Public Sentiment and Insight on the Stratford-Perth Museum

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Abstract

The Covid-19 has impacted museums across the world due to the lockdown measures and social distancing. Our study aimed to answer how the Stratford-Perth museum can sustain its operation and what museum digitalization is required in this turbulent time. Sentiment and insight analysis along with word cloud, topic modelling and correlation analysis were conducted by analyzing tweets and retweets surrounding the keywords of museum digitalization. Twitter was selected as the sole data source because it's the most active social platform during the pandemic. Roughly eight-month raw data starting April 1st when the country began to take anti-pandemic measures were extracted by Python TWINT library. The data was then cleaned by a Python program to remove duplicates and irrelevant information. A word cloud analysis was performed to visualize some frequently appeared words. An overwhelming positive (61%) and neutral (28.9%) sentiment among all tweets revealed a strong demand for museum digitalization. Eight topics were identified based on word frequency by leveraging Latent Dirichlet allocation. People are particularly interested in the virtual learning experience and live galleries worldwide. The access to digital exhibits can be paid subscription services since viewers can enjoy the interactive content from the comfort of their homes. We recommend the Stratford-Perth museum adopt a museum digitalization approach to sustain operation and develop a digital education system leveraging its historical and art exhibits strength. The education system and other digital content should be interactive to engage more viewers and be a paid service to recoup revenue loss due to the pandemic.

Keywords: COVID-19, Museum Tech, Museum Technology, Digital Museum, Data Analytics, Python

Contents

Research Project Introduction

Introduction

The Stratford-Perth Museum is a community museum located in the city of Stratford, Ontario, Canada. The museum typically sees more than 20,000 visitors annually (Stratford Perth Museum, 2020). Community museums hold collections and education programs that enable the community to interact more closely with historical artifacts and learn more about their community (Ontario Ministry of Heritage, Sport, Tourism and Culture Industries, 2020). By offering a variety of exhibits that uncovers the deep roots of the community, the museum is able to reach audiences of all ages, interests and abilities.

The Stratford-Perth Museum was established in 1997, the museum covers an area of 5 acres, which consists of a house, woodlots and trails. This house was built in 1870 and has a history of more than 100 years. Many outdoor exhibitions of the museum are held on woodlots. The Stratford -Perth Museum Association is a not-for-profit corporation dedicated to the preservation and exhibition of the artifacts, stories and rich cultural heritage of the County of Perth and the City of Stratford (Stratford Perth Museum, 2020).

To understand the exhibits at the Stratford-Perth Museum, we must first understand the history of the town of Stratford. Historically, the city was used as a railway junction. There are four Via Rail trains running daily through Stratford, between Sarnia, London and Toronto (Wikipedia, 2020). Furniture manufacturing and railway locomotive repairs were the most important parts of the local economy by the twentieth century (Wikipedia, 2020). Visitors can learn about the railway history of Stratford through the exhibit of Railway Century located at the Stratford-Perth Museum. Stratford is also the hometown of Justin Bieber, who is a famous singer not only throughout North America but worldwide. Fans of the young superstar or those interested in learning his life story, can see Bieber's memorabilia and learn about his rise to fame by visiting the "Steps to Stardom" exhibit, which displays many personal items

provided by Justin's family, including a set of drums used for practice during his youth days (Stratford-Perth Museum, 2020).

The Stratford-Perth Museum is unique because it combines the history of Stratford as well as Perth County in one location. The museum's collection dates back to the beginning of the 20th century. In 2008, the number of students of the Stratford-Perth Museum Association exceeded the size of the Stratford Normal School (Stratford Perth Museum, 2020).

Stratford-Perth Museum is recognized as a charming community museum. The Stratford-Perth Museum association made a strategic plan in January 2014, named VISTA, which defines five core goals for the Museum to continue attracting visitors. To summarize, they look to capitalize on all revenue opportunities, use marketing to increase membership and their brand profile, make better use of the entire museum site to expand their historical campus, focus on developing their public education program and strengthen the staff/volunteer dynamic (Stratford Perth Museum, 2020).

The City of Stratford and the County of Perth are the two principle funding partners for the museum, although over 40% of its total revenue from admissions, programs, fundraising, memberships, donations and grants, tourism is still the most significant aspect. Due to the COVID-19, the number of visitors to the museum has plummeted in 2020 (Stratford Perth Museum, 2020).

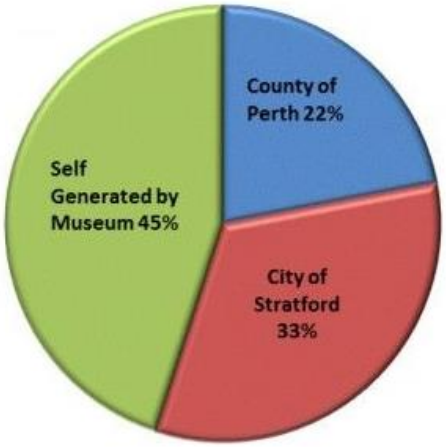

Figure 1. Source of Funding for the Stratford-Perth Museum

The Stratford-Perth Museum generates the majority of their funding themselves through charitable events and fundraisers (Stratford Perth Museum, 2020).

Literature Review

1.1 A broader definition of the tourism and museum industry

(Including the types of museums in Ontario, the economic contributions of Ontario Museums to the country)

Tourism is the entering of foreign nationals into a country often for visiting purposes. The tourism industry is a significant economic driver in the world and it has become one of the largest and fastest-growing economic sectors globally (Ramesh & Atul, 2017). The museum industry is apart of the tourism industry by offering its attractions throughout the year not only to tourists but to all the countries population as well. The function of museums has been defined as a means to control and visualize major social narratives (Coffee, 2006). Museums offer a form of education that people can engage with in person. They include displays and interactive activities representing a variety of topics and historical time periods that may not otherwise be available to the everyday person. The appeal to tourists involves the collection of displays in one location, allowing visitors to engage with a wide range of topics and historical time periods in a single visit (Bello, 2014).

There are approximately 670 museums located in Ontario spreader over many different regions of the province. Museum types range from archive, art museum or gallery, community museum, history, cultural, local history and others that may satisfy a niche. Of the museums in Ontario, 47.13% identify themselves as a community museum, the most frequent type by a large margin (Ontario Museum Association, 2019). Ontario's museums are well diversified ranging from not-for-profit to professional ones. Therefore, these museums are run by volunteers or provincial staff or professional agency employees. Ontario museums cover many different themes, such as agricultural museums, art galleries, botanical gardens, children's museums, First Peoples cultural centres, rail museums, science and technology museums, sports museums and halls of fame, to name a few (Museums Ontario, 2020).

Ontario museums spend $758 million in communities across the province; they employ 10,765 Ontarians (Ontario Museum Association, 2015). Research shows that if a museum attracts 30 new tourists, one new job would be created (Ramesh & Atul, 2017). The continuous increase in number of visitors to the museum will also contribute to the growth of Ontario's cultural economy. The museums industry supports tourism industry by contributing to the $22 billion cultural GDP in Ontario (Ontario Museum Association, 2015).

1.2 The changing faces of business operations by Museums in Ontario

The definition of museums has been relatively unified internationally, emphasizing the functions of historical collections and education, as well as the characteristics of openness to the public and non-profit institutions (Fyfe, 2018). Although museums are regarded as non-profit organizations and are separate from the business world, with the continuous development and innovation of the cultural and tourism industry, museums are no longer simply cultural display and dissemination, but also act as a regional cultural gathering. If only relying on displays and exhibitions to attract the audience, it is far from meeting the development of modern museums and the audience's demand for the museum. Therefore, the business operation ability of the museum is particularly important. Museums in Ontario are actively exploring innovative business operations to improve the competitiveness.

a. Enhance interactive experience through multimedia technology

The multimedia interactive methods of the Canadian Museum have gradually matured. The display and exhibition of the Ontario Museum in Canada continue to infiltrate multimedia technology. Through spatially bounded audio, floor-based multimedia, multimedia interior and other high-tech combined with traditional display content, it produces brand new display effects and increases the display possibilities and participation (Kortbek & Grønbæk, 2008).

While physical museums are networked and remote, completely virtual museums also appear in Canada, such as the Virtual Museum of Canada an online museum in Canada

with over 500 virtual exhibits. It is a virtual museum platform jointly created by the Canadian Museum Association and cultural heritage organizations (Fyfe, 2018). In addition, some museums across Ontario have adopted unique virtual technology as part of their exhibits. The Royal Ontario Museum explores ancient Egypt with a 3D CT scanner, which can get close to the mummified remains without unwrapping them (Morrison, 2020).

b. More frequent cultural exchanges and more influential pop up exhibits

Pop up exhibits that last for a limited time and only a limited amount of tickets are available have gradually become a means of making quick profit (Charr, 2019). These pop up exhibits can attract a large number of visitors, increase ticket revenue and museum store sales, and can also promote the development of tourism for the city. In the upcoming winter of 2020, the Art Gallery of Ontario will host the Major Diane Arbus exhibition honoring Arbus's collection of 522 works with a major solo exhibition of 150 works (Ago, 2019). As it becomes more trendy to attend pop up exhibits, these type of cultural exchanges will become more frequent across Ontario. They allow museums to market their main attractions, attract more visitors and garner more revenue with exhibits that cost less in maintenance fees due to them only being up for a limited time.

