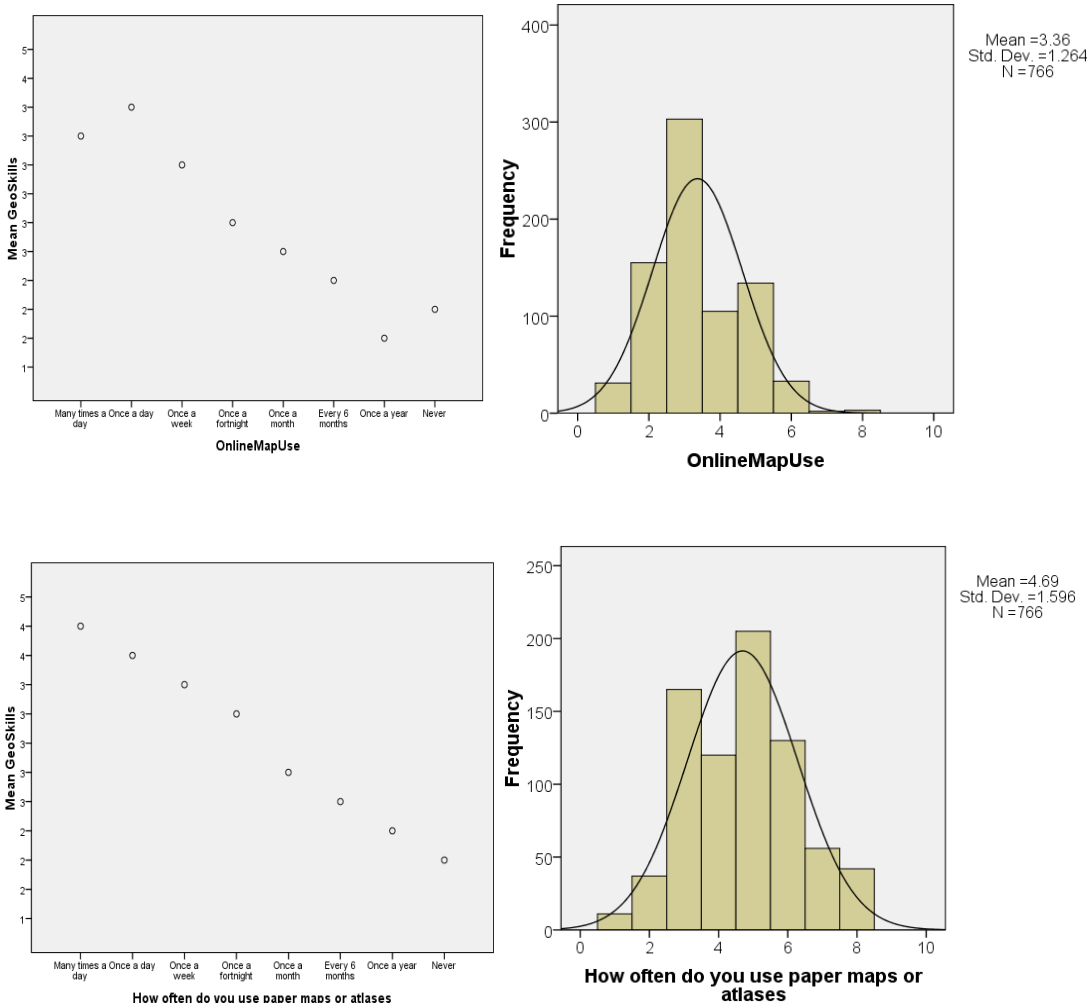


Figure 64 – Scatter plots and histograms showing online and paper map usage related to geo skill.

From analysing all the statistical test results it is apparent that an increase in geographic skill leads to an equivalent increase in 'frequency of use' of both digital and paper maps. Again this information further supports the argument that paper mapping is still an important aspect of geographic users' requirements, especially as map users gain geographic knowledge and experience.

Further data from the online questionnaire was analysed and a set of conditional and contextual map preferences have been extracted as shown in the table at Figure 65.

Question	Expert	Non-expert	Overall
Overall general preference	**Paper**	Digital	Digital
Finding Info about location	Digital	Digital	Digital
Navigation on foot	**Paper**	**Paper**	**Paper**
Navigation by car	**Paper**	Digital	Digital
Short distance route planning	Digital	Digital	Digital
Long distance route planning	Digital	Digital	Digital

Figure 65 – Table showing map preference by task related to geo skill.

Upon observing these results it is apparent there is a difference in overall map format preference and over which format is used for navigation by car. Otherwise experts and non-experts are in agreement. Interestingly, both groups prefer paper maps for navigation on foot which adds weight to the argument for the continuing existence of paper. After reviewing this information it became evident that there was a significant difference in the general preference for paper or digital maps between experts and non-experts. Therefore, to confirm the significance an independent samples t-test was run. The results shown at Figure 66 highlight a p-value of .000 revealing that the difference is statistically relevant.

	t-test for Equality of Means				
	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference
GeoSkills	3.697	721.568	.000	.228	.062

Figure 66 – T-test showing statistical significance of map preference based on geo skill.

These results subsequently led to correlation analysis to see if paper or digital map preference was in correlation with geo skill level. Because both variables are dichotomous the Phi correlation test was run as shown in Figure 67. The results showed a significant correlation of .133 with a p-value of .000 (Phi values of .115 and above are significant for calculations made with more than 500 responses as defined by Bryman (2005))

Symmetric Measures

		Value	Approx. Sig.
Nominal by Nominal	Phi	.133	.001
	Cramer's V	.133	.001
	N of Valid Cases	766	

Figure 67 – Results of Phi relationship strength analysis.

It became clear through this analysis that there was a growing ‘context of use’ issue surrounding experts and non-experts preference for paper and digital/online maps. Therefore, once again to confirm the significance a set of independent samples t-tests were run on the combined map format results. The results produced the following significant p-values.

- Short distance route planning (p-value .002).
- Navigation on foot (p-value .000).

- Navigation by car (p-value .013).

