A critical evaluation of the impact of controlled vocabularies on the exchange of data and information in Canadian museums

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Abstract

The study explores the relationship between controlled vocabularies and interoperability within museums. The research works to investigate, understand, and determine the level of interoperability within and between museums and how controlled vocabularies, either universal and unchanged or personalised, impact the success and ability of data sharing and exchange.

A digital survey provided open and closed-ended questions for qualitative and quantitative data from the sample. The sample was selected from the Canadian Museum Association (CMA) and expanded through listservs, from which 55 organisations participated.

The study finds museums lacking in cataloguing practices. The limited number of cataloguers with information management certification has impacted the effectiveness of cataloguing and completeness and consistency of records, primarily through the misunderstanding of rules and standards, and deviations from vocabularies and schema. Data and information exchange through the practice of interoperability largely does not exist within the data set, limiting the ability to make proper connections between vocabulary usage and interoperability strength and effectiveness.

Due to the limitations of the study and survey responses, further research into the understanding of interoperability and the use of controlled vocabularies in Canadian museums is recommended.

Keywords

Interoperability, information exchange, controlled vocabulary, museum, Canada

1. Introduction

Cataloguing is approached through the documentation of knowledge with data, which becomes information through standardised methods and tools to ensure consistency and retrievability. These tools include controlled vocabularies in their various forms and metadata schemata. To ensure maximum retrievability, dimensions to information quality include completeness, accuracy, conformance to expectation, and accessibility (Carpenter and Park 2009), with standards ensuring proper application and execution.

When used correctly and according to their rules and standards, controlled vocabularies heighten record recall and precision (Fenton 2010). When used "incorrectly," by deviating from the vocabulary or not following application standards as mandated, the speed, accuracy, and specificity of searches decrease along with the accuracy and consistency of records (Gilchrest 2003; Fenton 2010). Therefore, universal and personalised vocabularies are equally beneficial for cataloguing, both ensuring standardisation and effective retrieval. So long as there is little deviation and vocabularies and schemata are applied as dictated instead of how a cataloguer may perceive them (Fenton 2010; Smith 2021), they are equally valid forms of vocabularies.

Proper execution of vocabularies and schemata establishes the potential for interoperability (Azuara, González and Ruggia 2013). Considered the ability to exchange information between two or more different computer systems with limited human intervention (Taheri and Khosrowjerdi 2018), interoperability is reached through an agreement on the structure and meaning of information (Diallo et al. 2011). Controlling terms in the development of a vocabulary and further applying those terms to a metadata schema assists in creating consistency and initiating effective data exchange (Gilchrest 2003). With the increase in evidence on the effectiveness of vocabulary control in achieving data standardisation, it has become a developing priority for museums (Gilchrest 2003).

Libraries are a typical example of an organisation with ideal cataloguing methods; compared to libraries, museums' cataloguing methods are limited in both practice and understanding (Zoller and DeMarsh 2013). This study assesses the relationship between controlled vocabularies and both internal and external interoperability in Canadian museums. Canada's museums range from small to large, general to highly specific. The variety allows for a more diverse data set to assess the relationship between controlled vocabularies and information and data exchange.

1.1 Background

Research covering the impact of controlled vocabularies on the effectiveness of information and data exchange is comprehensive, concluding that while interoperability still faces roadblocks preventing complete success, controlled vocabularies have come a long way in supporting the process (Binding and Tudhope 2016). Experts such as Smith (2021), Azuara, González and Ruggia (2013), and Zoller and DeMarsh (2013) further discuss the necessity of adhering to controlled vocabularies and their application standards to ensure maximum interoperability efficiency between organisations. However, interoperability is contingent on successful resource access and sharing, and only possible when resource description is accurate, complete, and consistent (Park and Tosaka 2010). Consistency is ensured by schema usage primarily influenced by peer institutions and vocabularies, either universal or personalised, that are standardised (Park and Tosaka 2010).

Museum cataloguing remains comparatively inadequate despite evidence supporting effective cataloguing methods; limitations exist within the use of vocabularies and schemata, cataloguing approaches and practice, and success in data retrieval and exchange (Zoller and DeMarsh 2013). The relationship between controlled vocabularies and interoperability in Canadian museums is limited; however, the individual elements are discussed more frequently, and connections can be drawn between controlled vocabularies and interoperability (Smith 2021; Diallo et al. 2011). Further, the relationship between vocabularies and interoperability highlights the necessity of controlled vocabularies in cataloguing practices for effective and efficient data exchange to be possible (Azuara, González and Ruggia 2013; Binding and Tudhope 2016; Isaac et al. 2008).

