Data Visualization for Management Decision Making. A Case Study of WI-FI Usage Pattern in Victoria University Library.

FCOM 430 Research paper

Supervisor: Anne Goulding

Student: Guanzheng Li (300399840)

School of Information Management

Victoria University of Wellington

1 Introduction

Conventionally, data visualization techniques have been developed mainly for science and statistics, and were initially made to assist expert users present and analyse large amount of complex data quickly and clearly. However, in recent years, with the development of the technology, many data visualization tools have become available for non-expert users and offer more precise and intelligent information analysis (Quispel, Maes, & Schilperoord, 2018). Data visualisation provides decision-makers with flexible and intuitive tools that allow them to understand their macro situation. Therefore, an emerging number of organizations and companies have begun to apply various visualization techniques to help with analysing the data and guiding their management (Al-Kassab, Ouertani, Schiuma, & Neely, 2014). University libraries are no exception.

Academic libraries strive to provide efficient IT services to support teaching, researching and learning activities; this requires the adoption of advanced technology to operate information systems (Krishnamurthy & Rajashekara, 2011). Data visualization can provide libraries with information about trends and patterns in an accessible manner. Data visualization can provide libraries with information about trends and patterns in an accessible manner. For instance, the Ohio State University Libraries (2015) used interactive visualization to display their collections, and narrative dashboards to inform students of their digitization priorities.

In the past ten years, with the popularity of mobile equipment rising, there is a growing demand for reliable and efficient wireless network (Zickuhr, Rainie, & Purcell, 2013). However, university students are experiencing service disruptions, while library management is faced with burdensome budget spending on Wi-Fi maintenance that may be derived from its overlapping channels and complex Wi-Fi connection (Xu & Guo, 2018). This makes understanding and analysing Wi-Fi usage crucial to improving the university's current IT service especially within the library. There is an enormous amount of miscellaneous data being created by users such that conventional analysis methods have reached their limitations; data visualization methods may enable university libraries to make more informed decisions based on this miscellaneous data.

Existent literature, as explained above, focuses on how data visualization helps libraries demonstrate their Wi-Fi infrastructure and manage their wireless infrastructure. However, there is a lack of investigation from the users' actual usage, focusing on how and where users prefer to connect to wireless services, along with how decisions could be generated at library management level based on students' data usage. This research study aims to contribute to the current literature by producing different visualization pattern of the Wi-Fi usage data and evidencing the actual Wi-Fi usage within the University Library and by exploring how librarians intend to make decisions based on these visualization products. This is achieved through producing visualizations of Wi-Fi usage patterns within the university library, through and interviews with university librarians during which they are presented with the visualization product.

The research project first examines the existing literature, and then visualizes the Wi-Fi usage data in the university library Kelburn campus; subsequently the visualizations were presented to the university librarians to investigate how they might use them in decision making. Justification and explanation of interview and data analysis method will be offered. Findings and discussion will be presented afterwards. Finally, a brief summary of findings and implications will be presented at the end of this paper.

2   Literature review

2.1   Data visualization

Data visualization has been widely recognized as a useful tool in increasing efficiency when dealing with miscellaneous data (Al-Kassab, Ouertani, Schiuma, & Neely, 2014). There is a range of visualization techniques available and, as each different technique can be used to achieve a different objective, it is crucial to understand the different uses of visualization techniques. With its comprehensive supportive functions, visualization has been used in university libraries for different purposes. This review covers the nature and purpose of data visualisation, the process of producing a visualization product as well as utilizing visualization as a communication and decision tool within university libraries.

2.1.1   Definition

Data visualization has many definitions but the most cited one found in the literature is "the use of computer-supported, interactive, visual representations of data to amplify cognition" (Card, 1999, p.1). Data visualization is the process of mapping data to visuals (Murray, 2013). It reinforces human visual cognition, to enable the user to get knowledge about the internal structure of the data, causal relationships and dependences in it. Khan (2011) also explained data visualization as the transmission of abstract data through the use of statics or interactive visual interfaces. Data visualization offers visual representations and these interaction techniques take advantage of the human eye's broad bandwidth pathway into the mind to allow users to see, explore, and understand large amounts of information at once (Brown, 2015, p.184). To sum up, the objective of data visualization is to assist people to better perceive and acquire knowledge by visualising data.

2.1.2   Need for visualization

Nowadays, the emerging high volume, velocity, and variety of datasets require new forms of processing enabling analysis to enhance process optimization, insight discovery and decision making (Wang, Wang, & Alexander, 2015). In addition to this, Kosara and Hauser (2003) pointed out that, data visualization handles data that is usually abstract, high-dimensional and structured in a complex way. Logically, data visualization has been widely adopted as an effective tool to present information in a concise and accessible way. In conclusion, data visualization is considered an applicable solution to handle miscellaneous data, and improve viewers' comprehension, memorability and engagement (Yamaguchi & Richardson, 2018, p.141).