As shown by the p-values the differences between experts and non-experts are considered significant (less than .05). The significant t-test results again led to correlation testing using the Phi correlation test, the results of which are shown at Figure 68 to 70.

Symmetric Measures

		Value	Approx. Sig.
Nominal by Nominal	Phi	-.090	.013
	Cramer's V	.090	.013
	N of Valid Cases	757	

Figure 68 – Results of Phi correlation relationship for navigation by car by geo skill level.

Symmetric Measures

		Value	Approx. Sig.
Nominal by Nominal	Phi	-.128	.000
	Cramer's V	.128	.000
	N of Valid Cases	762	

Figure 69 – Results of Phi correlation relationship for navigation on foot by geo skill level.

Symmetric Measures

		Value	Approx. Sig.
Nominal by Nominal	Phi	-.112	.002
	Cramer's V	.112	.002
	N of Valid Cases	758	

Figure 70 – Results of Phi correlation relationship for short distance route planning by geo skill level.

Correlation was found to be significant in all three cases; navigation by car, navigation on foot and short distance route planning. This is due to resulting p-values being lower than 0.05 suggesting reliability in conjunction with their Phi values of -.090, -.128 and -.112 respectively, confirming their significance. The results of this analysis formed the basis for the next stage of inductive research (Bryman, 2008) with the emerging themes being used to design and execute a task based user study. The user study aimed to further prove and discover why there was a significant difference between non-experts and experts in selecting paper or digital maps for navigation by car or on foot and to some degree short distance route planning.

Additionally, the user study would also be used to discover why experts had a preference for paper maps overall.

Part 2 - Task Based User Study

From analysing the results from the online questionnaire it became apparent that there were high statistical differences between experts and non-experts regarding overall map preference, preference for short distance route planning, navigation on foot and to some degree navigation by car, therefore these areas became the focus for the task based user study. The analysis that follows will initially outline the findings of the user study uniquely followed by analysis by integration of all findings from all the research tools.

Digital Map Analysis

The user study revealed a number of interesting results that required further investigation and analysis. The following section describes the findings of analysing the digital map user tasks.

The graph at Figure 71 shows the overall average time it took the participants to conduct each task. It shows there is no significant difference between non-experts and experts in conducting the tasks with Google Maps.

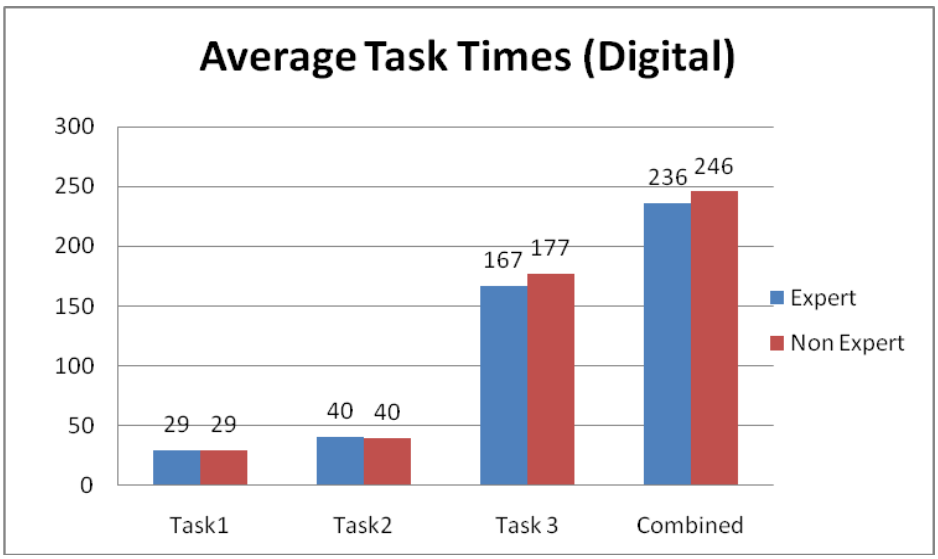


Figure 71 – Bar graph showing individual task results by digital/online maps.

Research by Mark and Frank (1992) outlined a number of important aspects of web based GIS systems. This research has found that Google Maps (Online GIS tool) has addressed these aspects as follows:

- The GIS should cater for all user skill levels – Across all geo skill levels 75% of participants agree that Google Maps was easy to use.

- The facilities should be easily accessed and executed – The user study found that all participants agreed the format enabled easy task completion.

- The number of system concepts is related to learnability – This study found that 75% of participants believed that Google Maps was easier to learn than paper maps.

- The look and feel must be consistent with other applications – Although not asked directly in the study it is safe to assume that Google Maps is consistent with Google search engine with which 97% of participants were familiar with. Therefore, showing a degree of application consistency.

Research by Erle and Gibson (2006) cited a number of innovations that made Google Maps successful. This research into digital/online map tools supported two of their findings:

- Satellite imagery – In this research access to satellite imagery when using digital/online maps was considered important by over 45% of non-experts and over 70% of experts. However, these findings do not correlate with research conducted by Easingwood (2008) who found that only 6% of participants used online/digital map tools to view or print aerial imagery, perhaps his questioning technique that constrained the respondent to one of five options hid the true extent of participants aerial imagery usage.
- Draggable maps – The ability to use advanced tools such as scroll, zoom and pan is considered important by more than 70% of non-experts and over 80% of experts.

Paper Map Analysis

The results of the paper map tasks have highlighted a number of interesting lines of enquiry that were suitable for further analysis. The following section describes the findings of analysing the paper map user tasks.

The results of each participant of the user study were averaged to provide a measure of efficiency between skill groups across each task as shown in Figure 72. The results highlight a significant difference between novices and experts across all the tasks especially Task 1. This is potentially linked to differences in ability, experience

and level of exposure to paper maps between the skill groups, however all participants stated they had experience of both paper and digital map use.