Despite literature highlighting the importance of successful interoperability for current and future data sharing and the necessary relationship between controlled vocabularies and successful interoperability, issues continue to inhibit its success. Most notably, these issues are present within institutions that have limited pre-existing experience with the topic.

1.2 Rationale

Museums are large complex organisations that create and hold large volumes of data and information, with collections and object records being their primary sources of information. They are used by internal (i.e. staff) and external individuals (i.e. visitors, academics conducting research, staff from other

museums). Research into the use of controlled vocabularies is vast, equally so when investigated against the potential and ability of interoperability; within a museum context, research between the relationship and impact of controlled vocabularies on interoperability is minimal.

With a growing focus on shared data and linked data, the need for interoperable systems is becoming more apparent. Although museums share information with the public through curations and exhibitions, this research focuses on sharing digital information and data between organisations, current practices, the effectiveness of the current state, and if there is room to improve. Interoperability decreases in strength with more areas and organisations sharing data while using personalised localised vocabularies (Park and Tosaka 2010). With little work done concerning museum interoperability, it is necessary to understand how it functions within individual organisations and between multiple organisations. Roadblocks and weaknesses with controlled vocabulary use and information exchange require examination to understand interoperability within museums fully.

The findings of this study enrich present data in the field and help to further the discussion around museums, their use of controlled vocabularies, and how interoperability in this context is affected. Further, it will supply museums with information and tools to develop and strengthen their systems to promote interoperability.

2. Aims and objectives

Aim:

> To investigate whether and how Canadian museums effectively exchange data, given their diverse or individual controlled vocabularies.

Objectives:

1. To determine the source of the controlled vocabularies used for indexing in museums
2. To determine whether museums follow rules in the use of controlled vocabularies
3. To examine issues involving deviations from the controlled vocabularies
4. To determine whether and how museums share data with one another
5. To examine whether differing controlled vocabularies and their application affects the exchange of data between museums
6. To make recommendations for future indexing methods based on current practices

3. Evidencing and literature review

3.1 Data versus information

Within the scope of the research, the use and exchange of both data and information in and between museums needs to be addressed. First, however, a distinction between the two is necessary. In the most simple terms, all information is data, but not all data is information (Diallo et al. 2011). To quote Ackoff (1989 p.3): “data are symbols that represent properties of objects, events and their environments”; they inherently do not have recognisable meaning without context. With context, data become recognisable, meaningful, and understandable information. Information “[…] reduces uncertainty, binding consequence to event, prior knowledge to a final effect, discrete occurrences to a single pattern” (Koch 1993 p.386), giving data meaning through context. Therefore, the context surrounding data creates information and can make storing and transferring it problematic (Kock, McQueen and Baker 1996). Kock, McQueen and Baker (1996) suggest storing data alone, generating the information based on contexts at the time of

retrieval. While this approach may work in more controlled environments, the diverse nature of Canadian museums in both size and content presents a challenge. As discussed in the following sections, the challenge of current museum cataloguing practices plays a significant role in the status of museum records and exchange methods. It would be remiss to focus merely on either data or information exclusively in the pursuit of understanding museum interoperability. Current museum methods are archaic compared to other institutions, and narrowing the focus would prevent an accurate understanding of the current situation.