2.1.3   Categories of data visualization

There are various data visualization techniques. Firstly, pie charts are used for providing clear percentage visualization and comparing percentage points of different properties to other data wedges. Pie charts divide a circle into numbers of sectors, each wedge describing a proportion

in the entirety (Spence, 2005). Secondly, bar charts are mainly used for discrete data, to represent a single data series and related data points are group in one series. These are the traditional data visualization techniques that will be used in this research paper but there are more types of visualization techniques that are available with respect to the objective of visualization.

The challenge of this conventional data visualization comes from providing data visually to be understood by observers effectively and effortlessly (Kosara & Hauser, 2003). For the purpose of mitigating this challenge, dynamic and interactive data visualization has been emerging. According to Wang et al. (2015), interactive data visualization often leads to discovery and improves performance quality over static data tools. Emerging technology has also brought about new visualization techniques. For instances, the heat map is an emerging visualization technique that evolved from shading matrices (Leland & Friendly, 2009), which is a graphical representation of data where individual values are represented as colours. Mostly it is applied to highlight information density (Pryke, Mostaghim, & Nazemi., 2007). With its popularity, nowadays an increasing number of software packages are available for heat map function.

2.1.4   Process of data visualization

Chittaro (2006) suggested that there are six steps that are involved in the visualization process, which are: mapping between data objects and visual objects; selection of the relevant data; organization of the visualization layout; suitability to the platform; consideration of the human perceptual factors; and final evaluation.

Another research study summed up the previous research work and conclude the process of data visualization, as showed in Fig.1 which summarises the different steps in the data visualization process (Al-Kassab, Ouertani, Schiuma, & Neely, 2014). Firstly, raw data is collected from different sources, which the secondly leads on to data transformation comprised of filtering of raw data, computation of derived data, as well as data normalization. This looks at the raw data before it is processed. The third step is mapping the transformed data, which allows the visual transformation to happen. It is then presented to the viewer in what the article

calls a corresponding visual structure. From there, a set of views can be generated which all end users to navigate through the various different graphs and piece of data visualization. Finally, the viewer can interact with the visual representation using interactive techniques such as zooming into different graph and the like.
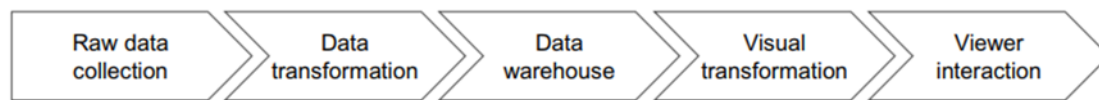

Figure 1 Data visualization process

In conclusion, there are different definitions of the visualization process that can be found in numerous pieces of literature. However, their overall intention is similar, which is to trim the raw data into the data selection, and then map it into a visualization format in order to make it accessible to the end user. Each process within the visualization has a critical influence on the final product depending on the goal to be achieved.

2.1.5   Visualization as a decision-support instrument

The use of data visualization as a decision-support tool has been broadly recognized. Visualization can be considered as a 'visual vehicle of thought' to assist managers in making decisions (Al-Kassab, Ouertani, Schiuma, & Neely, 2014). One of the reasons for using visualization suggested by Ma et al. (2000) is that it can present information in an easily accessible and understandable way for the viewer to translate the data into knowledge that in turn can be used to support decision making. This suggests that problem solving could be improved if visualization is adapted in the decision-making process. In addition to this, visualization is recognized as a way of facilitating an individual's reasoning as it enables solutions to be captured more effortlessly (Wallace, Fleet, & Downs, 2011). Data visualization can also help decision-makers tackle problems that require the synthesis and analysis of an abundance of data (Sloman, 1996).

2.1.6   Visualization in library management

The utilization of data visualization is becoming an emerging trend in library management. Data visualization tools can help the librarian leverage large amount of data from creating both engaging and dynamic visualization. Murphy (2015) pointed out that incorporating data visualization tools into library assessment initiatives is a valuable investment of library resources and time. Chen (2017) also suggested that there is a growing trend of libraries creating a culture in which staff are trained in information visualization, as it provides an advantage to the library as an entity, its staff and end users. The utilization of data visualization in library management has rapidly identified concerns or issues to be addressed to improve services.

Data visualization has supported university libraries in various ways. The Ohio State University library's visualized interactive survey results helped librarians better understand the results of their user satisfaction (Murphy, 2015). Another instance is the librarians from different State University of New York institutions who used visualization to reveal current price-changing trends and price prediction of e-resources, which proved that data visualization could be undertaken in small academic libraries without any additional cost (Cheng, Hayes, Lee, Locascio, & Lougen, 2018). As data visualization has been adapted successfully and efficiently, it has become a valuable tool in the university library.

2.2   Library IT services

IT services play an essential role in the running of the university library. Studies have found that providing high quality services is recognized as the primary contributing factor in library success (Helena Vinagre, Gaspar Pinto, & Ochôa, 2011). Emerging technologies in libraries and pioneering information systems are under constant development and change. Ensuring a high quality of library service requires the enhancement of Library IT services. Bekele (2010) pointed out that user satisfaction was technology and support driven, relating to factors around software quality, degree of technology use and support from the administrators. In addition to this, studies have also indicated that novel technologies employed by libraries are beneficial

and meaningful for the learner (Huang, Chiu, Liu, & Chen, 2011). Overall, IT services and the degree of technology use offered by the library plays an important role in determining library service quality.