1.3 Challenges faced by tourism and museum industry in Canada during COVID-19

Prior to the emergence of COVID-19, attending a museum was an activity that many travellers engaged in to heighten their travel experience. 69% of travellers surveyed reported that they visit a museum when travelling (Teleresearch, 2013). Museum goers show most engagement in interactive exhibits that allow them to immerse themselves in a historical time period through touch and virtual reality that otherwise may not be possible (Shaby & Assaraf, 2017). Barriers created by COVID-19 currently hindering the Canadian tourism and museum industries include government regulations such as 14 day quarantine protocol for travellers, social distancing limits on gathering sizes and the closing of non-essential businesses (Government of Canada, 2020). These all limit how museums conduct their daily operations. Small museums (accommodating less than

20,000 visitors a year) are especially vulnerable to the economic impacts of COVID-19. Small museums are facing economic challenges, public funding is stagnating or declining and COVID-19 creating a decline in attendance (Pauget, Tobelem, & Bootz, 2021). All signs point to Canadian museums requiring government assistance to sustain financial security. As lockdowns remain an option to control the spread of COVID-19, museum closures could occur again and their existence remain at risk. 1 in 3 museums of all types may face permanent closure in the wake of the pandemic (Wyld, 2020).

With uncertainty of how museums can run a sustainable operation throughout the pandemic becoming reality, museums may need to diversify to a more digitalized experience. As populations age and become more diverse across Canada, Canada is becoming more urbanized (Ontario Museum Association, 2015). This is another reason digitalization remains an interesting opportunity. Digitalization acts as a solution that solves both the challenges caused by COVID-19 and the realization that Canadian populations are leaning towards urbanization and a more digitalized museum experience is complementary to both.

Research Problem

Museums in Ontario have been faced with obstacles effecting their operation since the emergence of COVID-19. Government appointed quarantine protocol for travellers entering Canada has made it less likely that tourists will attend museums as they are forced to quarantine for 14 days. Social distancing and fear of contracting the coronavirus have led to museums adjusting their exhibit setups and eliminating interactive exhibits that involve touch. With interactive exhibits being some of the most engaged with, visitors have become less enthusiastic about attending museums. These obstacles have played a role in the overall decline in daily visitors seen throughout Ontario Museums.

Study Rationale

The challenges caused by COVID-19 and the realization that exhibits that offer visitor interaction are most engaged with have made it clear that Ontario museums and more

specifically the Stratford-Perth Museum needs to move towards digitalizing more of their operation to an online form. Identifying whether the public shows any interest in an online interactive museum experience will be valuable in deciding whether to invest into further developing a more technological based virtual museum experience. This type of program would allow the museum to construct a schedule for when exhibits would be used for online purposes, allow the museum to keep track of their online engagement and give employees more responsibilities and job opportunities. This type of structured program is something the Stratford-Perth Museum can use to depend less on tourism throughout COVID-19 and more on their exhibit content. As long as the museum can produce interactive exhibits that visitors find engaging they can ensure a steady flow of visitors. This type of program allows for data regarding viewer engagement to be tracked and stored and can be used to create presentations for funding from various sources including levels of government. This offers the museum a path to success and delivers a plan that museum organizers can present to government officials when requesting funding.

Research Objectives

Our research will look to improve the Stratford-Perth's Museum's digital platform. This will be done by examining the sentiments and public opinions about museum digitalization during these global pandemic times. We will also look to identify the major topics of discussion surrounding museum digitalization during these pandemic times. We will look to use the results of sentiment analysis to help drive the Stratford-Perth Museum's online engagement.

Research Questions

What are the sentiments and public opinion about museum digitalization during these global pandemic times. We will also look to answer what are the major topics of discussion regarding the digitalization of museums during the emergence of COVID-19.

Significance of Research

It is of great practical significance to study public perceptions about museum during the pandemic period. In the digital age, data is regarded as a form of business capital. The ever-changing digital information technology drives the museum to continuously update its technical facilities and overall operating strategy. Based on the analysis of sentiment and themes of the data, the museum can explore diverse needs, to upgrade its business operation model to a more digital model and improve viewer engagement. In addition, through exploring and establishing a new business operating model, the Stratford-Perth Museum will introduce more visitors to their museum, have access to data regarding the publics sentiment towards digitalization of museums and be able to make more data driven decisions regarding the type of virtual exhibits they decide to create and to make them available to the public eg. subscription service or free (paid through advertisement).

The Innovativeness of the project

The innovativeness surrounding this research is to use data analytics to study sentiment and themes regarding public opinions on the digitalization of museums during COVID-19 pandemic. Instead of using traditional surveys, data will be scraped from a social media platform of choice and then cleaned to remove unwanted data and spam. By scraping, cleaning and analyzing user data from social media, the public's main views and sentiment regarding museum digitalization can be extracted and irrelevant information can be excluded. The themes will be extracted through the analysis of the most frequent words that people discussed and then the cleaned data will be coded appropriately based on the theme that it best represents. Then public sentiment (positive, negative, or neutral) of the constructed themes will be analyzed to identify the polarity of the data. As the trend of using big data to make important business decisions becomes more apparent, this approach allows us to collect data in the tens of thousands and analyze the data in an efficient manner that otherwise would not be possible. This is a more efficient method than a traditional survey or focus group approach for sentiment analysis because more data can be captured and analysis can be conducted in a much quicker manner. Such

analysis will allow us to make business recommendations regarding how the Stratford-Perth museum should adjust their operational approach to their digital museum platform.

Structure of the Research

The structure of the research will begin with the research methodology that will be used, including the data source and tools used to gather, clean, store and analyze the data for sentiment analysis purposes.

1) Choose a digital media platform for data collection and give reasons why it was chosen.
2) Choose the analytical tools used for data extraction and scraping of data.
3) Identify the key words for search of the data.
4) Choose a time frame from which the data will be collected that best reflects COVID-19 period.
5) Ensure the type of data collected for analysis is relevant to the study by undergoing a data cleaning process.

Next we will undergo the Data Analysis process. This will Include planning an overview of the types analyses that will be conducted, how analyses will be conducted using our analytical tools and how they will achieve our goal of sentiment analysis for our report.

1) Word Frequency Analysis will be used to identify the most common words used in the data, and this analysis will be used to construct the themes of the study.
2) Themes will originally be constructed by unsupervised coding, but supervised coding will then take place to refine the construction of themes and construct nodes that properly relate to the themes.
3) Theme Analysis will use the constructed themes to identify the frequency of the themes in the data. This will allow for trends to be identified to help answer the research question using natural language processing.
4) Sentiment Analysis will take place to discover the publics view on the digitalization of museum content and what digital museum content they value

most. This will be analyzed by defining the polarity of data and the frequency of each polarity category among the data.

5) Cluster Analysis will then be used on the constructed themes to evaluate their relation to each other in terms of coding relationship in regards to the research problem.
6) Trend analysis will be conducted to identify patterns in themes throughout different periods of the data collection time frame
7) All the results will then be summed up in a conclusion, in order to give a recommendation to the Stratford-Perth Museum on what to include in their digital museum portfolio based on the Sentiment Analysis performed and how they can use it throughout COVID-19 and beyond.

Methodology

Research Methodology

The methodology used to conduct sentiment and insight analysis on public opinion regarding the digitalization of museums involved gathering data from Twitter using a program run within Python. Data collected came in the form of tweets and retweets. Twitter data was imported into Python and then cleaned to remove duplicate tweets, usernames, and other irrelevant data. The final dataset that was used for sentiment analysis comprised of 25,420 cleaned tweets. These tweets were used as resources to construct themes. The constructed themes were analysed to reveal public sentiment and insight towards the digitalization of museums during the COVID-19 pandemic.

Data Collection Process and Techniques

1. **Explain the digital media platform used for data collection and give reasons to why that platform was chosen.**

Twitter was the digital media platform of choice for data collection. Twitter's platform offers millions of users the ability to express their feelings and opinions openly about a wide range of topics and share their sentiment towards those topics (Kanavos, et al., 2017). Twitter acts as a social listening tool in which key word searches can be leveraged to filter tweets and capture them for referencing. By tailoring key word searches around museum digitalization, our research group was able to gather data for sentiment analysis that centered our topic of interest (Museum Digitalization) during the period of interest (COVID-19 period). Twitter offered our research group the best opportunity for insight without needing to survey the public. Twitter also offered the most efficient approach to gain public insight and sentiment, and store it in the form of data for analysis and trend identification.