3.2 Controlled vocabularies and museums

Controlled vocabularies are "on the most basic level, […] a list of discrete terms used to standardise communication in order to facilitate understanding" (Smith 2021 p.186) and used to "index content and/or retrieve content through browsing or searching" (Harpring 2010 p.12). Vocabularies promote consistency in indexing and access to catalogued items in retrieval by ensuring the same specific terms are used, regardless of the cataloguer (Harpring 2010). They are developed by carefully selecting terms, potential synonyms and variant terms, and mapping relationships between concepts. Many controlled vocabularies already exist and are comprehensive enough to be used by various museum organisations in their cataloguing and indexing efforts. These include the Getty Vocabularies (The Getty Research Institute n.d.), Nomenclature for Museum Cataloguing (Canadian Heritage Information Network 2021), the Library of Congress Authorities (The Library of Congress 2019) and the Thesaurus for Graphic Materials (The Library of Congress n.d.). Regardless of the number of universal vocabularies, individualised vocabularies exist within museum cataloguing (Zoller and DeMarsh 2013). Individual vocabularies are often created for specialised fields and offer more stability, accuracy and currency than universal vocabularies can provide (Smith 2021). Harpring (2010) suggests that while such vocabularies are acceptable and work well within specific environments, they must also follow national and international standards and be sharable and accessible by any external authority participating in information exchange.

The primary goal of a controlled vocabulary is to ensure there is little room for misunderstanding categorised data through the development and emphasis on relationships between concepts represented by terms in the vocabulary (Smith 2021; Harpring 2010). Furthermore, if multiple organisations utilise the same data, vocabularies help eliminate data conflicts and "improve the description and organisation of information resources for later retrieval" (Smith 2021 p.186). Smith (2021 pp.187-188) further describes controlled vocabularies as "a vital component of modern cataloguing as a means of providing a stable and consistent framework of description to facilitate retrieval through search and discovery". In addition to the aforementioned benefits of controlled vocabulary usage, they save time; in using one (or multiple), "cataloguers do not have to repeatedly record the same information" (Harpring 2010 p.133).

Most importantly, especially within museum cataloguing, controlled vocabularies make undiscoverable items (i.e. objects that are not text-based) discoverable (Gross, Taylor and Joudrey 2014). Due to the physical nature of many museum exhibits, objects would be nearly unretrievable without subject headings. Therefore, careful attention to documentation is required, with consistency and accuracy in record creation ensuring accurate and comprehensive retrieval (Smith 2021).

Within museums, controlled vocabularies organise and manage collections, allowing access to information and understanding of knowledge on a broader scale (Isaac et al. 2008). Due to museums' wide variety of objects, museums utilise multiple controlled vocabularies covering fields that range from general to specific (Government of Canada 2020). However, the use of individual or diverse controlled vocabularies can create problems of heterogeneity that affect interoperability, where the vocabulary

formats may not be compatible, or the vocabularies contain identical concepts with different names or labels (Isaac et al. 2008). Therefore, making personalised vocabularies available is the most appropriate action, second to standardising said vocabulary to universal rules and creation methods.

3.2.1 Types of controlled vocabularies

Regardless of the type of controlled vocabulary, they all have the same core purpose: to ensure unambiguous indexing and item retrieval regardless of the user.

Controlled lists are of the more straightforward vocabularies; they are made strictly of simple terms with no overlapping meaning to control terminology and are generally designed for one specific database (Harpring 2010). Because of the limited terms, controlled lists ensure a high level of consistency but are more accessible to navigate than other forms of vocabularies. The nature of controlled lists, if specialised and personalised to an individual organisation, can benefit local cataloguing in small organisations. Smaller collections and fewer staff bring an increase in familiarisation with objects, records, and retrieval within small local organisations, where more complex vocabularies would not be necessary without frequent external data exchange. However, the lack of relationship mapping, synonyms or variant terms, and term definitions does create inconsistencies and will negatively impact interoperability at an inter-organisational level.

Authority files consist of names or terms with a preferred term or name used as an authority (Harpring 2010). Authority files are primarily used to control index terms or variants within collections to ensure consistency in spelling and term variation (i.e. using an individual's married name versus their maiden name) (Government of Canada 2020). Most controlled vocabularies have authority terms, such as the preferred terms in thesauri, providing specific terms for cataloguing and preventing ambiguity through the use of qualifiers and parent strings (Harpring 2010).

Taxonomies are controlled terms within a hierarchical structure, where each term is in at least one broad/narrow relationship (Harpring 2010). The relationships do not have as much depth or structure as a thesaurus, but there is enough to create relationships and links between concepts (Harpring 2010).