2.2.1   Success factors for library IT services

A study based on the previous information success model (Delone & McLean, 2003), developed a library success model (see figure 2), which indicates the five component for library success: system quality, information quality, library service quality, usefulness and library satisfaction (Landrum & Prybutok, 2004). This model indicates that overall library success is partly dependent on system quality, on information quality and on service quality.
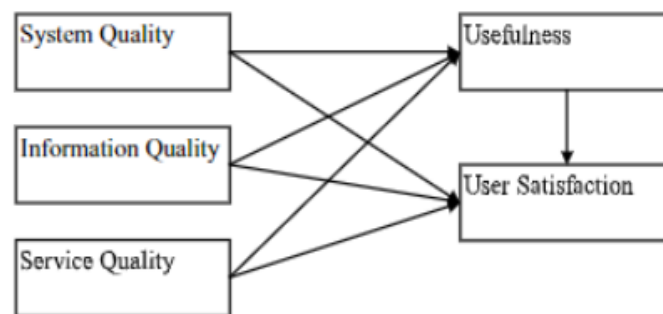

Figure 2 Model of library success

Apart from this, usefulness and users satisfaction also indicate that the evaluation of library services is no longer limited to a library-centred perspectives, but also user-centred perspectives. In addition to evaluation in the library itself, it is also critical to measure its services from users' actual usage. Michaelk (2003) observed that library services should be user-centred rather than data-centred as user perception is an essential and important factor for digital library evaluation.

In the following sections, some of the core library IT services and their importance will be presented, including: the digital library and wireless support.

2.2.2   Digital library

Digital library services play an important role in students' study success. Studies have indicated that there is a positive correlation between student success and the use of library E-resources (Allison, 2015; Goodall & Pattern, 2011). Therefore, McCarthy (2017) concluded that student use of library resources improves student performance. However, over time the concept of a digital library service has also evolved.

The definition of what is a digital library has been constantly renewing in recent years. The digital library is not only a digital collection of documents, but also a platform for users' communication, e-learning and e-research (Hu, Hu, & Yan, 2014). In addition to this, Ahmad and Abawajyb (2014) also explains a digital library as an continuously emerging library service, which includes electronic or digital collections, electronic publishing, web-portals, online reference, online document deliver, helpdesk and online library instructions. Digital library services are depicted as a modern form of library service and delivery assistance for users (Alzahrani, Mahmud, Ramayah, Alfarraj, & Alalwan, 2019).

2.2.3   Wireless support

Wireless support is also been considered as a critical factor in the provision of library services. With the enhancement of IT services, the foundation of a robust wireless connection has risen up the agenda. According to one survey (Zickuhr, Rainie, & Purcell, 2013), 77% of the participants considered access to computers and the internet as a 'very important' IT service in libraries. Forlano (2009) also pointed out that Wi-Fi hotspots in the library can be understood as places of informal interaction, social support, collaboration, and innovation. To sum up, the wireless connection in the library is offering a critical foundation to support other IT services.

Location of the wireless infrastructure is considered most important in order to enhance wireless network performance. Geier (2012) pointed out that relocating the wireless router to

the center of the necessary coverage without obstruction could enhance the wireless range and speed. In addition to relocating the access point, Xu and Guo (2018) also pointed out that keeping the older router to support older devices with older standards, and employing the new scheme only for the new devices suited to the latest standards would also help improve the wireless connection performance. Apart from the connection speed and stability, filtering, security and privacy could also influence the wireless support. One study found out that a lack of privacy could lead to the users altering their preferences for using the network services (Straubhaar, 2012).

To summarise, data visualization reinforces human visual cognition, to enable users to get knowledge from miscellaneous data, especially with the emerging high volume, velocity and variety of data sets. Utilizing visualization as a decision-support tool is becoming an emerging trend, including in university libraries. Much of the existent literature focuses on university libraries utilizing different visualization techniques to assist their IT services. There is a lack of literature on users' actual usage analysing libraries' IT services, drawing on users' Wi-Fi usage pattern. This gap should be filled to assist decision making on IT service improvements in the Victoria University Library.

To address the knowledge gap, this research paper visualized the users' Wi-Fi usage in the university library by utilizing different visualization techniques which were then presented to university librarians to understand which type of visualization they consider most useful and why, along with their thoughts on the kinds of future decisions the visualisation would support. Therefore, the main research questions are:

1. Which type of data visualization do university librarians consider most useful for decision-making purposes?
2. How can data visualisation inform university libraries' IT decision making process?

The answer to the research questions requires familiarity with the operation of the library and knowledge about how the library runs from a management perspective. Therefore, interviewing the university library's management team is considered an appropriate method.

3 Methodologies

This research project includes two parts, which are producing data visualization products and interviewing university librarian.