2. **Explain the types of analytical tools used for the extraction of data.**

Python TWINT libraries was used to extract data from Twitter because of its ability to capture large amounts of data from social media and leverage that data to gain insight and develop sentiment analysis. Using big data to conduct research allows researchers to maximize sample size and also collect data from various ethnic groups worldwide that may share different views and opinions towards topics (Roesch, Stahl, & Gaber, 2014). Our research group prioritized gathering reliable data to accomplish effective analysis. Python's TWINT libraries allowed us to collect three rounds of tweets with different key words, all centered around "Museum Digitalization". This increased the probability of extracting reliable data from different users and allowed us to combine the data for analysis. This strategy made our research group confident that we would capture filtered tweets that centered around our topic of interest. We were also optimistic that the big data being collected was going to be analyzed effectively and efficiently.

3. **State the time which data was collected and give reasons to why that time frame was selected.**

Data was collected from April 1, 2020 to December 5, 2020. It was during late March that lockdown measures were introduced in Ontario, affecting the operation of many businesses and public spaces (Vogel, 2020). Our research aimed at capturing data from when museums began to feel the effects of the coronavirus and the lockdown measures that were introduced because of it. During this time museums were faced with the challenge of finding creative ways to deliver their exhibits to the public, while dealing with social distancing measures, scaling back their interactive exhibits and in some extreme cases closing their doors and being unable to have visitors inside their museum (Unesco, 2020). During this time discussion from the public was beginning to gain traction as the public was beginning to adjust their lifestyle in response to COVID-19 and museums were beginning to see a decline in visitor engagement. We also wanted to include as much up to date data as possible because COVID-19 continues to impact the world today and public insight and sentiment changes on a day by day basis as updates regarding worldwide cases and vaccine development continue to change daily. This 8 month period gives enough time for the public to decide what type of museum engagement they feel

comfortable participating in with COVID-19 continuing to impact life each day. Within this time frame the public was able to establish sentiment towards the digitalization of museums in response to COVID-19 and share their public insight and opinion on the topic. This time frame allows for enough meaningful data to be generated for analysis.

4. Explain the type of data collected for the study.

28,000+ tweets and retweets originally collected included user opinions and news articles related to museum digitalization in response to COVID-19. Data in the form of tweets and retweets were used because they allow us to gain public insight and sentiment in the same tweet and store it in the form of data so that it can be later analyzed. Trends could also be identified from them during data analysis.

Keywords: Museum Tech, Museum Technology, Digital Museum

These keywords best captured our topic of interest “Museum Digitalization”. The key elements to museums digitalizing their exhibits involve technology or “tech”, digital content and of course the museum itself. By the number of tweets collected, our research group is confident we were able to scrape data successfully to obtain reliable data for analysis.

Data Cleaning Process

The 28,000+ tweets collected from Twitter were cleaned by running a program within Python to remove information irrelevant to the research at hand. Before data could be cleaned, the data was first saved as an Excel file to initially store data before data could undergo cleaning. The unsupervised cleaning process then began by running a Python program, removing duplicate tweets, avatars, location id’s, usernames, and other irrelevant data. In addition, white spaces, stop words, punctuation and URLs were also removed in an effort to optimize the perfect machine learning environment. In particular, lambda functions were used to remove HTML tags and JavaScript. This new Excel file generated at the end of the cleaning process contained only the clean data. After data

was cleaned 25,420 tweets still remained as there were some duplicate tweets that were removed during the cleaning process. The cleaned tweets were then used for analysis.

After the initial data set was collected in Python, it was then exported into Excel for storage. Data storage involved tweets being stored in a spreadsheet format within an Excel file. The Python program undergoing the cleaning process was removing the irrelevant aspects of each tweet. This process was essentially removing data that was stored in rows and columns within the Excel file that was deemed irrelevant to the research at hand. Duplicate tweets involved entire rows being removed and unwanted information such as twitter usernames being removed involved entire columns being removed. The final product of the cleaning process involved the information that was relevant to our analytical research.

A topic labelling framework was used for data storage. Data was stored within codes representing different themes related to museum digitalization. These autogenerated themes were the framework of the topics that our sentiment analysis research was focused on. An unsupervised approach was used to generate the coded themes in which data was being stored and segregated in, but a supervised approach was used to determine which coded group was best suited for sentiment analysis in order to answer our research questions. Supervised coding allowed for better insight and understanding of sentiment towards the digitalization of museums in response to COVID-19. This framework made it possible to create a story surrounding what the public was discussing regarding the digitalization of museums in response to COVID-19 and why they were doing so.

Data Analysis and Discussion

Overview of Data Analysis

The goal of this research is to learn the publics opinion on museums digitalizing their exhibits in response to COVID-19. To accomplish this various analysis were performed using Python libraries. The goal of analysis was to generate themes regarding museum digitalization and capture the publics sentiment towards those themes. Only cleaned data was used for performing analysis. The first type of analysis conducted was word frequency analysis that analysed the frequency of word occurrence in tweets centred around museum digitalization. Word frequency was visualized using a word cloud that displayed words within the cloud at different sizes depending on how often they were referenced in the scraped tweets. This allowed researchers to visualize public insight regarding the most talked about topics. Topic modelling was conducted within Python to establish 9 groups of topics that reference museum digitalization. Topic modelling was used in conjunction with word cloud analysis to select the group containing topics that best suited the research study regarding insight and sentiment of museums moving toward offering a more digitalized experience. The topics selected were used to establish the themes for analysis. Themes were analysed based on the polarity and public sentiment shown towards them. Cluster analysis was also performed using a heatmap to analyse the coding similarity between themes. The additional heatmap matrix constructed for correlation analysis allowed for quantifying measures of correlation between themes, which combined with our cluster analysis provided the perfect analytical data to construct a narrative around the public's view on museums digitalizing their exhibits in response to COVID-19.

Word Cloud Analysis

Figure 1. Word Cloud containing the most frequent words found in scraped tweets

Word frequency analysis was conducted initially by leveraging AI search algorithms to identify the most frequent words found in the cleaned tweets. **Figure 1** displays the words "museum", "digital" and "technology" as the most frequent words collected in the dataset. This is due to the mentioned words being the search words used during the data scraping process. For this reason, these words were not used when conducting analysis. Word cloud analysis uncovered words such as science, history, art, world, virtual, tour, education, interactive and online just to name a few. This analysis allowed our research group to discover that in regard to museum digitalization during the pandemic period, the public was interested in obtaining a virtualized online museum experience for educational purposes in fields of study such as science, history and art. What is interesting

is that while in person museum experiences can no longer offer interactive exhibits due to COVID-19 social distancing restrictions, the public is showing interest in online interactive content that allows users to engage with exhibits from the comfort of their home. Museum goers show most engagement with interactive content that allows them to immerse themselves in a historical time period through an immersive experience and virtual reality that otherwise may not be possible (Shaby & Assaraf, 2017). The ability to engage with content online from anywhere in the world, allows the user to have an experience that may not have been attainable without the use of virtual technology, but also allows the museum to reach visitor engagement levels that may have never been attainable in the past. It is estimated that some museums see 10 times more traffic online than in person (Marty, 2008). Furthermore, word frequency analysis is pointing towards structuring online museum experiences around an education system that can be offered to teach users about fields such as science, history and art in a virtual setting, which is similar to how school programs are currently being offered in response to the COVID-19 pandemic. Users that are visiting museum websites are doing so because they have different needs compared to when they visit a museum in person (Marty, 2008). The current online education model that has emerged due to COVID-19, gives museums an opportunity to piggy-back from school systems and offer their own education system, that some may view more interactive and immersive for those looking to educate themselves through a more hands on learning experience.

It is crucial to learn the way in which users are interested in using digitalized museum resources because this information reflects the need of the consumer (Hertzum, 1999). Interestingly, word frequency analysis revealed the type of digital museum resources that the public seems to be interested in engaging with, including video, live content, virtual content, interactive content, and events. By digitalizing the culture and heritage within the museum and offering it to visitors through the use of technology, the museum experience that was once contained within the walls of the museum can be brought to the user in the comfort of their home.