A thesaurus is a more complex version of the taxonomy, combining unique concepts, relationships, broad/narrow contexts, related concepts, and explanatory information (i.e. definitions, bibliographic citations). Recommended for art or cultural heritage databases (Harpring 2010), thesauri are especially useful within museums. Search results are more comprehensive but equally relevant by having preferred terms, non-preferred terms, synonyms, language equivalencies, and broad/narrow terms for each entry in the thesaurus (Government of Canada 2020). Additionally, thesauri assist in choosing appropriate terms to describe objects and collections, using scope notes to assist in understanding the "precise meaning and usage of particular concepts found in the thesaurus" (Government of Canada 2020). Describing the meaning of terms limits ambiguity and misinterpretation of term meanings, limiting inconsistency and improving accuracy in retrieval.

Ontologies are not controlled vocabularies; however, they utilise vocabularies to define "concepts, properties, relationships, functions, constraints, and axioms" (Harpring 2010 p.24). With the ability to structure concepts, instances of such, and relations within a domain, ontologies have been used more frequently in museums in recent years (Le Boeuf et al. 2005). Within the museum community, there have been attempts to create an ontology-based system to mediate between potentially incompatible systems, though widespread use has currently not been adopted (Le Boeuf et al. 2005).

These four types of controlled vocabularies exist within museum cataloguing and provide a specific and unambiguous way to index items in museum collections. The different types of vocabularies do not act as roadblocks to understanding data or interoperability; instead, standardisation methods in creating vocabularies facilitate universal understanding and compatibility. However, regardless of the benefit one type of vocabulary may have over the other, Isaac et al's. (2008) warning of heterogeneity in the face of conflicting formats impresses the importance of either conforming to an existing vocabulary or making local cataloguing and vocabulary information available externally.

Alphanumeric classification schemes, synonym ring lists, folksonomies, and subject heading lists are additional variations of controlled vocabularies. However, they have minimal impact, infrequently exist within museum cataloguing and are not relevant within this context.

Despite the benefits of adopting a controlled vocabulary, and while museums are centres of information and research (Soares and Smeds 2016), vocabularies are not widely adopted in the museum community (Gilchrest 2003). Furthermore, documentation methods and schema adoption within museums are considered substandard (Zoller and DeMarsh 2013). Issues such as funding and suitable personnel, a lack of understanding between cataloguing and documentation, divisions between curatorial and registrarial roles, and the failure to recognise the role an information specialist can play contribute to the inability to meet the level which libraries achieve (Zoller and DeMarsh 2013).

3.3 Museum cataloguing

While library cataloguing and information analysis have been influences for museums, in comparison, museum cataloguing is currently quite substandard (Zoller and DeMarsh 2013). Zoller and DeMarsh (2013 p.69) have found there is a "reluctance to embrace community-wide, as opposed to local, cataloguing standards" and that there is a general lack of agreement about what constitutes as cataloguing within museums. While museums are more diverse than the average library through size, specialisation, and purpose, but do not necessarily follow the strict practices of libraries, consistent cataloguing will benefit the institutions.

Zoller and DeMarsh (2013) found the necessity of multiple vocabularies and schema in museum cataloguing due to the diversity of unique and special collections. Cataloguing would become too convoluted, and the terms too simple for efficient retrieval should it be limited to the use of one vocabulary (Zoller and DeMarsh 2013). However, using diverse methods for cataloguing creates different issues such as heterogeneity and redundancy (Isaac et al. 2008). Of the issues with museum cataloguing, the lack of comprehensive and effective implementation carries the most weight.

Roberts and Light (1980) define the documentation problem within museums as a result of insufficient resources to cope with the number of items in collections and the expected quality and completeness of cataloguing records. Inaccurate, incomplete, and inconsistent records are the result of current museum approaches (Roberts and Light 1980; Zoller and DeMarsh 2013). While there is an effort to put more resources towards cataloguing, there are still barriers to cataloguing within museums that prevent efficient information sharing (Zoller and DeMarsh 2013); *efficient* not in the sense that all human intervention is no longer needed, but where issues such as data redundancy, problems with sharing services and functionality, lack of interdepartmental coordination, high operational and maintenance costs, and data integrity and quality are minimal. These cataloguing issues will always exist; however, incorporating the strict use of vocabularies and schemata mitigates the extent to which they affect record creation, keeping, and retrieval.