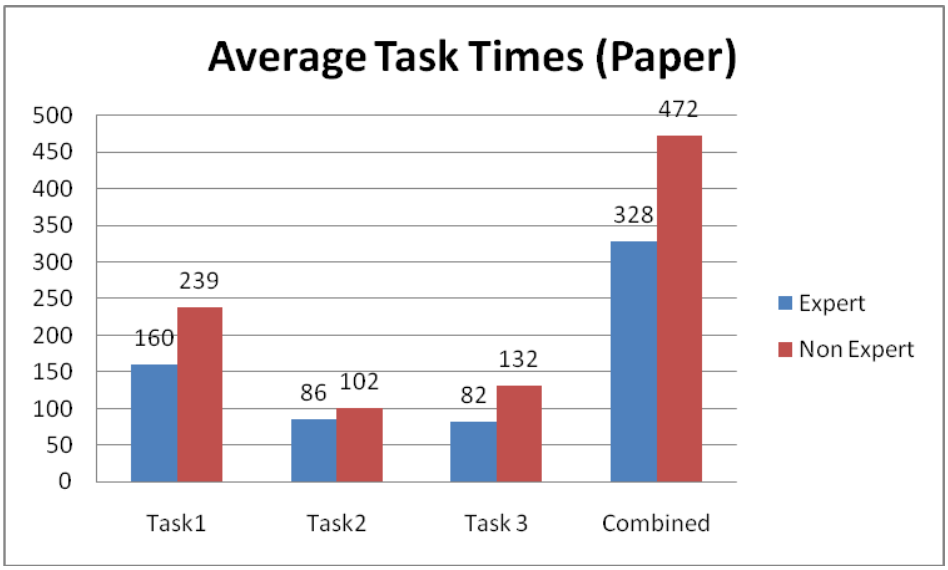


Figure 72 – Bar graph showing individual task results using paper maps.

Previous research by Goodchild (2000) cited a number of factors that have defined and constrained paper maps, this research found the following results supported his work:

- The map must appeal to the visual senses (Goodchild, 2000) – In this research 50% of participants agreed that paper maps show information in a visually pleasing manner.
- The information on paper maps is precise (Goodchild, 2000) – In this research 66.7% of participants agreed that the results of using paper maps were relevant and accurate.

Combined Map Format Analysis

Observing the results from the final section of the task based user study produced interesting areas for analysis. Overall there was an equal preference for paper and digital maps by participants which does not correlate with the findings of Pederson et al (2005) who found that 79% of students preferred paper maps. However, when considered in context there is agreement when assessed using similar sampling frames. Pederson's research involved geography students (i.e. with some geographic knowledge) and when compared to expert users from this research there is a high degree of correlation with 83% preferring paper.

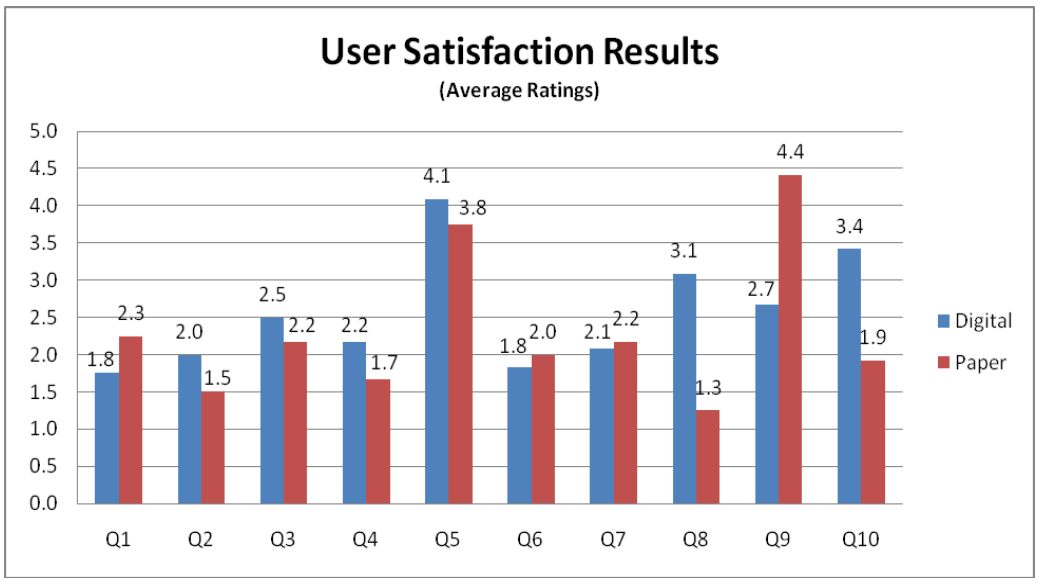


Figure 73 – Combined user satisfaction results split by map format.

The following list is the key to the questions for Figure 73:

- Q1 – The format enabled easy task completion.
- Q2 – The task results were relevant and accurate.
- Q3 – Information on the map is easy to find.
- Q4 – The map presents information in a visually pleasing manner.
- Q5 – The map is confusing and difficult to read.
- Q6 – The map is easy to use.
- Q7 – The map is well structured and easy to navigate.
- Q8 – The quality of the maps are high.
- Q9 – The map is too small.
- Q10 – I would be happy to purchase the map.

Figure 73 depicts the overall user satisfaction results from the user study. It displays a high level of correlation across a number of questions (Q1-Q7 and Q10) with differences of 0.5 or less. The areas showing greatest disagreement are over the quality of maps and whether the maps are too small (Q9). Paper maps display a high score (4.4) and digital maps show an average score (2.7) highlighting a general consensus that digital maps are too small. Upon further investigation the reason for this was due to the size of the Google Maps print output being inadequate and badly formatted. More interesting is the difference over map quality (Q8) with paper maps being rated significantly higher (1.3) in quality than digital (3.1). Again upon further investigation participants stated that paper maps have a more refined and polished

finish and look far superior to a similar digital/online map print out. These findings are analogous to findings from the online questionnaire that identified that poor digital print quality was a major drawback.

Analysis Integration

By observing and integrating the results of both survey instruments (questionnaire and task based user study) the findings of each stage can be either supported or refuted. This section aims to integrate the most relevant findings of this study to help answer the research question by listing the major findings.