3.1 Data collection and visualization of data

The visualization process adopted in this research paper followed the guidelines suggested by Al-Kassab et al. (2014), which includes raw data collection, data transformation and warehouse, visual transformation and viewer interaction.

3.1.1 Raw data collection

The first step of data visualization is raw data collection. This was done with the help of Information Technology Support (ITS). An information enquiry was sent to the ITS by email, to enquire if and when the data can be accessed. In order to investigate Wi-Fi usage in the university library, the researcher aimed to acquire data collected during peak usage times. The reason for analysing the time period was due to advice given by the librarian that, according to their experience, that time is most suitable for analysis due to the high intensity of library users. The required data included the X and Y coordinates of users' Wi-Fi connection inside the library from floors 1 to 6 within one 24 hour period. After communication with ITS, the data collection date was set on 10/07/2019, which is the first Wednesday of trimester 2.

Due to ethical considerations, the collected data has been roughly filtered by ITS, which means the data was anonymous, and all identifiable user information was removed.

3.1.2   Data transformation and warehouse

The next step of producing visualizations is data transformation and warehouse. The data received was stored in a Json file, in order to access the data using Excel. The data needed to be simplified by cutting down the huge amount of irrelevant data (some repetitive data such as 'ssid: victoria', 'band: IEEE_802_11_A' etc. are under every piece of data). This was done by using 'Sublime text', as it offers the ability to multi-select codes, which is helpful with editing Json file. After the data was cleaned, it was converted to an Excel file. This conversion was done by using Python script.

There were two lessons learned during the raw data processing, which were, firstly, when selecting the editor, the author did not have a proper estimation for the length and size of the given data. "Sublime text" loads the entire file into memory, which made data converting very impractical and problematic. In the future, when dealing with large amounts of data, Python would be a feasible solution to consider. In addition to this, in order to read the Json in Excel, the author utilized different software programs. However, in the newer version of Windows Excel, it natively supports reading Json files. This would significant reduce workload if the author were aware of it beforehand.

3.1.3   Visual transformation

After the data was cleaned and converted, the next step was the visual transformation stage. The author worked on producing visualization products by utilizing different types of data visualization techniques that are typical and can be achieved based on the data given from ITS. These included pie and bar charts that illustrated the total daily connection between different floors (figure 3); Stacked area charts which illustrated the detailed daily Wi-Fi connection in 30 minute intervals throughout a day (figure 4) and six interactive heat maps which illustrated users' location when connecting to the Wi-Fi in Rankine Brown building level 1-6 (figure 5). With the last of these visualizations, viewers are able to click the play button to view the density change of library use in 30 minute intervals throughout the day. Viewers are also able to zoom

out to look at the overall density on a floor or zoom in to look at individual's specific location when connecting to Wi-Fi.
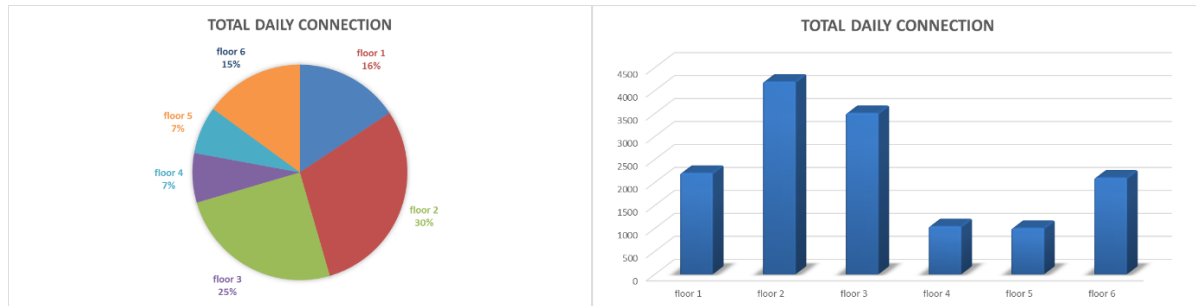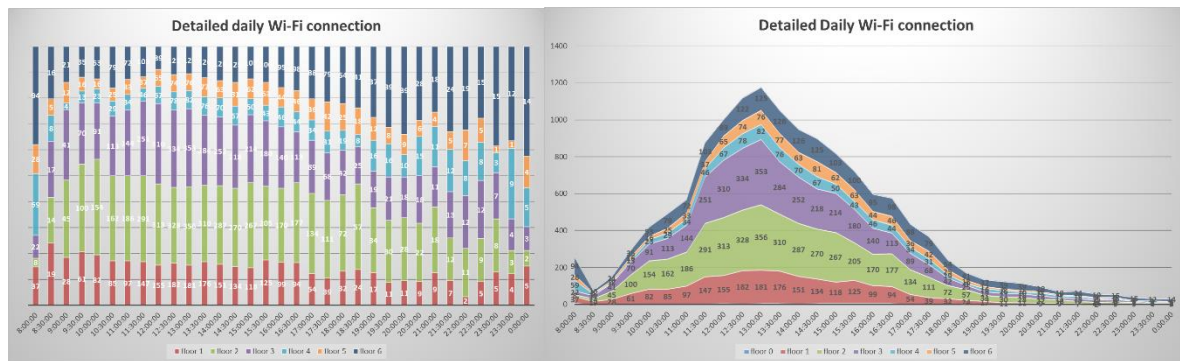