As mentioned in Section 3.2, various factors inhibit museum cataloguing from meeting the level of libraries. These factors, in turn, prevent opportunities such as performing work more efficiently and accurately, using repurposed collections data to build applications or programs, and the ability to share collection information beyond the museum (Zoller and DeMarsh 2013). Of the many issues museums face concerning cataloguing, the lack of qualified information specialists is at the centre (Zoller and DeMarsh 2013). This role is different from that of a curator or registrar; museum cataloguers organise documentation whereas curators and registrars create and optimise it for retrieval (Zoller and DeMarsh 2013).

Though documentation is crucial for museums, Zoller and DeMarsh (2013 p.57) discover only four basic kinds of information are required: "what it is, when it was acquired, and who gave it or from what fund it was bought". Additionally, they found that there was no requirement to make the "information easily [retrievable] by criteria other than known details about the object" (Zoller and DeMarsh 2013 p.57). Due to such limited standards, should an item be entered in multiple museum systems but through different standards and with different terminology, in addition to problems with data export and import, there is a considerable possibility for data redundancy and an increase in human intervention (Carlisle and Lee 2016). Effective collections management is contingent on immediate comprehensive documentation of an object (Roberts and Light 1980); however, with limited staff and staff with limited qualified specialists, exhaustive, accurate, and standardised entries are rare (Zoller and DeMarsh 2013; Dibakar et al. 2011).

3.4 Interoperability within and between museums

While the term is "ambiguously defined" through various existing definitions (Diallo et al. 2011), Taheri and Khosrowjerdi (2018 p.2) offer a succinct definition, explaining interoperability as "the capability of interaction among multiple information systems with the aim of data exchange and services." This is possible when linguistic, terminological, and verbal differences in the cataloguing of objects are overcome (de Almeida Campos, Campos and Barbosa 2020).

Interoperability, in all its descriptions and definitions, maintains two common themes: information exchange—the ability to share and exchange information between two different computer systems—and usability of information (i.e. the usefulness of the shared information) (Diallo et al. 2011). The direction of information flow determines its usefulness, with those on the receiving end being the judges as they ultimately determine what information is essential (Diallo et al. 2011). However, sharing information is only possible when "linguistic, terminological, and verbal differences that are defined by the idiosyncratic conditions of each environment" are overcome (de Almeida Campos, Campos and Barbosa 2020 p.682).

The existence of universal metadata schemata (such as the Cataloguing Cultural Objects schema) helps regulate data across systems. However, alterations to the standards at a local level can negatively impact interoperability (Binding and Tudhope 2016) through the increased necessity of human intervention to combat inconsistency and inaccuracies. While the negative impacts will not completely inhibit information exchange, changing or deviating from data entry requirements can lead to data redundancy, problems with sharing services and functionality, lack of application interconnectivity, lack of interdepartmental coordination, high operational and maintenance costs, and problems with data integrity and quality (Dibakar et al. 2011).

To achieve interoperability, how information is described and how it will be exchanged require agreement (Diallo et al. 2011). Without consistency of information between the two systems, interoperability will significantly decline, and the potential of sharing accessible and understandable information will

decrease. As further discussed in Section 3.2, certain variables can increase interoperability efficiencies. Using universally recognised metadata schemata and controlled vocabularies (in any of their forms) creates a level of consistency in data entry across organisations (Diallo et al. 2011). In addition, the benefit of standardising information description is helpful for the flexibility of capturing information and using common infrastructures (Diallo et al. 2011).

Furthermore, it is recommended in the European Interoperability Framework by the European Commission that "interoperability should be guaranteed in a sustainable way" (2017a p.23). The approaches taken to achieve interoperability within or between organisations must be permanent and consistent. The European Commission (2017a p.24) suggests six steps to managing the fundamental standards to ensuring interoperability:

1. Identify candidate standards and specifications based on their specific needs and requirements;
2. Assess candidate standards and specifications using standardised, transparent, fair and non-discriminatory methods;
3. Implement the standards and specifications according to plans and practical guidelines;
4. Monitor compliance with the standards and specifications;
5. Manage change with appropriate procedures; and
6. Document standards and specifications, open catalogues, using standardised descriptions.

These steps are the foundation of the research study and will aid in the investigation into data and information exchange in Canadian museums.