Subjectivity Analysis

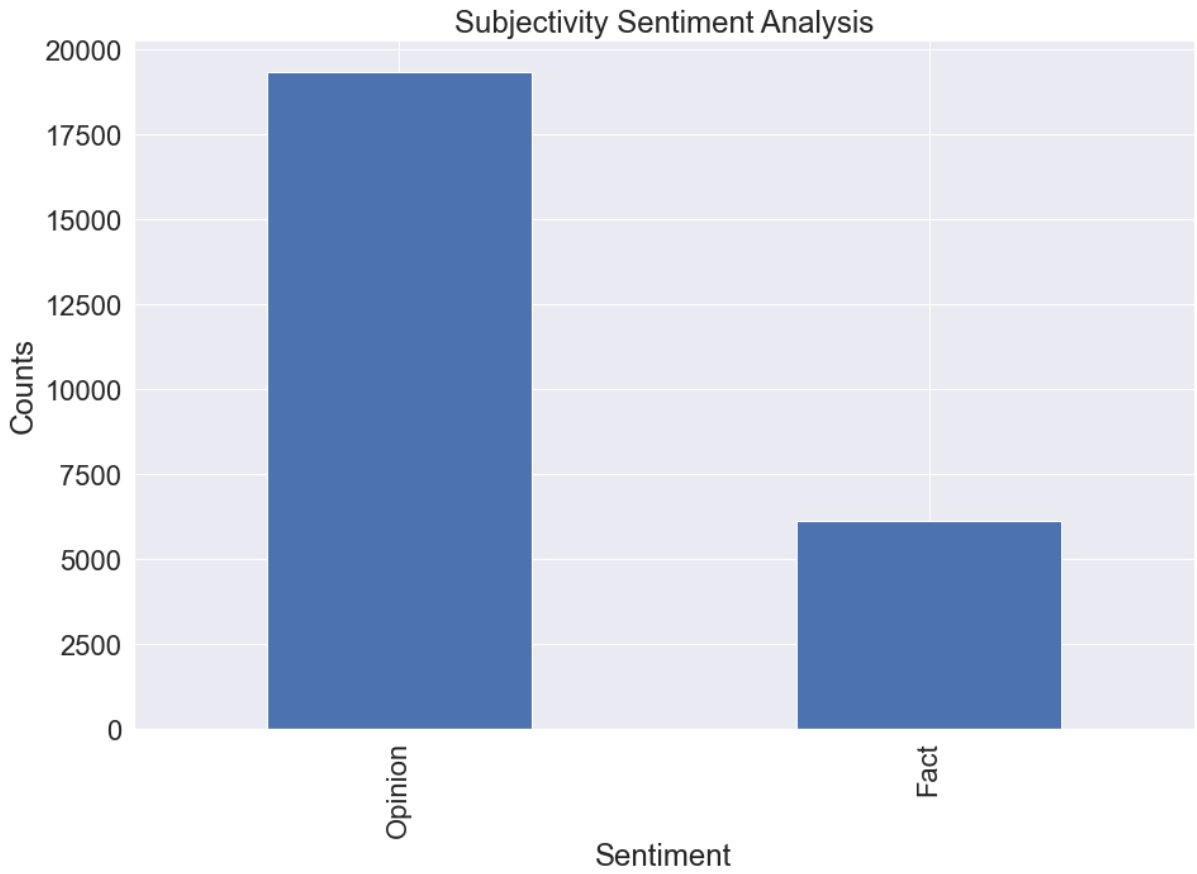

Figure 2. Subjectivity Sentiment graph reveals 19,311 tweets reflect opinion, 6109 tweets reflect fact.

The analysis of the subjectivity of sentiment revealed that the majority of data captured in the research is public opinion. Approximately 3 times more public opinion was captured than fact. This is of importance due to the purpose of this study being sentiment analysis of the public and gaining insight on public opinion. The public opinion regarding museum digitalization during the COVID-19 pandemic can be classified sentiment polarity. Further analysis was required to establish the polarity of the data collected.

Sentiment & Polarity Analysis

Figure 3. Polarity and Subjectivity Plot of cleaned tweets

Polarity and subjectivity analysis identify the positive, neutral, and negative sentiments detected in the data and visualizes how close to opinion vs fact the data represents as portrayed in **Figure 3**. Data points on the Subjectivity axis closest to 1.0 represent opinion and those closer to 0.0 represent fact. Data points on the polarity axis range between (-1.00 to 1.00) where -1.00 represents the most negative sentiment and 1.00 represents the most positive. As most of the sentiment data lies between the region 0.00-1.00, we can conclude that the public is displaying a higher proportion of positive sentiment than negative sentiment towards the digitalization of museums. Some data also show extreme positivity, which is a sign that there are supporters publicly discussing the museum digitalization initiative. This is a good reason for museums to promote more on social media and develop their social media brand on social media platforms such as Twitter. The findings from the polarity and subjectivity plot reveal useful information but

incorporating frequency distribution of sentiment polarity will be helpful in understanding the magnitude of positive sentiment data in comparison to neutral and negative.

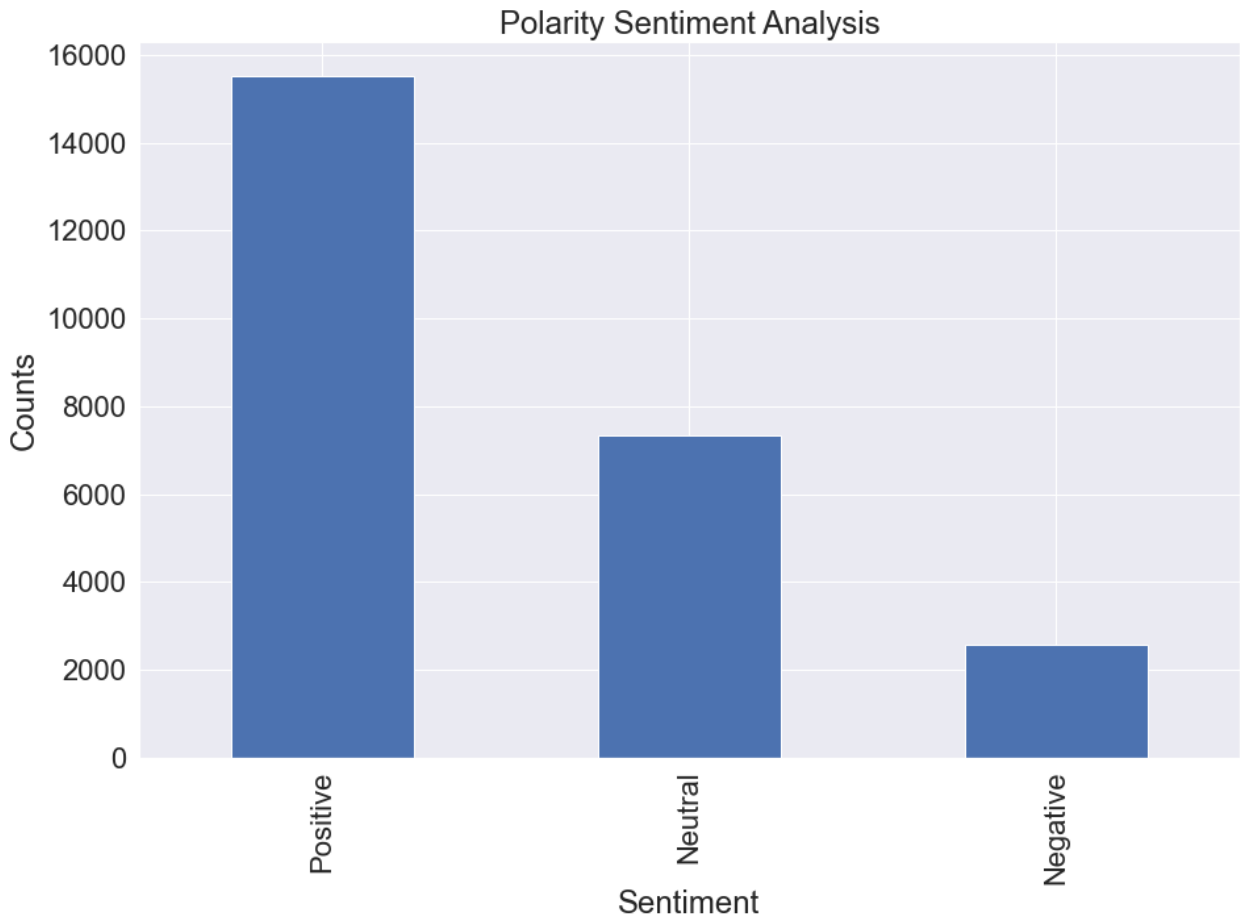

Figure 4. Polarity and Sentiment Bar Graph displaying Positive tweets: 15,512, Neutral tweets: 7336 and Negative tweets: 2572.

Sentiment analysis of the digitalization of museums revealed 61% positive tweets, 28.9% neutral tweets, 10.1% negative tweets. Analysis reveals six times more positive tweets than negative, providing overwhelming evidence that during the COVID-19 pandemic there is a demand for digital museum content. Museums should feel optimistic in digitalizing their exhibits into content that can be offered to viewers online and in a virtual setting. Although almost two thirds of data are displaying positive sentiment, it cannot be ignored that approximately 10% of data shows negative sentiment. These users showing negative sentiment may only be interested in a in-person museum experience, not because they are not satisfied with the current digital museum offerings, but because

their needs and expectations for a museum experience may be accomplished only through the in person experience e.g. attending a museum for the social experience. Museum goers would rather attend a museum in person to view artifacts, collections, galleries and exhibits (Marty, 2008). Activities like these are unique to the in person experience, and through their display of negative sentiment, the public seems to agree that trying to gain this experience in an online setting will not brings the same satisfaction as seeing it in person. Understanding the topics of discussion that the public was engaging in required further analysis. Topic modelling was conducted to create a narrative that accompanies the sentiment that was being displayed throughout the data.