Figure 3 Pie chart and bar chart

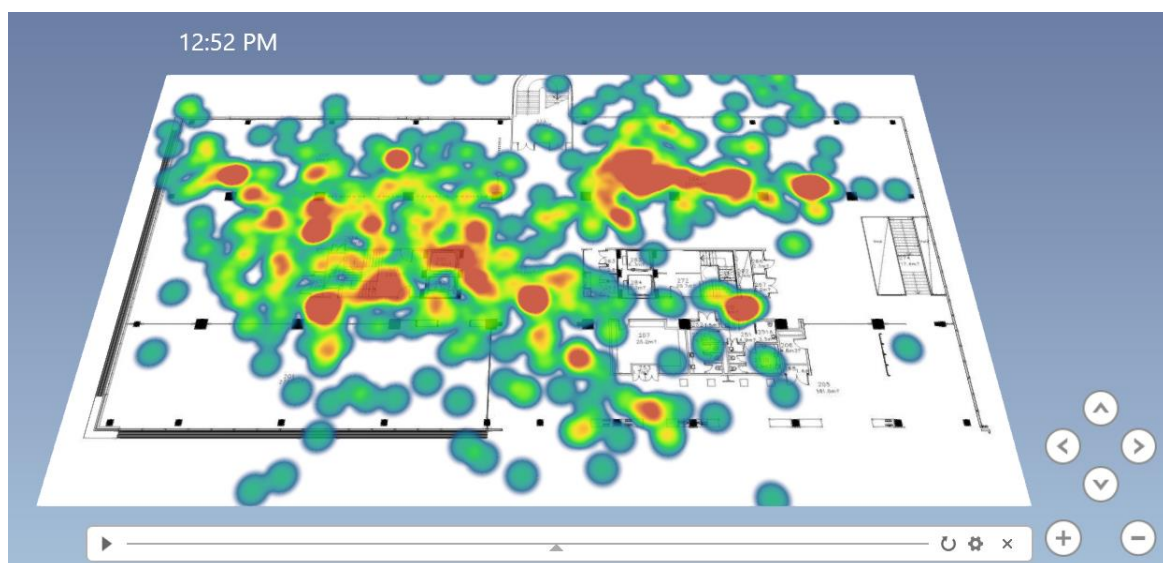*Figure 4 Stacked area chart (percentage and number)*

Figure 5 Interactive dynamic heat map (level 2 Rankie Brown building)

As for the viewer interaction stage, which was done during the interview with university librarians. This will be presented in the next section.

3.2 Interviews

In order to find out how IT related decisions are made inside the University libraries, it is necessary to obtain opinions from librarian. Therefore, interviews were undertaken for this research paper. The reasons for selecting interviews are: firstly, the qualitative interview tends to be more constructionist than positivist. With an interview, the participant can produce the answer themselves, rather than being passive conduits for retrieving information from a list of possible answers as in a questionnaire (Warren, 2011, p. 2). Interviews also offer the interviewer additional valuable information which can be added to the verbal answer of the questions; observation during interviews will also assist the interviewer to grasp the key points being made (Opdenakker, 2006). For instance, when showing participants the visualization products, which visualization do they keep looking at? Which part of the visualization do they focus on the most? Needing to directly see this makes the interview more suitable than other techniques.

To be more detailed, semi-structured interviews were used to collect the data. This offers the opportunity to the interviewers and the participants to react to what the other says/does more spontaneously; this makes the interview a responsive technique by reducing the time delay between question and answer (Opdenakker, 2006). Last but not least, follow-up questions are available in a semi-structured interview, which offer flexibility for the research questions (III & W, 2010); this makes the semi-structured interview more productive for both the interviewer and the participant (Galletta, 2012).

Due to ethical considerations, a HEC application was applied and approved before conducting the interview.

3.2.1   Sample selecting

After the visualization projects were complete, the next step was the selection of the interview participants. This research used expert sampling, which is a type of purposive sampling. The aim is not to establish a representative sample but to identify key informants with context-specific knowledge and expertise (Johnson, Buehring, Cassell, & Symon, 2007). Therefore, interviewing librarians provided the perspective of those with expertise in managing the university library. In pursuing this aim, the sample consisted of participants who are familiar with the operation of the library and are involved with management level decision-making. This required access to the management team in the university library. A list of university librarians was located on the Victoria University website; five participants were invited for this interview, whose roles covered a wide range of roles within the university library. These included the overall strategic direction, planning and quality, academic and research, information and record, as well as collection and client services.

3.2.2   Invitation

After selection of intended participants, an interview invitation was sent to the selected librarian by email to enquire if they were available for the interview. It included basic information about the interview such as time, location, as well as an information sheet and consent form. A list of interview questions was sent to the participants before the interview.