- An increase in Geographic knowledge leads to an increase in use of both paper and digital/online paper maps.

- Google Maps is the online map tool of choice by 70.9% of participants with 95.2% stating that they regularly use the tool.

- The most common type of map used across both formats is the route maps/atlas with percentages of 81.2% (digital/online) and 70.1% (paper). These results provided the reason for using route finding as the basis for the task based user study.

- There is a high degree of agreement between geo skill groups about what map features are deemed most and least important across both map formats. However, there is a clear statistical difference across skill groups over the importance of a number of features especially over access to grid referencing and relief information. Experts perceive them with greater importance than non-experts, a difference that is likely to be related to geographic experience and their likely modes of use.

- Overall preference for map format across the research instruments reveal experts prefer paper and non-experts prefer digital/online. However, when assessed contextually it is found that geo skill groups agree on digital maps for finding information about locations and for short/long distance route planning and agree with using paper for navigating on foot. They only differ over map format for navigating by car where experts preferred paper and vice versa. When compared with post task results disagreement appears between experts who preferred paper for short distance route planning and non-experts prefer digital/online maps. This research shows a clear difference between skill levels with experts being more likely to choose paper maps to suit their needs. This

confirms that paper maps still have an important role to play as all participants across the research consistently chose paper for navigation on foot.

- User Satisfaction with both formats is similar with some disagreement around digital/online maps being too small and paper maps being regarded as higher quality. The time it took to complete the user tasks clearly favoured digital/online means, but users still had issues with Google Maps over the poor walking map output. It is apparent that both formats have a role to play in the provision of geographic information with online/digital maps mainly suitable for long distance route planning and paper maps suited for planning short distance walking routes.

Summary

From analysing all the results of this research it is predicted that paper maps will continue to be used to fulfil geographic needs for many years to come, especially for those wishing to navigate on foot. It has been revealed from results of both research instruments that paper and digital/online maps have a number of strengths and weaknesses that define their usage limitations. In addition, it is clear that users at all levels of geographic skill perceive the importance of features and attributes of both formats differently. Therefore if both formats (especially paper) are to remain viable in the future they must evolve to meet the customers changing needs as described throughout this research.

Chapter 6 - Conclusions

The overall aim of this research was to identify whether it was the end of the road for paper maps in the digital age. This aim has been achieved and it can be stated with some degree of certainty that the paper map format of some description is here to stay for the foreseeable future. In addition to answering the research question the objectives set for this project have each been met in turn and are discussed within the main sections of this report. All the findings of the project have been analysed and combined to form a holistic picture of the future of paper and online/digital mapping in the digital age.

Objectives

The research has been aligned closely to the objectives set at the beginning of the project to ensure the overall research question could be answered. The objectives were addressed in this research as follows:

- Objective 1 - Identify the key issues relating to map use across both paper and digital formats and investigate future developments in map design and availability. This objective has been achieved by conducting a literature review. The results revealed a lack of focussed research in this area, therefore it was hoped this research would result in a piece of original research.

- Objective 2 & 3 - Investigate the current use of both paper and digital mapping, identify future mapping requirements and determine the future requirements of both map formats in the digital age. These objectives were achieved by conducting a large scale online questionnaire. The questionnaire was answered by 766 people and produced 47,492 individual data items from 62 questions. The questions were aimed at acquiring information about current and future map requirements in both paper and digital map formats. The survey revealed that both non-experts and experts believe that both paper and digital maps are equally important. Also they are agreement over which map features are most and least important in both formats.

- Objective 4 & 5 - Investigate how users carry out a number of tasks using paper and digital maps in order to determine which format is used most effectively and why. Also, determine whether user perceptions of paper and digital map use are coincident with their ability to use both formats. These objectives were achieved by conducting a task based user study. The study was carried by 12 respondents and involved the completion of a number of travel/navigation type

tasks over a range of distances using paper and digital map formats. The study revealed that both non-experts and experts agree both paper and digital maps are important, but experts are more likely to favour paper maps. The results revealed that paper was the most efficient and preferred format for short distance route planning. Conversely, digital/online maps were preferred and proved most efficient for planning long distance routes.

- Objective 6 - Make recommendations regarding the future of mapping in the digital age based on the research findings and identify any further research opportunities related to the topic. This objective was achieved by analysing and integrating the results of all the research instruments used within this project. It was discovered that whilst paper is still preferred for short distance route planning it has a number of limitations that must be addressed to make it more user friendly. It is believed that the paper map format will remain viable, but the future mode of consumption must adapt to keep pace with technology. Users should be able to edit and manage their own map content digitally and output to paper more efficiently using 'map print kiosks' for instance.

Literature Review

The initial literature review for this research provided an excellent platform and knowledge base for study by identifying current issues and future developments across both map formats. The literature highlighted a number of key issues between the map formats that helped to focus this study. The apparent rise in general paper usage observed by Guimbretiere (2003) may also signify a similar trend in future paper map use. The qualities of paper maps identified by Johnson et al (1993) such as "ease of use, transportation and storage" may be deciding factors that maintain the popularity of paper maps. However, the development of Internet mapping and Web GIS has created a new "medium for cartography" (Peterson, 2005) that increasingly provides users with "immediate and real-time access" to map content (Kraak, 2004). This rise in online map availability has resulted in a number of mainstream companies offering online map tools such as Google and Yahoo. This investment has created a wide choice of online map content that presents geographic data in a variety of ways with each site displaying both positive and negative characteristics. It is evident from engaging with the literature that paper and digital maps both have a role to play in meeting current map requirements. With previous research by Pederson et al. Verdi et al. and Harrower et al. all identifying that both user perceptions and usage of paper maps are still high and in some instances paper maps are preferred over current digital/online maps. The future of mapping is

therefore not expected to be constrained to development of just digital/online content. There is still an overwhelming requirement for paper maps, but with an increasing focus on providing paper maps that are user defined and display both bespoke and user generated content.