3.4.1 Four layers of interoperability

Legal interoperability covers potential restrictions due to sectoral or geographical barriers, including data usage and storage, differing licencing models, obligations to specific technology use and outdated security (European Commission 2017a). Identifying these limitations increases the potential for stronger interoperability. Given the size of Canada and the independent nature of museum organisations, legal interoperability is necessary to overcome and assist in the exchange of data between museums that are separated by distance, both physically and divisionally.

Organisational interoperability is achieved through the aligning of processes, responsibilities, and expectations within organisations. Furthermore, its focus centres around users' needs, making "services available, easily identifiable, accessible and user-friendly" (European Commission 2017a p.28). Standardisation of vocabulary and schema usage and cataloguing methods in museums has the potential of aligning processes, but more so will simply enlighten the process to identify similarities, differences, and compatibilities that affect organisation interoperability, either positively or negatively.

When the format and meaning of the exchanged data are "preserved and understood," semantic interoperability is reached (European Commission 2017b). Within semantic interoperability, there are semantic and syntactic aspects. The former refers to the "meaning of data elements and the relationship between them" (European Commission 2017a p.29), whereas the latter covers the format of the data (i.e. grammar and formatting). Diallo et al. (2011) further discuss semantic interoperability as only being reached when the meaning and structure of information have been agreed upon, meaning both parties of the data exchange must meet the standards for the data to be understood. When looking at controlled vocabularies and how they are used in museum cataloguing, semantic interoperability holds the primary focus of the research. Controlled vocabularies define terms for a universal understanding that allows for unambiguity and precise item retrieval.

Technical interoperability "covers the applications and infrastructures linking systems and services" (European Commission 2017a p.30). It goes beyond the systems to include "interface specifications, interconnection services, data integration services, data presentation and exchange, and secure communication protocols" (European Commission 2017a p.30). Within the context of the study, technical interoperability is investigated to determine if museums use multiple systems internally, link to others externally, and how interoperability is affected in the face of different cataloguing practices.

Within all four layers of interoperability, it is clear that the main objective is to create an environment that is agreeably uniform with the user as the focus. However, due to the increasing heterogeneity and dynamism within individual systems, strong, long-term interoperability remains a significant problem (Blair et al. 2011).

The focus of the research includes all four layers of interoperability in the pursuit to understand data exchange between museums.

3.4.2 Roadblocks to interoperability

Despite the work done to educate people on the benefits of interoperability, information exchange still faces many roadblocks. The primary force behind interoperability is the capability for participating organisations to collaborate inter-organisationally (Scholl and Klischewski 2007). While universal schemata and vocabularies are commonly used, Scholl and Klischewski (2007) identify social and political organisation, purposes, issues and values, and leadership capacity and style as contributors to low interoperability capability.

4. Methodology

Given the nature of the study and the intended focus of the data to be collected, typical qualitative analysis approaches will not be applied to the data. While there will be open-ended questions in the data collection method, their focus is to expand upon the quantitative questions and supplement them with deeper explanations. It is not appropriate to apply hermeneutic approaches such as semiotics or discourse analysis because while it is vital to consider biases and nescience, the study intends to obtain data concerned with system interoperability, not human ideology or perception. As discussed further in Section 4.3, cross-tabulation and simple statistical analysis will be the core methods for analysing the collected data.

4.1 Research methods and data collection

The initial intention for the study was for a more diverse and mixed-method approach to the data collection; due to COVID-19, the restrictions of such, and the impact it has had on museum organisations, there was no interest in participating in interviews or an observational study. The response for the survey, however, was higher than anticipated, yielding 55 submissions from diverse respondents. The layout of the survey, as further discussed in Section 4.1.1, includes both open and closed-ended questions, giving participants the chance to expand and speak in their own terms—a beneficial element, with the absence of interviews and observation as research methods, that allowed for a form of qualitative data to be collected.

Situating the research within a Canadian museum context was to keep the study large enough for the possibility of generalisation but within set geographical boundaries so that the data would be relatable between the respondents.