Due to ethical considerations, it was noted in the email that this research is confidential, which means the data is combined and participants' identity would not be revealed in any reports, presentations or public documentation. It was also explained to interviewees that in small projects their identity might be obvious to others inside the university library. In addition to this, the participants had the right to withdraw from the study any time before 11/10/2019 by emailing the author.

3.2.3   Interview process

During the interview, basic questions about the running of the university library were asked, along with the participants' current understanding of current university IT services. After this, the visualization outputs of the Wi-Fi usage pattern were presented to them, asking which data visualization they considered most impressive or helpful, and why. In addition to this, based on the visualization products, participants were asked about decisions based on their area of responsibility in the library. An interview question guide can be found in Appendix A.

As for ethical considerations, during the interview, the participants had the right to choose not to answer the questions or turn off the recording at any time during the interview. In addition, after the interview, the interview data was stored on a laptop with password and fingerprint security measures to protect the confidentiality of the data.

3.3   Data analysis

After collecting the interview data, interpretation of the data is crucial for drawing final conclusions. Inductive analysis was used to interpret the data. In inductive analysis, themes will be directly derived from the interview data (Patton, 1990). It provides a convenient and efficient way of analysing qualitative data for many research purposes. As suggested by Thomas (2003), this has a number of benefits. Firstly, it helps condense extensive and varied raw text data into a brief summary format. Secondly, it can establish clear links between the research objectives and the summary findings. Thirdly, it helps to develop the model or theory about the underlying structure of experiences or processes. A growing number of researchers are finding that the inductive approach is more straightforward than other traditional approaches (Thomas, 2006). The number of interviews is comparatively small in this research paper, which offers the opportunity for inductive analysis to be used.

The interview recording was initially converted into transcripts. The transcripts were reread multiple times to ensure familiarity with the texts. After this there was data coding before the

thematic analysis. Coding is the pivotal analytic step that moves the researcher from description toward conceptualization of that description. It allows the researcher to discover and understand participants' views (Charmaz & Belgrave, 2012, p.11). By using coding, the researcher more easily understood the participant's views. Using it allowed the interviewer to process the data gained from interviews with the librarians and made it far more helpful for answering the research questions. During the coding, the interviewer went through and analysed the transcripts. To do so, similar and/or reoccurring answers were pulled from the transcripts. Once identified, these similar answers were classified into common themes, (for instances, router, laptop were coded as "hardware"). During this process, researchers must make "sense" out of what was uncovered and compile the data into sections or groups of information, also known as themes or codes (Creswell & Poth, 2017). Conclusions were derived and summarized from interviewees' phrases, expressions or main ideas (Kvale, 2007). This was achieved through the qualitative thematic analysis where elements of the interview were coded and grouped into classifications. After categorizing, there was a comparison and contrast exercise of the different classifications from which the conclusions were formed.

4   Findings

4.1   Library IT services

2.6 million visitors came to the University library in 2018. In order to manage such large numbers of users, the university library divides their operation into a wide range of roles/functions, which include the overall strategic direction, planning and quality, academic and research, information and record, as well as collection and client service etc. The main objectives of a university librarian are to support student and staff's learning, teaching and research needs.

There are different IT services that are supported by university library. Managing the print and digital collection is one of their main functions. However, many of the librarians interviewed also believe that traditional printed media is an essential part of a library and so they are also responsible for this. As explained by the librarians, there are some resources where printed

media is the best medium, and in some cases where the material has been digitalised, the print version has more detail, for example things like plans or maps or other graphic materials.

> *"Even students would say, I like the printed books, but their behaviour due to the immediacy of eBooks means this can often conflict. Students may like printed books, but they use eBooks due to convenience and that's what's challenging."*

The university librarians interviewed have experienced the transition from the beginning of digitalisation of media to nowadays where it is almost total. Although they think that print collection will be essential in the future, because of their users' behaviour, its importance is lessening. The digital library now provides access to information and discovery and access to teaching and research resources online. To provide this service, the university library manages the online catalogue, Te Waharoa. There are system developers who look after discovery of the physical versions too, enabling people to find physical books online. The University library also manages the buying and maintaining of digital collections. Additionally, producing and maintaining the University Library website as a user friendly platform is an important part of their role. They are consistently evaluating this goal of providing access to information by surveying students' and lecturers' opinions, often with the assistance of UX developer.

The university library also works closely with ITS on the technical side. The ITS staff in the library are mainly there to look after specific system's software and hardware. For instance, ITS manages the hardware such as Wi-Fi, desktops and printing services, and software such as platform support for the digital collection.

Based on the IT services the library currently provides, the next section will analyse how visualization helps with their decision making in relation to these IT services.