Topic Modelling

Although sentiment analysis revealed overwhelming positive polarity, what exactly the public was discussing in reference to their sentiment was yet to be revealed. Topic modelling was a necessary step in identifying the patterns within the dataset referencing museum digitalization in response to COVID-19 to uncover the narrative surrounding the results of sentiment analysis. Topic modelling was accomplished by leveraging Latent Dirichlet allocation (LDA) and Python's pyLDAvis package. The results of topic modelling have been visualized in **Figure 5,** which auto generated topics using a natural language process. A machine learning algorithm analysed the contents within the dataset containing tweets and grouped these tweets into 8 groups. Natural language processing then began to identify which group of themes occur more frequently and show best relation to museum digitalization in response to COVID-19 as visualized by the size of bubbles in **Figure 5's** Intertopic Distance Map. The Intertopic Distance Map revealed topics 1 through 6 overlapping, while topics 7 and 8 were evenly distributed away from the rest of the topics. After the unsupervised NLP was complete, a supervised approach was taken to select topics that appeared to be occurring most frequently within the dataset but most importantly also showed relevance to achieving the research objectives regarding the improvement of museum digital platforms. Topics underwent theme analysis to look further into the public sentiment towards each of the 8 identified topics.

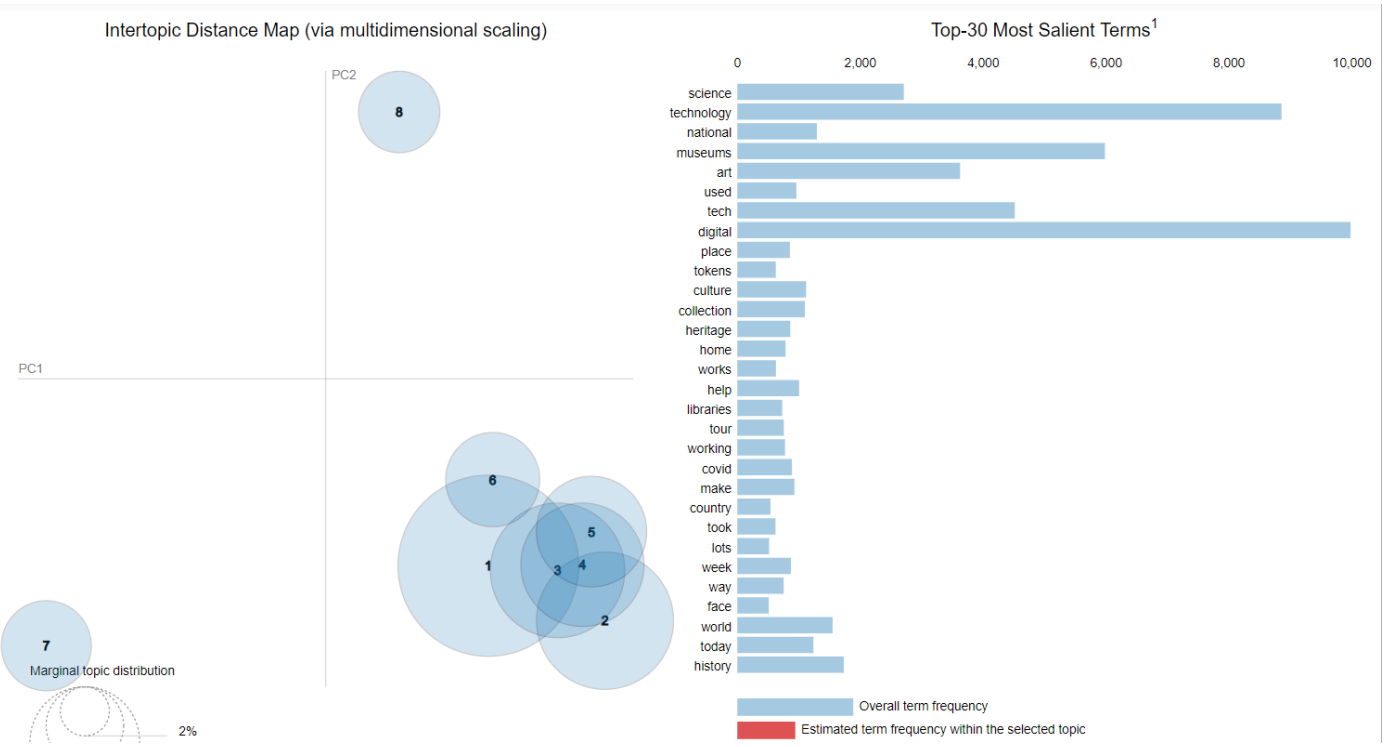

Figure 5. Results of LDA topic model based on 8 topics related to Museum Digitalization in response to COVID-19 and the top-30 most frequent terms within the data

The topics that were extracted through analysis in correspondence with **Figure 5** include:

Table 1. topics associated with museum digitalization in response to COVID-19

Top 10 words for topic #0:
['game', 'great', 'display', 'video', 'piece', 'need', 'social', 'high', 'ago', 'make', 'don', 'look', 'use', 'know', 'think', 'good', 'really', 'time', 'work', 'people', 'love', 'museums', 'old', 'new', 'years', 'just', 'digital', 'like', 'tech', 'technology']
Top 10 words for topic #1:
['paget', 'natural', 'day', 'week', 'students', 'jose', 'kids', 'canada', 'china', 'space', 'life', 'open', 'children', 'news', 'new', 'engineering', 'digital', 'virtual', 'history', 'san', 'art', 'kaohsiung', 'taiwan', 'amp', 'tech', 'took', 'place', 'national', 'science', 'technology']
Top 10 words for topic #2:
['fashion', 'los', 'discover', 'history', 'port', 'station', 'century', 'light', 'using', 'digital', 'amp', 'world', 'observing', 'fix', 'alternative', 'replace', 'leaving', 'given', 'visit', 'jurassic', 'cultural', 'museums', 'going', 'experience', 'face', 'way', 'home', 'tour', 'art', 'technology']
Top 10 words for topic #3:
['virtual', 'sounds', 'amp', 'past', 'online', 'technology', 'liquidity', 'figuratively', 'versa', 'vice', 'representing', 'amusement', 'visitors', 'expected', 'japan', 'speaking', 'admission', 'reality', 'art', 'value', 'increase', 'park', 'technologies', 'tickets', 'digital', 'original', 'token', 'tko', 'tokens', 'used']
Top 10 words for topic #4:

['das', 'der', 'und', 'die', 'namo', 'baat', 'innovatively', 'celebrated', 'despite', 'recharge', 'app', ' emotional', 'week', 'covid', 'fully', 'today', 'heritage', 'libraries', 'world', 'make', 'working', 'lots', 'help', 'country', 'technology', 'collection', 'works', 'museums', 'culture', 'digital']
Top 10 words for topic #5:
['world', 'tech', 'experiences', 'access', 'check', 'live', 'galleries', 'people', 'future', 'free', 'cultu ral', 'project', 'archives', 'covid', 'technologies', 'today', 'learning', 'work', 'heritage', 'content', 'technology', 'collections', 'join', 'virtual', 'online', 'art', 'new', 'amp', 'museums', 'digital']
Top 10 words for topic #6:
['arts', 'exhibition', 'best', 'technologies', 'people', 'use', 'gogh', 'great', 'public', 'visit', 'moder n', 'tokyo', 'van', 'just', 'building', 'science', 'future', 'think', 'collection', 'free', 'city', 'world', 'lik e', 'new', 'amp', 'technology', 'tech', 'art', 'digital', 'museums']
Top 10 words for topic #7:
['thanks', 'natural', 'today', 'did', 'american', 'space', 'year', 'artifacts', 'culture', 'center', 'exhib it', 'design', 'high', 'big', 'using', 'old', 'museums', 'world', 'black', 'director', 'war', 'time', 'comp uter', 'virtual', 'new', 'amp', 'technology', 'digital', 'tech', 'history']

Theme Analysis

The topics that were extracted using machine learning, reflected museum digitalization in response to COVID-19. Theme analysis was used to identify 8 topics of discussion that best represented the narrative surrounding museum digitalization. Constructing a narrative was key in accomplishing the research objective of making recommendations towards the improvement of digital museum platforms. Our research group selected **Topic 5** for analysis due to the collection of words included within the topic and their ability to help achieve the research objective. The themes selected from **Topic 5** were world, experiences, live, galleries, free, learning, virtual, digital. Although topics 1 through 6 show similarity to each other through the overlap displayed in **Figure 5**, the selected themes from **Topic 5** show potential for a narrative surrounding museum digitalization that will give insight in to how the public expects to engage with the online museum experience and how it differs or shows similarity to the in person museum experience.

To evaluate the sentiment of each of the established themes, polarity sentiment analysis was conducted on each theme. The results of polarity sentiment analysis are visualized in **Figure 6**.