Online Questionnaire

By conducting a large scale detailed online questionnaire it was hoped that the current usage and future development of both formats could be gathered from a wide range of the population. The research uncovered a wealth of pertinent information that has helped quantify and clarify the findings of the literary research. An initial finding proved that an increase in geographic skill leads to an increase in usage of both paper and digital/online maps, proving that as knowledge increases there is no obvious shift in preference for either map format. The main findings of the survey identified that participants assess the most/least important characteristics of both map formats similarly. However, there is a high statistical difference between experts and non-experts over a number of map format features. Of most interest are expert geo users who prioritise map characteristics based probably on their skill level such as the importance of access to relief and grid reference information. Overall, it is clear from both groups that access to route information is essential whilst being able to locate places of interest is not a priority. When comparing paper and digital maps overall there are a number of situations when format preference is defined. For instance when locating information about a location, navigating by car and route planning most participants select digital/online maps whilst most participants still prefer paper maps for navigation on foot. This context driven choice of map format led to the development of a task based user study to further investigate the findings.

Task Based User Study

The user study aimed to put the results of the online questionnaire into practical context by assessing the perceptions and abilities of participants across a number of likely navigation tasks. The results of the study were analogous to those from the online questionnaire, but uncovered a number of important practical and contextual issues. It is clear that the choice of map product is closely related to context of use, i.e. there is no one format that suits all situations. This is apparent from the selection of online/digital maps, paper maps/atlas or mobile GIS across the map medium choice question. When considering user preference for map format in relation to their ability to use the formats it is concluded that satisfaction between the two formats are similar and their overall abilities show that across the three tasks participants were more efficient using the digital format. Previous research by Pederson et al (2005)

and Verdi et al. (2003) found that student map skill did not differ greatly between map formats and students preferred paper maps, whilst this research found that overall tasks took longer to complete with paper maps and participants preferred paper and digital maps equally overall. It is worth pointing out that Pederson's research involved using maps for the purpose of teaching generic geographical knowledge, whereas this research was highly contextual and based on likely user tasks. This has proven important in the overall suitability for each map format, therefore this research was unlikely to show correlation with Pederson's findings. Research by Harrower et al. (1997) into how experts and non-experts viewed Internet maps found that despite differences in experience the skill groups viewed them similarly. This research supports Harrower's findings in that both experts and non-experts completed tasks with digital/online maps in similar times and both recorded similar responses across all aspects of user satisfaction; a correlation that is not present in the paper map results.

Research Limitations

The research described within this report is extensive and detailed. However, with any research there are always limiting factors and scope for improvements. This project has revealed a number of limitations that have constrained the research. The online survey produced a large amount of qualitative data and due to the time constraints and scope of this research only a small proportion of the data was analysed. Therefore, there is still a valuable research opportunity available in analysing this data further. The choice to conduct a task based user study was effective, but the use of a limited range of paper map scales and the online focus on Google Maps in a static desktop environment has meant that the scope of the research is relatively narrow. Previous research by the author into user preference for online map tools found that Google Maps was the optimum. However, when reviewing the other tools it was discovered that MultiMap displayed digital mapping analogous to OS paper products. Using this tool in the user study would have allowed OS digital maps to be compared directly with their paper equivalent, but it was decided more suitable to use the optimum map tool by user preference.

Future Research

The results of this study have highlighted a number of areas for potential further research. There could be significant benefit in running the task based user study across a wider range of paper products and digital/online tools to remove any constraints or bias from the use of only Google Maps and the limited OS and paper atlas products in this research. This research did not assess the impact of handheld

portable GIS devices beyond the literature review, therefore there could be significant benefit in running practical research into the usage of paper maps versus mobile maps.

The Future of Paper Maps

It is evident from this research that paper maps have a number of qualities that make them relevant in the digital age. Even with the spread of Internet access and the rise in mobile GIS devices, paper maps are still in use and held in high regard. Although there has been a marked decrease in paper map usage there is still a significant number of niche markets, expert users and specific usage contexts that exist that will keep the format alive. However, it is obvious that paper maps in their current state are becoming unsuitable and outdated and must evolve to meet changing user requirements. Future focus should be on developing digital/online tools that allow users to generate their own bespoke and user defined content that can be output to paper media. The creation of map printing services or kiosks for instance would encourage users to develop their own maps to suit their needs. These developments would ensure the continuing existence of paper products, whilst including the obvious benefits of digital/online maps.

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Appendix 1 – Map Use Survey

Dissertation Map Use Survey

1. RESEARCH PROJECT INFORMATION SHEET

Research Title - "Will we be lost without paper maps in the Digital Age?"

1. Participation Invitation
You are being invited to take part in a postgraduate research project being undertaken by Paul Hurst on behalf of the University of Sheffield. Before you decide whether to participate in the research it is important that you understand why the research is being carried out and what your participation will entail. Please read the following information:

2. What is the project's purpose?
The aim of this research project is to compare the usage, usability and suitability of both traditional paper maps and digital maps for accessing geographic information in the Digital Age.

3. Why have I been chosen?
You have been chosen to participate in this project as you are either an associate of Paul Hurst, a military/civilian geographer or a member of Sheffield University. Taking part will allow the researcher to answer the questions raised in his project aims and objectives.

4. Do I have to take part?
I would be extremely grateful if you would contribute to this project, however you are not obliged to do so. If during the project you decide you no longer wish to participate you can elect to do so at any point during the process. If you choose not to participate any information already provided by you will be destroyed and you will not be contacted any further.

5. What do I have to do?
If you agree to participate in this project you will be required to complete a short questionnaire and in some instances you may be asked to take part in an informal interview. Any information you provide will only be used to answer the research question and your identity will remain anonymous throughout.

6. Further Information?
If you have any questions or require any further information about this project, please contact Paul Hurst by email at: lip09pah@sheffield.ac.uk

7. Thanks.
I would like to thank you in advance for taking the time to participate in this project. You can rest assured in the knowledge that your participation will be contributing to valuable research into the understanding of mapping in the Digital Age.