4.2   Visualization with management

When shown the visualization product, all the librarians pointed out the heap map is very supportive of decision making, because it offers an interactive and dynamic way to illustrate the density of library use in Rankine Brown building. It offers a sense of time, which can help them to better manage the library's physical space by clearly understanding which floors are most used and when. This visualization also provides data as well as sparking their interest to understand library users' behaviour, such as "why the Wi-Fi usage in level 6 is much higher than lever 4 and 5, considering it is further away?" The answer to this question needs to be further investigated with future surveys or interviews with the library users. Three librarian thought the stacked chart with numbers were helpful, as it illustrates the peak hours of use within the library. This helps them understand the population flow between different floors, therefore staff allocation/capacity or population dispersion could be better planned according to this. Another common theme the librarians pointed out was that the combination of different types of visualization complement each other nicely. To be more detailed, viewers are able to get an overall view of the population allocation within a day, and then look into detailed information on how population is dispersed at different times, then combined with the heat map to locate which area has the highest density at a certain time.

It seems that visualization converts miscellaneous data into valuable visual representation. By doing so the university librarians are able to improve their comprehension and engagement by viewing the visualization product. It brings data to life, which sparks librarian's interests to explore more perspectives within the university library.

Although all of the librarians considered these visualization product useful and interesting, with regards to actual decision making, they believe decisions based solely on these data visualizations are insufficient because these visualization products only account for one piece of the bigger picture. They contribute to the decision making, but they cannot be the sole resource for decision making. In order to make decisions, visualisation would need to be more supportive in conjunction with other information to look at other perspectives, such as the students' voice and budget estimation. As one librarian suggested:

"These visualizations provide the information, which tells part of the big story, in order to make decision, I need to know the full story. I don't want to make assumptions, so this makes me want to explore more. I want to go to library and talk to student and ask what they feel important, these are the other ways we can get more kinds of data to tell the complete picture."

"The Wi-Fi data shows X, our student are telling us Y, we know from previous experiences observing other libraries that they are telling us Z, so we just take all these bits of information and then come up with a plan."

These comments show that visualisation by itself is not as helpful as it is when complemented by additional sources of information.

As for utilizing visualization for the future, there were many potential situations mentioned by the university librarians. For instance, utilizing visualization in the staff capacity or collection management to reveal price-changing trends and price prediction. Librarians are also considering using heat maps for future website design, to detect how users would actually use the webpages and links in library website and Te Waharoa. For instance, to show where users have clicked on a page, or how far they have scrolled down on a page to find the result. There are three librarians who also considered the real time heat map or seat monitoring systems to assist students and staff look for study/collaboration spaces.

5   Discussion

Data visualization converted miscellaneous data into valuable visual representation. It offers a chance for university librarian to get better understandings of their users' behaviour from meaningless numbers. Among all the visualization techniques, the interactive and dynamic visualization are considered by university librarians as the most supportive for future decision making, as this offers a lively way to sparks librarians' interests to explore more within the

library. As for current decision making, a sole visualization is not sufficient, as this only contributes to one part of the big picture, and will be more supportive when it's in conjunction with more information.
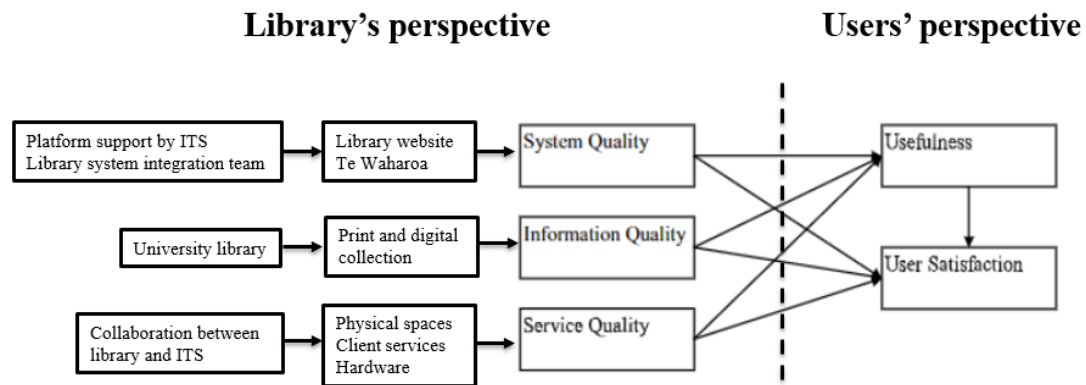

Figure 6 University library services based on library success model

Based on the library success model, the university library is enhancing system quality with the library website and Te Waharoa. This is produced and managed by the system integration team and with platform support from ITS. In the future this could be enhanced by utilizing heat maps to make the library website more user friendly. As for the information quality, which mainly refers to the purchasing and managing the print and digital collection by the university library, this could be enhanced by reducing the cost by visualizing the price trend. Besides, with regards to service quality, this refers to the physical support from the library, which includes managing the wireless support, hardware, physical spaces and client services. In this instance, visualization could be used to enhance this by managing the staff capacity and revealing the population dispersion. The combination of the above three aspects contributes to the university library's success.

As for user satisfaction, it is not only an important outcome of system quality, information quality and service quality, but also an important measurement that needs to be investigated. The University library also takes great importance to look at students' and lecturers' voices. This would be improved by visualizing users' survey responses in the future.