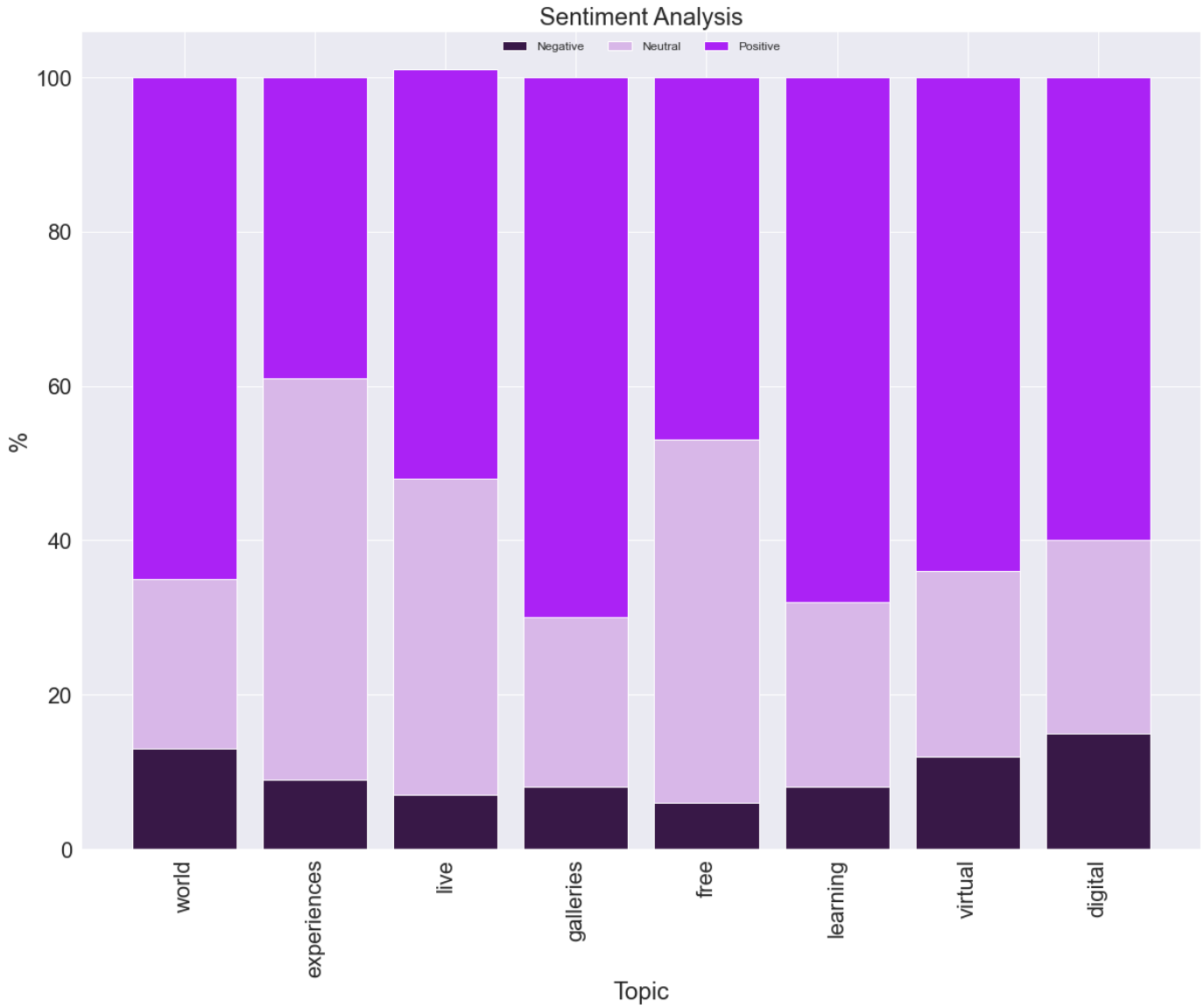

Figure 6. Polarity Sentiment Analysis of Identified Topics regarding Museum Digitalization in response to COVID-19.

Sentiment Analysis of identified topics are consistent with the results of Sentiment Analysis of the overall data. Each topic shows higher proportions of positive polarity than negative. The themes world, live, galleries, learning, virtual and digital show higher positive polarity than both negative and neutral combined. These findings are early indicators that viewers across the world show interest in experiencing live museum galleries and content, virtual tours and engaging with a digital museum platform for learning purposes. There is evidence that the public prefers free access to digitalized

museum experiences with approximately 50% positive polarity. Interestingly, with “free” displaying approximately the same amount of neutral polarity as positive polarity, we are optimistic that there is room to introduce paid subscription services to digital museum platforms. With COVID-19 still impacting public gatherings globally and museums in Ontario closing their doors until provincial lockdown measures are lifted, a subscription service to digitalized museum content will allow museums to recoup revenue lost due to COVID-19 (OMA, 2020). To best identify how to structure a digitalized museum platform, correlation analysis is necessary. By determining the topics that are most correlated to one another, we can make recommendations regarding the types of digital resources to include, what users are going to be using those digital resources for and how to offer them to the public (free vs. subscription based).

Correlation Analysis

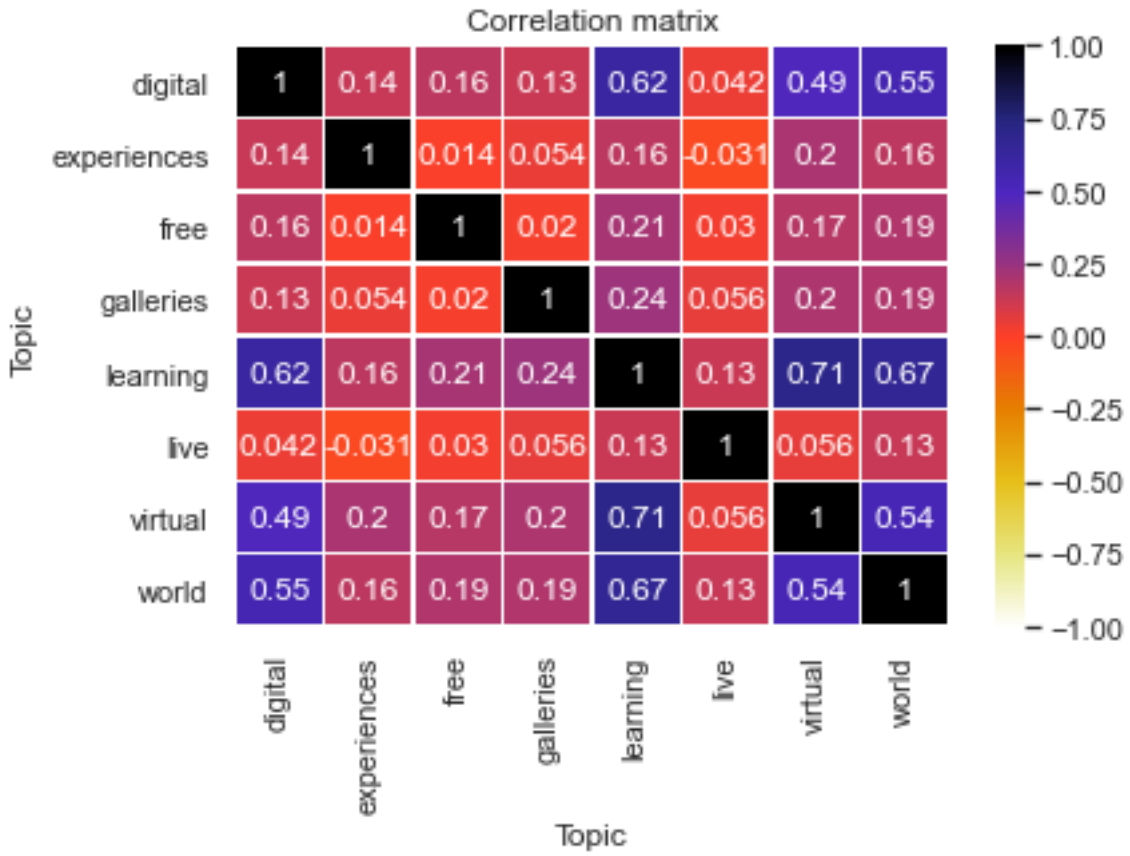

Figure 7. Correlation Matrix of Identified Topics regarding Museum Digitalization in response to COVID-19

The topics formed that reflect the public sentiment on Museum Digitalization in response to COVID-19 underwent correlation analysis using a heatmap. This was made possible by leveraging the seaborn library within Python to calculate correlation levels within the collected data. A correlation between 0.00 to 1.00 indicates a strong correlation and -0.01 to -1.00 indicates a weak correlation. What is of most relevance is what the public views as most correlated. Virtual and learning show the highest correlation with a score of 0.71. With a score on 0.67, world and learning show the next highest correlation. These findings suggest that virtual learning is an experience that the public has positively adopted globally and may even remain when COVID-19 has become an afterthought, due to virtual learning allowing for a revolutionary learning experience that can be performed from anywhere across the world. The virtual learning experience provided by virtual museums allow students to learn facts, concepts and theories through the immersive nature of the museum exhibit (Daniela, 2020). This learning experience may help students and teachers struggling with virtual learning by adding a dimension to learning that combines education with the museum field trip environment in an at home setting. Correlation analysis also revealed digital having strong correlation to learning, virtual and world. This is due to digital being used in the context of using technology to offer virtual museum content to enhance the learning experience. All other correlation scores were below 0.25, which indicates that although there is some correlation between the rest of the identified themes, the strongest correlation is seen between world, virtual, digital, and learning. This is of significance because the objective of this research is to make recommendations towards the digitalization of museums. We are optimistic that due to themes showing strong correlation and the majority of polarity seen in sentiment analysis being positive there is strong evidence that the public will react positively to museums offering digital museum content for virtual learning purposes. Since some museums don't offer a virtual museum experience at all and the museums that do, offer a virtual museum experience with limited digitalized offerings, it is of upmost importance to identify what museums

should prioritize in their digital platform (Sinotte, 2020). Cluster analysis was conducted in order to identify how museums should structure their digital museum platform.