N.B By completing the electronic questionnaire you are agreeing to participate in the project

Paul Hurst BSc MSc (IS) Programme
Information Studies
University of Sheffield

Dissertation Map Use Survey

2. Participant Classification Section

The following questions are aimed at gathering general information about you to create a framework for analysis.

Please answer all the questions that follow:

1. What is your age?

◯ <20 ◯ 21-30 ◯ 31-40 ◯ 41-50 ◯ 51-60 ◯ 61+

2. What is your Gender?

◯ Male ◯ Female

3. Which of the following best describes your profession?

◯ Academic (e.g Teacher, Student)
◯ Government (e.g Nurse, Fireman)
◯ Military (e.g Soldier, Airman)
◯ Public Services (e.g Postman, bus driver)
◯ Professional
◯ Self Employed
◯ Unemployed
◯ Retired
◯ Other

Current Job Title

4. What is your level of Computer/Internet skills?

◯ None ◯ Basic ◯ Intermediate ◯ Advanced ◯ Expert

5. How often do you use the Internet?

◯ Many times a day
◯ Once a day
◯ Once a week
◯ Once a fortnight
◯ Once a month
◯ Every 6 months
◯ Once a year
◯ Never

6. Which search engine do you use most frequently?

◯ Alta Vista
◯ Ask Jeeves
◯ Bing (formerly MSN)
◯ Google
◯ Lycos
◯ Yahoo

Other (please specify)

Dissertation Map Use Survey

7. What is your level of map and geographic data knowledge?

- ◯ None
- ◯ Basic (Sometimes use online/paper maps)
- ◯ Novice (Regularly use online/paper maps)
- ◯ Intermediate (Sometimes create maps and geographic information)
- ◯ Expert (Regularly use GIS and frequently manipulate geographic data)

Dissertation Map Use Survey

3. Online/Digital map use section

The following section deals with your previous and current online and digital map use habits.

Online maps include any maps accessed from a webpage on a computer or interface (such as Google maps or RAC Routefinder). Digital maps refers to any maps/map data that is accessed through software on a computer or an interface (such as memory map or anquet map data).

Please answer all the questions that follow:

1. How often do you use online map services/tools such as Google maps?

- ◯ Many times a day
- ◯ Once a day
- ◯ Once a week
- ◯ Once a fortnight
- ◯ Once a month
- ◯ Every 6 months
- ◯ Once a year
- ◯ Never

2. Which of the following online Map Services/Tools have you used? (Select all that apply)

- ☐ AA Routeplanner
- ☐ Google Maps
- ☐ Getamap OS
- ☐ Mapquest
- ☐ Michelin maps
- ☐ Multimap
- ☐ RAC Routeplanner
- ☐ Streetmap
- ☐ Yahoo Maps

Other (please specify)

3. In General, Which one of the following online map Services/Tools do you prefer and why?

- ◯ AA Routeplanner
- ◯ Google Maps
- ◯ Getamap OS
- ◯ Mapquest
- ◯ Michelin maps
- ◯ Multimap
- ◯ RAC Routeplanner
- ◯ Streetmap
- ◯ Yahoo Maps

Please explain your preference

Dissertation Map Use Survey

4. When looking for maps/routes online which search terms would you use? (enter one term per line)

5. What type of online/digital maps do you commonly use? (Select all that apply)

- [ ] City maps/guides
- [ ] Archeology/Geology maps
- [ ] Walking/cycling map
- [ ] Aerial Imagery maps
- [ ] Driving route maps/directions

Other (please specify)

Dissertation Map Use Survey

6. Indicate the importance of the following features of online map services/tools.

	1 - Very Important	2	3	4	5 - Not Important	Unknown
Ability to bookmark your favourite locations	◯	◯	◯	◯	◯	◯
Positional Accuracy of Features	◯	◯	◯	◯	◯	◯
Currency of Map Information	◯	◯	◯	◯	◯	◯
Adding Local Amenities (Pubs/Hotels Etc)	◯	◯	◯	◯	◯	◯
Advanced Tools (Pan/Drag, Scroll, Zoom, Etc)	◯	◯	◯	◯	◯	◯
Access To Aerial Imagery Maps	◯	◯	◯	◯	◯	◯
Ease of Navigation Around Screen	◯	◯	◯	◯	◯	◯
Ability to add your own data or information	◯	◯	◯	◯	◯	◯
Efficiency and Speed of Search Results	◯	◯	◯	◯	◯	◯
Grid Reference Availability	◯	◯	◯	◯	◯	◯
Print Functionality and Print Quality	◯	◯	◯	◯	◯	◯
Readability of Map Features	◯	◯	◯	◯	◯	◯
Available Map Scales (Zoom Levels)	◯	◯	◯	◯	◯	◯
Software Usability	◯	◯	◯	◯	◯	◯
Low price	◯	◯	◯	◯	◯	◯
Relief information (Contours)	◯	◯	◯	◯	◯	◯
Simple map symbols	◯	◯	◯	◯	◯	◯
Route information	◯	◯	◯	◯	◯	◯
Locations of natural beauty (eg caves/viewpoints)	◯	◯	◯	◯	◯	◯
Location of manmade places of interest (eg theme parks)	◯	◯	◯	◯	◯	◯

Other features (please specify)

Dissertation Map Use Survey

7. What do you think your preferred map tool should include to improve your user experience (e.g Show Speed Cameras or print at A3 size)

8. How would you normally access Online/Digital maps? (Select all that apply)

- [ ] Desktop PC
- [ ] Mobile Phone
- [ ] Handheld GPS Receiver
- [ ] In Car SatNav (GPS)
- [ ] Laptop
- [ ] None

Other (please specify)

9. Do you normally print your online/digital maps?

- ◯ Never
- ◯ Usually
- ◯ Sometimes
- ◯ Always

If Yes, Why?

Dissertation Map Use Survey

4. Paper Map Use Section

The following section deals with your previous and current printed paper map use habits.