6 Conclusion

Data visualization provides a solution to improve viewers' comprehension, memorability and engagement with miscellaneous data. It converts data into easily understandable visualizations such as bar charts, pie charts, stacked charts and heat maps. The interactive and dynamic visualization are recognized as the most supportive visualization for decision makers. Additionally, the combination of different types of visualization enables better comprehension. This research focuses specifically on university libraries, as they are facing an increasing volume of complex data to process. This research paper is based on a visualization project of the Wi-Fi usage pattern in the Victoria University Library, to investigate how librarians' decision-making can be supported by a visualization product.

Data visualization brings analytics to life. It helps convert the miscellaneous data into valuable and understandable visual representations. It makes viewing data more likely to spark people's interest in it. In turn, this allows them to understand and explore what they can get from the data and therefore it is considered critical by university librarians. Based on these visualization products, university librarians are able to get valuable information from miscellaneous data to improve librarian's comprehension, memorability and engagement. It also offers evidence to back up what librarian perceived, such as the peak hour in university library. However, with regards to the future decision making, these visualization products are only considered as one part of the picture, which is not sufficient by themselves. In order to make decisions, librarians need more information such as students' opinion, their previous experience or budget estimation to complete the full story and facilitate decision making. As for utilizing visualization for the future, there are a lot of potential situations which librarians have suggested according to their particular job focus, such as monitoring library density and testing website usefulness.

7   Limitation

There are some limitations to this research that can be addressed in any future studies.

7.1   Location inaccurate

Since this project is based on Wi-Fi positioning, the positioning is only accurate when the device is simultaneously connecting to three or more routers. Users' location will be offset to a certain extent when the device can only connect to two routers. Users' location will be very inaccurate when it can only be connected to one router. In addition, in reality, the location is measured by x, y and z axes, however the locations are viewed on a 2D graph, so the height axis will also influence the data accuracy.

7.2   Non-Wi-Fi users

Considering most patrons have individual devices nowadays, this research paper considered Wi-Fi connections as individual discrete users. However in reality, there's a possibility that some users are reading books without connecting to the wireless network. This would cause the deviations between location of Wi-Fi usage and real library usage. Additionally, there might be people who have multiple devices, which could lead to data inaccuracy also. In the future, this can be fixed by verifying the Wi-Fi data with real-time head count.

7.3   ITS opinion

Given the time constraints, this research study only considered the opinions of library management. As the university library works closely with the ITS, and ITS supports most hardware and platforms for the university, a more complete understanding would be generated if more interviews were planned including ITS staff.

7.4   Limited useful data

Based on the HEC and information privacy considerations, the information given by ITS is anonymous and very limited. Therefore the data points that are reflected in the heat map are anonymous. This means they cannot provide information about how long the user stayed in the library, as it could be same person sitting at one place or another person who came and replaced them. The anonymity means that there is no way to tell if individual data points over time are different users or not. If one person got up and moved to a different location, they would be registered as different discrete users. This poses a clear limitation in accurately judging how many individual people are using the library. Additionally, there aren't many types of visualization which can be generated from this limited data.

8   Implications

The visualization product can be accessed by the university library, and can be used as evidence to back up librarians' perception of library usage. Librarians know intuitively when the library is busiest but this provides a visual representation. In addition, this answer to the research question also helps to understand how decisions in the university library were made, which is viewed in combination with all existing information, such as users' actual usage, users' opinion and librarian's previous working perception etc.

The current literature focuses on how data visualization can help university library manage their different services. In this research project, the process section provides a real-world example of how to produce visualization products according to the guideline from previous literature. It also shows how different services that are supported by the university library impacts on the library's success. In addition to this, the result of this research paper offers a better understanding of the need from university librarians in regards to what they can expect in order to make decisions for the future. These are broken down into the following themes.

9 Lessons learned

Firstly, before conducting this research project, it was assumed by the author that the university library manages all the services within the university library. However, although the university library has their own integration and development team, it also works closely with ITS, which supplies the hardware and platform support. The research would have gained more information about how visualization helps with IT services if the interviews had covered ITS staff.

Secondly, with the research question, the author thought narrowly about the decision making and believed this visualization project can directly guide decision makers with decisions. However, after the interview, the author realized it was unwise to make decisions based on one sole factor.

Thirdly, with regards to the data cleaning and converting process, due to author's inexperienced estimation of file size and length, this caused problematic inefficiencies as "sublime text" loads the entire data into memory. Therefore in the future, the selection of data sorting software could be improved based on the proper estimation of data size.

9 Lessons learned

10 Bibliography

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11 Appendix A: Interview questions guide

Can you tell me a little about your job within the university library?

What IT services do we have in the library?

From your perspective, which IT services do you consider as a strength of the university library? What are the weaknesses that need to be enhanced as a priority?

Which information visualization do you think most supportive? Why is that?

What kinds of decisions do you think could be made, based on the information from visualization product?

Are there any other library services that you think might benefit from data visualisation?

Is there anything else you would like to add?