4.1.1 Survey

Data were collected through the use of one complete survey. As one of the most commonplace approaches to social research, surveys have three main characteristics: comprehensive and inclusive coverage, the ability to show behaviours and practices at specific points in time, and to provide empirical research data (Denscombe 2010). Additionally, surveys "inform knowledge, challenge existing assumptions, and shape policies" (Gideon 2012a p.3). Effective surveys are by no means simple to create, requiring more than just merely "asking questions" (Gideon 2012a). However, if created correctly, with survey methodology in mind and supported by preliminary research into the topic, they are a useful data collection method, obtaining relatively uncomplicated data from a large population about a specific issue (Rugg and Petre 2007; Denscombe 2010; Gideon 2012a). Primary advantages to using a survey as a data collection method are:

- Being able to produce empirical data, as responses are based on real-world observations;
- Having results generalisable to a population due to the breadth of coverage;
- The ability to collect qualitative and quantitative data; and
- An efficient method for extensive data collection in limited timeframes for low costs (Kelley et al. 2003; Denscombe 2010).

When lacking appropriate introductory details and built with poorly framed questions, surveys are at risk for response and non-response bias, leading to poor prediction ability (Gideon 2012b). To ensure the survey would be effective in its data collection and avoid collecting unnecessary and perhaps useless data, a literature review of the topic and survey methods ensured questions were structured appropriately. Additionally, to ensure the survey was free of double-barrelled or double negative questions, overly complex questions, leading or loaded questions, and unnecessary repetitiveness, it underwent multiple stages of review during the creation stage.

Despite the response rate for surveys being relatively low at approximately 20% (Kelley et al. 2003; Krosnick 1999), a survey was determined to be the most appropriate data collection method in the face of COVID-19 and its current limitations and restrictions, the time restraints on the research project, and the type of data to be collected.

The survey used was split into four separate categories for clarity and presentation purposes (Kelley et al. 2003): (1) Participant Information, (2) Controlled Vocabularies, (3) Metadata, and (4) Interoperability. While closed-ended questions are preferred for survey questions and are perhaps more efficient for analysis, open-ended questions are considered more reliable and valid (Krosnick 1999). Therefore, a combination of open and closed-ended questions made up each section of the survey, allowing participants to share how they interact with their data within specific parameters as well as share individual perceptions regarding current practices.

Where possible and necessary, free text and 'I don't know' options were offered as potential answers, increasing the participants' ability to complete the survey at their level of comprehension. Since free text questions improve the validity of the survey but may impact data analysis due to the potentially wide range of answers (Rugg and Petre 2007), most of the questions were closed-ended instead of open-ended to limit such complexity.

The survey was distributed to an individually selected sample through MailChimp. The body of the email introduced the topic and reason for the research, added a small overview of the background, purpose,

and privacy, and supplemented the information already located at the beginning of the survey to ensure informed consent.

4.1.2 Sampling

A non-random sampling approach ensured diversity in the sample. While random sampling is more common with survey-based data collection (Kelley et al. 2003), because of the geographical context and the discovered impact of COVID-19 on organisation operations via preliminary inquiries, directly targeting curators and administration within museums as recipients of the survey gave more of an assurance of appropriate participants.

Of the three non-random sampling techniques Kelley et al. (2003) discuss, purposive sampling was the primary technique for sample selection, focusing on museum curators as ideal respondents to the survey. Furthermore, the survey and the cover email encouraged multiple responses and further distribution within organisations; a number of those participating made it known they posted the survey on internal forums.

Data collection from every museum regardless of size, type, or location would be unpractical. Therefore, the sample was narrowed to remain within Canada and excluded any Associations or Library Archives listed on the Canadian Museums Association (CMA) roster. Due to their similarities from an organisational standpoint through forms and types of collections and non-text-based object cataloguing, Art Galleries with membership to the CMA were included in the sample, though the response rate was limited. Furthermore, the sample included only those that had contact information available.

Size and type of museum were not determining factors within the sample selection process, with the intention of having a diverse set of data across various organisations. While narrowing the sample to a particular size (large with diverse collections versus small with a singular collection) or type of museum (specialised versus multi-interest) would have created a more focused data set, the intention of investigating information exchange across Canadian museums requires the inclusion of all organisations.