Paper maps include any maps that are paper based. This includes not only purchased maps (e.g OS 1:50k landranger), but maps printed from websites(such as Google maps) and those printed using mapping software tools (such as anquet mapping)

Please answer all the questions that follow:

1. How often do you use paper maps or atlases

- ◯ Many times a day
- ◯ Once a day
- ◯ Once a week
- ◯ Once a fortnight
- ◯ Once a month
- ◯ Every 6 months
- ◯ Once a year
- ◯ Never

2. What type of paper maps do you commonly use? (Select all that apply)

- ☐ Geology/archaeology map
- ☐ Guide books/travel map
- ☐ Hobby map (eg Orienteering)
- ☐ Route map/atlas
- ☐ Street map
- ☐ Walking/cycling map
- ☐ None

Other (please specify)

3. How do you acquire your paper maps? (Select all that apply)

- ☐ Never use paper maps
- ☐ Download for free from website (eg Google maps)
- ☐ Borrow from library
- ☐ Borrow from friend/colleague
- ☐ Buy from a shop
- ☐ Order from an online site

Other (please specify)

Dissertation Map Use Survey

4. Indicate the importance of the following features of paper maps/atlases

	1 - Very Important	2	3	4	5 - Not Important	Unknown
Durability (good wear and tear)	◯	◯	◯	◯	◯	◯
Low price	◯	◯	◯	◯	◯	◯
Usability	◯	◯	◯	◯	◯	◯
Readability of Map Features	◯	◯	◯	◯	◯	◯
Relief information (Contours)	◯	◯	◯	◯	◯	◯
Simple map symbols	◯	◯	◯	◯	◯	◯
Route information	◯	◯	◯	◯	◯	◯
Locations of natural beauty (eg caves/viewpoints)	◯	◯	◯	◯	◯	◯
Location of manmade places of interest (eg theme parks)	◯	◯	◯	◯	◯	◯
Positional Accuracy of Features	◯	◯	◯	◯	◯	◯
Currency of Map Information	◯	◯	◯	◯	◯	◯
Grid Reference Availability	◯	◯	◯	◯	◯	◯
Print Quality	◯	◯	◯	◯	◯	◯

Other features (please specify)

5. What additional features would you find useful on a paper map? (eg Fuel station locations)

Dissertation Map Use Survey

6. In general, do you prefer Paper or Online/Digital maps?

- ◯ Paper
- ◯ Digital/Online

Explain your preference

7. Are there situations when you would prefer one over the other?

8. Indicate your preference for Paper or Online/Digital maps for the following tasks (Select one answer per row)

	Paper map	Online/Digital map
Finding information about a location	◯	◯
Navigation on foot	◯	◯
Navigation by car	◯	◯
Short distance route planning (upto 50 miles)	◯	◯
Long distance route planning (over 50 miles)	◯	◯

Appendix 2 – Task Based Study - Participant Brief

PARTICIPANT BRIEF

The aim of this usability study is to compare the effectiveness, efficiency, quality of digital/online maps (Google maps) with standard paper maps (Ordnance Survey Maps/Atlas)

The study will be undertaken by 12 participants of whom you are one. You will be expected to complete all the tasks given to you within a 10 minute time frame, however if you cannot complete a task you can move onto the subsequent task.

You will be asked to follow 2 basic Scenarios each with 3 tasks involving short/medium/long range navigation/route planning exercises. You will be expected to use both digital/online and paper map mediums. The Digital medium will involve the use of Google maps and the Paper medium will involve the use of standard Ordnance Survey 50k maps and additional route maps/atlases. Once you have completed the scenarios there is a short satisfaction questionnaire to complete along with a brief interview.

My aim is to determine, from your perspective the optimum features of both the map formats and also to record any issues their use may reveal. I aim to answer some of the following:

- Can you complete the task?
- If yes, how long does it take?
- What sequence did you follow to find the information?
- Where did you get stuck?
- Do you see any problems?
- Where did you get confused?

If you have any questions during the tasks please raise them and I will address them as they arise.

Appendix 2 – Task Based Study - Task Scenarios

TASK SCENARIOS

Scenario 1

You are going on a walking holiday with your family to Wales by car and want to organise your travel arrangements and plan a number of activities you wish to do during your visit. You must use your assigned map format (either paper or digital) to complete the tasks.

Task 1

You are travelling from your home in the centre of Sheffield and will be travelling to Haverfordwest. Using your assigned map format create an appropriate set of directions and route information for you to use on your journey.

Task 2

You have reached your hotel in Haverfordwest and now wish to visit the town of Broadhaven. Once again using your assigned map format choice create an appropriate set of directions and route information for you to use on your journey.

Task 3

Whilst at Broadhaven you decide to take your family for a short walk along the coast (North) to Nolton Haven also you wish to visit a public house (PH) during your walk for your dinner. Using your assigned map format create an appropriate set of directions and route information for you to use on your journey.

Scenario 2

You are going on a walking holiday with your family to Wales by car and want to organise your travel arrangements and plan a number of activities you wish to do during your visit. Using your assigned map format create an appropriate set of directions and route information for you to use on your journey.

Task 1

You are travelling from your home in the centre of Sheffield and will be travelling to Cardigan. Using your assigned map format create an appropriate set of directions and route information for you to use on your journey.

Task 2

You have reached your hotel in Cardigan and now wish to visit the town of Aberporth. Once again using your assigned map format create an appropriate set of directions and route information for you to use on your journey.

Task 3

Whilst at Aberporth you decide to take your family for a short walk along the coast (East) to Llangranog also you wish to visit a public house (PH) during your walk for your dinner. Using your assigned map format create an appropriate set of directions and route information for you to use on your journey.

Appendix 2 – Task Based Study – User Satisfaction Survey

1. User Tasks and Satisfaction Survey

1. Participation Invitation
You are being invited to take part in a piece of postgraduate research being undertaken by Paul Hurst on behalf of the University of Sheffield. Before you decide whether to participate in the research it is important that you understand why the research is being carried out and what your participation will entail. Please read the following information:

2. What is the project's purpose?

The aim of this research is twofold:

a. Investigate how users carry out a number of tasks using paper and digital maps in order to determine which format is used most effectively and why.

b. Determine whether user perceptions of paper and digital map use are coincident with their ability to use both formats.