Cluster Analysis

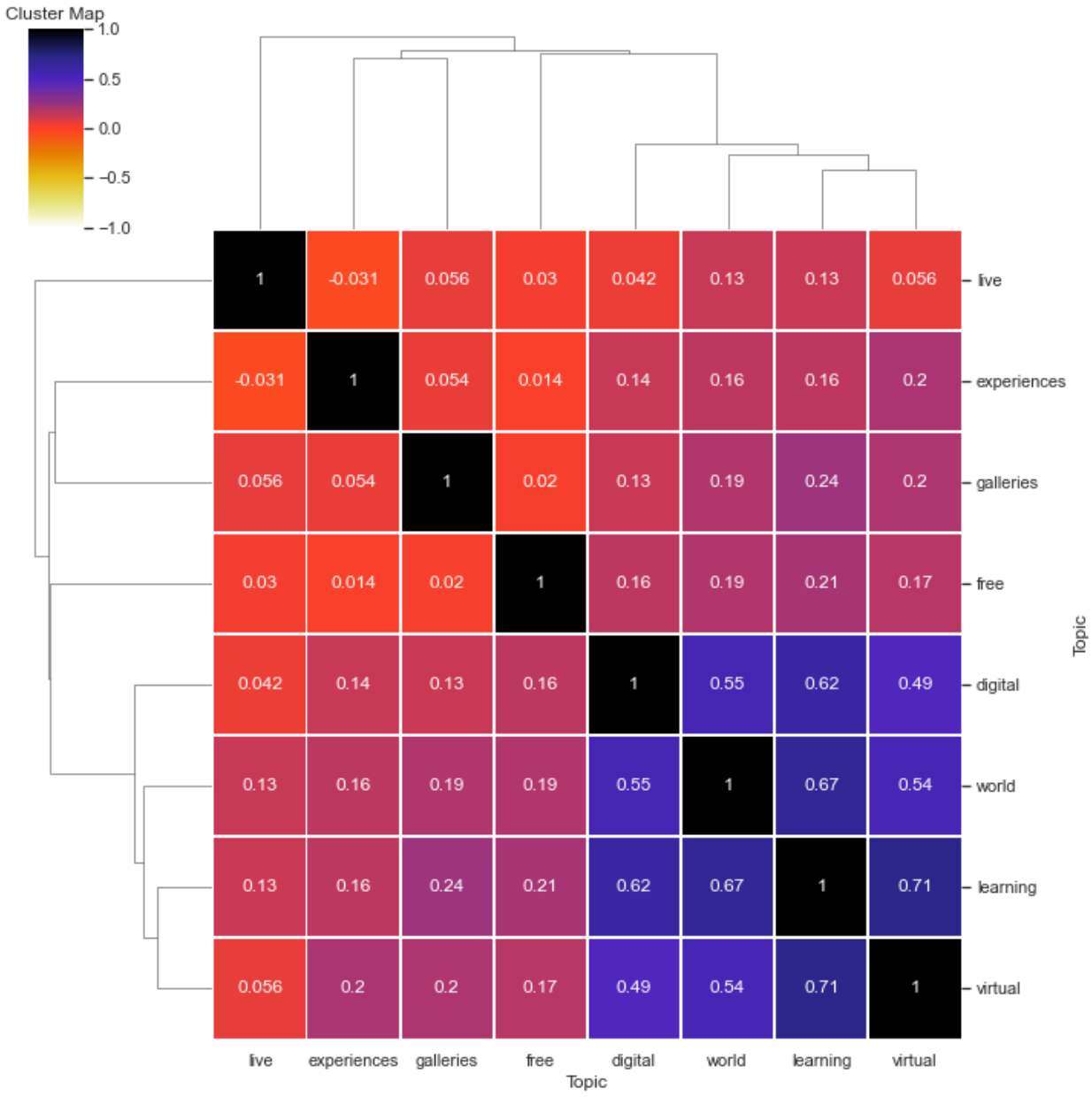

Figure 8. Hierarchical Cluster Analysis

To aid in classifying topics into related groups, cluster analysis was performed. Cluster analysis leverages a heatmap to quantify the relationship among topics a visualize the

relationship using a range of colors. Results of cluster analysis revealed the topic of live as the originating branch that connects to free, galleries and experiences. This suggests that the public will view live museum galleries online only if they are offered for free. This leaves little room for museums to gain revenue from these types of experiences. Digital forms the originating branch for world, virtual and learning. Although this second cluster is connected to the topic free, the second cluster shows the potential for museums to add revenue by museums digitalizing content for a virtual learning experience that can be distributed across the world. This revelation is similar to what was identified through correlation analysis, in which digital, world, virtual and learning showed the strongest correlation. In addition, users of online museum content believe that visiting a museums website can substitute visiting the museum in person when looking for information, but not when viewing artifacts or exhibits (Marty, 2008). Thus, museums looking to digitalize, should start by making an information based virtual learning platform. With the public currently showing interest in learning information through virtual learning and the COVID-19 pandemic currently limiting the learning experience for many students, a digital museum platform with a virtual learning experience is an idea that has many applications today and for the future when the COVID-19 pandemic is behind us. At this time museums offering live streams, galleries and exhibits without information to accompany them leaves little potential for consumer engagement and museum profit. This is due to the idea that virtual museum platforms can only be used for learning purposes if the consumer is motivated to learn about the content or has background knowledge of the content that will help them understand the information. Otherwise, a teacher is necessary to help guide the viewer through what is being portrayed in the virtual museum experience (Daniela, 2020). It is for this reason that museums collaborating with schools to offer a virtual learning experience that allows students to step out of the virtual classroom and immerse themselves in a virtual museum with the guidance of a teacher is mutually beneficial for all parties involved. The museum gains a new stream of revenue from the partnered school, the school adds an element to their education stream, and the student is no longer limited to the virtual classroom and restricted from experiencing

a school field trip. In the past, this type of collaborative experience would only be an imagination. Today, with modern technology the virtualized museum experience can be brought to the classroom in a experience similar to a real life “Magic School Bus”.

Research Discussion

Practical Recommendations

1. Improve the construction of digital platform

The 2020 COVID-19 pandemic has promoted the upgrading of museum business operations and further realized the in-depth integration of digital technology and museum cultural resources. On May 26, ICOM and UNESCO released their full reports "*Museums, museum professionals and COVID-19*". The report shows that the epidemic has enhanced the construction of digital museums. Many museums have increased their digital activities by more than 50%. Therefore, museum digital platform is an important way to meet public needs and promote cultural relic resources in the future (ICOM, 2020).

Many museums in Canada have carried out the construction of digital platforms (Museums during the pandemic, 2020). Therefore, The Stratford-Perth Museum should take the digital strategy as an important strategic direction for the transformation of the museum's business operation model.

First, they should update the current digital resources, and realize the digital collection and reprocessing of traditional exhibition resources with the help of informatization and networked means, which can help develop the existing digital resource database. In addition, the results of our research illustrate that the public shows interest in online interactive content. The Stratford-Perth Museum needs to integrate new technologies, new media, and museum content productions together, coupled with utilizing modern information technology methods such as 5G, VR/AR, big data, etc. to carry out "cloud displays". Such technologies make the interface easier to use and brings a good interactive experience. Through such technologies, the cultural relics can be presented to the audience in a panoramic manner, and the interactive mode can be controlled by the audience. People can manually zoom in, zoom out or rotate to view the relics. By displaying the unique museum culture in multiple dimensions, it will enhance the publicity effect and realize the wide spread of cultural relics value.

2. Strengthen the cross-border cooperation

During the epidemic, the museums have cooperated with social media platforms such as YouTube and Facebook to launch multiple live events and achieved good social effects, which highlights the importance of cross-border cooperation between museums and the media (Museums at home, 2020). In addition, there is another strong evidence in our research that the public will react positively to museums that offer virtual learning. Therefore, museums should become an important platform for school education and social education (Daniela, 2020). The Stratford-Perth Museum can build an information based virtual learning platform, which can be offered to teach users about fields such as science, history and art in a virtual setting.

For example, The Stratford-Perth Museum should strengthen the cooperation with social media platforms to innovate the way of users' viewing. They can combine the cultural needs of the audience and cooperate with social media to create more cloud display activities by digging deeply into the unique characteristics of museum exhibitions and collections. Through professional explanations and digging into details, the relics that cannot be exhibited in off-line visiting can be broadcast live so that the audience can enjoy a visual feast that is different from offline, which can maximize the function of social education, as well as helps the museum to get more attention and traffic. Meanwhile, the Stratford Perth Museum could partner with Justin Bieber to offer a unique piece of content only available through a subscription to the Stratford Perth museum. The fact is that Justin Bieber grew up in Stratford Ontario, the museum should leverage that history and offer it digitally by holding an exhibit dedicated to him, it will help promote the museums digital platform and entice visitors to subscribe for a fee. In addition, the Stratford-Perth Museum can strengthen cooperation with schools and provide virtual learning activities for students to deepen their understanding of textbook knowledge through an immersive experience and virtual reality. The cross-border cooperation between the Stratford-Perth Museum and schools can achieve its function of school education, and at the same time, is conducive to broaden museums' revenue sources.

3. Normalize the mode of combining online and offline

The epidemic will eventually end, and the museums will reopen. Therefore, from a long-term perspective, the combination of online and offline model is the general trend. People's feeling experience of offline viewing cannot be fully replaced by the online tour (Mee-yoo, 2020). The sentiment analysis above also proved that some people hold the idea that the experience in an online setting will not bring the same satisfaction as seeing it in person. The layout of the exhibition hall, the light and even the smell, the actual size of the exhibits and some other factors constitute an important framework for the audience's perception of the exhibition. This is impossible to achieve online, because online is more of a single exhibit or virtual exhibition that is separated from one to another. Therefore, The Stratford-Perth Museum should give full play to the advantages of both, complement and integrate both two ways.

4. Strengthen the capacity building of museum staffs

The museum staffs are the link between the museum and the audiences. Therefore, the professionalism of the museum staffs plays a very important role in the spread of museum culture (Boylan, 2020). Faced with the impact and changes brought by the epidemic on museums, the staffs of the Stratford-Perth Museum must have a mindset of keeping pace with the times and not just stay in the traditional museum model.

The rapid development of museum cloud displays under the epidemic requires the museum staffs to have the knowledge and skills to master new technologies. At the same time, museum staffs also need to have the ability to expand the scale of target audience and disseminate the museum culture, and it will be an important content for museum staffs to bring museum culture to more audience in the post-epidemic era.

Theoretical recommendations

Our analysis clearly showed that for museums to survive and grow during the pandemic or even when our lives go back to normal in future, adopting a digitalized approach is no longer merely an option to consider but a must for them to take seriously. The virtual

museum satisfies the public's many needs, from seeking information to online education to killing spare time, all from the comfort of their homes. The public showed an overwhelmingly positive and neutral attitude towards museum digitalization, so there's nothing for the Stratford-Perth museum to afraid of going digital. The associated question, though, is how to go digital. Our analysis results demonstrated that people are more interested in interactive content than plain text or video. An immersive experience is the key to attract museum-goers to the online version. The Stratford-Perth museum has not done a great job in this regard as their website contains mostly articles and pictures as exhibit content, which delivers a totally dry and dull experience. Therefore, the first theoretical recommendation focuses on preparing exquisite yet uncommon interactive content for viewers to enjoy.

The sentiment analysis of identified themes found that the topic of free has an approximately equal amount of neutral polarity and positive polarity. Understandably, free access to digitalized museums is always preferable. Still, the point here is that nearly half of the analyzed Tweeter users do not oppose the idea of paying for virtual museum access. Consequently, we are confident that there is room for the Stratford-Perth museum to introduce paid subscription services to their digital platform. As we do not foresee when the COVID-19 pandemic will come to a complete end, the museum's steady income cannot rely on the typical operation model of opening doors for museum-goers. Paid subscription services to the museum's digital content is expected to sustain its operation and perhaps compose a significant portion of revenue post the pandemic. We recommend the Stratford-Perth museum to launch a rational pricing scheme. It could be a one-time fee only or a consecutive charging model on a monthly basis. It could permit viewers full access or offer stratified services for different contents. Anyhow, the emphasis here is that a paid access to the digitalized Stratford-Perth museum is acceptable to the majority of the public.

The word frequency analysis demonstrated that the public was interested in digitalized virtual museums for educational purposes in some study fields. The strong correlation between the themes of virtual and learning again confirmed the public intention. People

turn their heads to museums for obtaining knowledge, most likely because the protection measures fighting against the COVID-19 pandemic have restricted students across the country from learning it at school physically. It is imaginable that teaching quality would be significantly compromised since students can no longer feel as much pleasure of study as before without their peers being physically around. The learning conditions are also minimal. For instance, there is no way to learn from conducting experiments at home as we used to do in the chemistry or physics classes. Therefore, it is reasonable for the Stratford-Perth museum to develop its own education system to complement the current school system and, thus, to attract online traffic from local and perhaps national student communities. Remember, the museum education system may even remain post the pandemic as a revolutionary learning experience. Given the rich history as a railway conjunction and being the hometown of Justin Bieber, the museum can bring its superiority in historical and art collections into full play when preparing interactive teaching content.

Going back to the first recommendation of producing the museum's own digitalized content and the second recommendation of introducing paid subscription services to these contents, the business viability faces another challenge of how the cost and revenue can breakeven, let alone recording a financial surplus. We don't really know how much would making interactive exhibits and an online education system cost, but it will be by no means inexpensive. For a museum suffering from a precipitous revenue decline due to the lockdown measures like the Stratford-Perth museum, the digitalization strategy appears more like a big bet if there might be insufficient paying viewers. Given the nature of a community museum, the current audience is concentrated on local residents who can visit the museum in person. It is not impossible to not having enough online visitors once it goes virtual. Since the public displays a higher proportion of positive sentiment than negative sentiment towards the museum digitalization, we recommend the Stratford-Perth museum promote more on social media such as Twitter and develop its social media brand. Another unparalleled advantage to leverage on is being the hometown of Justin Bieber. We recommend the museum to produce more interactive

content around the superstar to attract his fans from all over the world. Paying a small fee for full access to many unique exhibits and probably little-known stories when he was a kid endows the museum a sustained competitive advantage.

Study Limitations

Firstly, there are a lot of discussions about the Stratford-Perth Museum from public on various digital platforms during the epidemic, but our data all come from Twitter, which excludes user views on other platforms. In addition, the language of the data selected in this study is limited to English, which limits the extensiveness of the research results. Also, the data collected in this research comes from Twitter, where a portion of daily users may be bots using tweets to create spam. This type of data in the form of spam would hinder the accuracy of our results. Even though the remaining 25,420 tweets survived the cleaning process, spam may have remained in our data and it would be impossible to manually inspect all 25,420 tweets to ensure they did not contain spam. Keywords used in the study such as Museum Tech, Museum Technology and Digital Museum helped filter data to retrieve only information relevant to business use of AI amid the COVID-19 pandemic. However, since the logical relationship between these keywords is "or" in Twitter, it is possible that the captured data contains only one of the keywords, which may impact the accuracy of the results.

Conclusion

Our research aimed to answer the question of how the Stratford-Museum can sustain its operations by adopting museum digitalization, especially during the COVID-19 pandemic. We applied word frequency analysis, topic modelling, cluster analysis, sentiment analysis, etc., on about twenty-five thousand cleaned tweets. Our study revealed that the public showed great interest in museum digitalization, with only 10% of people expressed a negative attitude. Negative sentiment among people who prefer an in-person museum experience is not avoidable, so we conclude that going digital for the Stratford-Perth museum is imperative.

The word frequency analysis, topic modelling and correlation analysis indicated that virtual learning by accessing the museum's digital content gives online visitors an immersive experience and comfort at their homes. For one thing, the museums' content can supplement the limited learning resource and unsatisfying remote class experience of the school system due to lockdown measures during the pandemic. For the other, museums offer abundant exhibits in science, history, art, etc. The engagement of interactive content online allows viewers to better understand and absorb knowledge in these fields of study.

Thus, the Stratford-Perth museum should consider establishing its own education system by leveraging its unique collections and exhibits. Virtual learning is the type of digital museum experience that the public calls for now and even when COVID-19 has become an afterthought. The museum should also consider what kind of technology investments are needed to produce interactive content and deliver an immersive experience.

Our analysis also showed that the public is unlikely to oppose a paid subscription of the digital content, so the revenues from subscription fees would recoup the museum's revenue lost due to COVID-19, which provides a direct inventive for the museum to adopt a digitalization approach to remain sustainable.

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