3. Why have I been chosen?
You have been chosen to participate in this project as you are an associate or colleague of Paul Hurst and your individual viewpoints are considered useful.

4. Do I have to take part?
I would be extremely grateful if you would contribute to this project, however you are not obliged to do so. If during the project you decide you no longer wish to participate you can elect to do so at any point during the process. If you choose not to participate any information already provided by you will be destroyed and you will not be contacted any further.

5. What do I have to do?
If you agree to participate in this project you will be required to complete a set of simple map based tasks, fill out a short user satisfaction questionnaire which should take 30 mins. Additionally in some instances you may be asked to take part in an informal interview. Any information you provide will only be used to answer the research question and your identity will remain anonymous throughout.

6. Further Information?
If you have any questions or require any further information about this project, please contact Paul Hurst by email at: lip09pah@sheffield.ac.uk

7. Thanks.
I would like to thank you in advance for taking the time to participate in this project. You can rest assured in the knowledge that your participation will be contributing to valuable research.

N.B By completing this questionnaire you are agreeing to participate in the project

Paul Hurst BSc MSc (IS) Programme
Information Studies
University of Sheffield

2. Participant Profile

*** 1. What is your age?**

◯ <20 ◯ 21-30 ◯ 31-40 ◯ 41-50 ◯ 51-60 ◯ 61+

2. Gender

◯ Male ◯ Female

3. Which of the following best describes your profession?

◯ Academic (e.g Teacher, Student)
◯ Government (e.g Nurse, Fireman, Soldier)
◯ Public Services (e.g Postman, Waitress)
◯ Professional (e.g Solicitor, Management)
◯ Self Employed
◯ Unemployed
◯ Retired
◯ Other

*** 4. What is your level of computer/Internet skills?**

◯ None ◯ Basic ◯ Intermediate ◯ Advanced ◯ Expert

5. What is your level of Geographic knowledge?

◯ Novice (Non-Expert) (Sometimes use online/paper maps)
◯ Expert (Regularly use GIS and manipulate Geographic data)

6. Have you used the following map formats before?

	Yes	No
Online/Digital Maps (eg Google Maps)	◯	◯
Paper Maps (eg OS LandRanger)	◯	◯
Portable digital maps (eg Mobile Phone/IPad/SatNav)	◯	◯

7. What map format would you choose in the following situations

	Online/Digital map	Paper Printout of Online/Digital map	Mobile GIS (eg Mobile Phone or Ipod)	Export digital map to portable device (eg Ipad/PDA)	Paper maps/atlases
Planning Navigation by car	◯	◯	◯	◯	◯
Executing Navigation by car	◯	◯	◯	◯	◯
Planning Navigation on foot	◯	◯	◯	◯	◯
Executing Navigation on foot	◯	◯	◯	◯	◯
Planning to travel a short distance (upto 10 miles)	◯	◯	◯	◯	◯
Executing a short distance journey(upto 10 miles)	◯	◯	◯	◯	◯
Planning to travel a long distance (over 100 miles)	◯	◯	◯	◯	◯
Executing a long distance journey (over 100 miles)	◯	◯	◯	◯	◯

8. What are the positive/negative aspects of using a portable Digital map interface (eg Ipad/Mobile/SatNav)?

9. What are the positive/negative aspects of using paper maps/atlases?

10. Which combination of map format and scenario will you be using? (ask assessor for clarification)

	Scenario 1	Scenario 2
Paper	◯	◯
Digital	◯	◯

3. User Satisfaction

Please answer the questions about the first map format you have just used

1. Please rate the following map format features:

	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
The format enabled easy task completion.	◯	◯	◯	◯	◯
The task results were relevent and accurate.	◯	◯	◯	◯	◯
Information on the map is easy to find.	◯	◯	◯	◯	◯
The map presents information in an visually pleasing manner.	◯	◯	◯	◯	◯
The map is confusing and difficult to read.	◯	◯	◯	◯	◯
The map is easy to use.	◯	◯	◯	◯	◯
The map is well structured and easy to navigate.	◯	◯	◯	◯	◯
The quality of maps are high.	◯	◯	◯	◯	◯
The map is too small	◯	◯	◯	◯	◯
I would be happy to purchase the map	◯	◯	◯	◯	◯

2. What do you like and dislike about the map format?

4. User Satisfaction

Please answer the following questions about the second map format you have just used

1. Please rate the following map format features:

	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
The format enabled easy task completion.	◯	◯	◯	◯	◯
The task results were relevent and accurate.	◯	◯	◯	◯	◯
Information on the map is easy to find.	◯	◯	◯	◯	◯
The map presents information in an visually pleasing manner.	◯	◯	◯	◯	◯
The map is confusing and difficult to read.	◯	◯	◯	◯	◯
The map is easy to use.	◯	◯	◯	◯	◯
The map is well structured and easy to navigate.	◯	◯	◯	◯	◯
The quality of maps are high.	◯	◯	◯	◯	◯
The map is too small	◯	◯	◯	◯	◯
I would be happy to purchase the map	◯	◯	◯	◯	◯

2. What do you like and dislike about the map format?

5. Overall Map Format Comparison

1. Which map format did you prefer overall?

◯ Digital/Online Maps ◯ Paper Maps

Give the advantages/disadvantages of your chosen option

2. Which format did you prefer for the following tasks?

	Paper	Digital
Task 1 (Long distance route)	◯	◯
Task 2 (Short distance route)	◯	◯
Task 3 (Short walking route)	◯	◯

3. Rate your overall Map format preference based on the following Usability factors

	Paper Map	Digital/Online Maps
Usability	◯	◯
Learnability	◯	◯
Efficiency	◯	◯
Reliability	◯	◯
Appearance	◯	◯
Presentation	◯	◯
Accuracy	◯	◯