From the CMA membership roster, 785 organisations were deemed appropriate for the study. In addition to the sample extracted from the CMA roster, four listservs expanded the potential reach of the survey:

- **Canmuse-L Listserv:** a bilingual forum for museum and heritage professionals within Canada to discuss topics of interest within a museum context; the largest listserv of its kind in Canada
- **BCMA Listserv:** a forum for individuals to discuss museum-related topics; through the BC Museums Association
- **MCN-L Listserv:** a forum for sharing and discussing within the musetech community
- **CS-AAM Listserv:** a forum for the Collections Stewardship of the American Alliance of Museums (AAM)

The anticipated response rate to the survey was 1-5%. While postal questionnaires generally perform at an approximate 20% response rate (Kelley et al. 2003; Krosnick 1999), factors of COVID-19 and participation ability lowered the average anticipated rate. Concern for an adequate number of responses was managed through the various distribution methods. In contrast, the low anticipated response rate eliminated concerns for exorbitant data collection and analysis from such a large sample size.

4.1.3 Piloting

A pilot of the survey was conducted prior to the execution of the study. Kelley et al. (2003 p.263) highlight the importance of piloting as a way to "identify whether respondents understand the questions and instructions, and whether the meaning of questions is the same for all respondents." Gideon (2012b p.104) further explains that "running a pilot test […] is also important to detect the more mundane errors such as typos, grammar mistakes, jumbled question order, and numbering, unnecessary repetitiveness." Piloting the research method further indicates validity and reliability, identifies unnecessary questions and over-complicated terminology, and offers a better understanding of the target population (Gideon 2012b).

Krosnick's (1999) alternative methods of behaviour coding and cognitive coding were too complex for the simplicity of the survey and are more appropriate for interview pretesting. While Krosnick (1999 p.542) criticises the conventional method for being unreliable, they place the same criticism on the cognitive coding method and go on to propose that said unreliability may "reflect the capability of a particular method to continue to reveal additional, equally valid problems across pretesting iterations." Thus, a conventional method of pretesting was used by assessing answers and feedback from pilot participants and making changes to the survey where necessary.

The pilot was sent to five individual museums and posted on the BIBCANLIB-L listserv. Responses to the pilot illuminated areas that required rewording; complex terms were replaced with more general vernacular, and description and explanation were added where needed. Additional questions were included to fill gaps in the survey found by the pilot.

4.1.4 Validity and reliability

The validity of a survey is its ability to accurately measure the scalable data it is set out to measure (Litwin 1995; Kelley et al. 2003), whereas reliability refers to the ability of the survey to be consistent in its measurements (Long and Johnson 2000; Kelley et al., 2003). In other words, "'reliability' is the extent to which a measurement procedure yields the same answer however and whenever it is carried out; 'validity' is the extent to which it gives the correct answer" (Kirk and Miller 2021 p.19). The study intends to examine the relationship between controlled vocabularies and information exchange between museums; therefore, the survey does not intend to find 'correct' answers, only correct in that they are answered consistently throughout the survey.

Detailed design and review of the survey mitigated many common validity errors. Measurement error, primarily in the form of inconsistent respondent answers due to design flaws (Henninger and Sung 2012), was avoided through close attention to the layout and ensuring sections were separated by topic (see Section 4.1.1 for more detail). Sampling and coverage errors were avoided by drawing the sample from the Canadian Museum Association, thus ensuring a large and diverse sample, and distributing the survey through museum-focused listservs. The nonresponse error was unavoidable. However, including the optional question of organisation name in the survey (which had a ~7% response rate) allowed insight into the type of respondents and context for the responses. While bias within nonresponse is based on differences between those who do and do not respond (Henninger and Sung 2012), identification of respondents has shown that the responses were reasonably equal across type and size and could have been representative of the larger population if the data set had been larger.

Henninger and Sung (2012 p.304) suggest the "simplest way to ensure consistency is to provide each respondent with the same set of questions, in the same order, and with the same formatting." As such,

the responses are based on the individual themselves instead of differences in the survey (Henninger and Sung 2012). As discussed in Section 4.1, this study's lack of additional research methods limited available data collection methods exclusively to survey usage. By using one survey for data collection, consistency was guaranteed in the research method. Further, the pilot process ensured that the survey questions remained concise and unambiguous with simple, universally understood terminology. In doing so, all respondents would then experience the questions the same way and any confusion would be limited.

Including an equal range of size and types of museums in the sample to represent the larger population ensured the external validity of the survey.

4.2 Ethical considerations

The ethical considerations for this research are low; however, obtaining informed consent is necessary. It is not the intention of the study to find faults in the systems currently in place; rather, the intention is to discover how the current systems work and how, if necessary, they could be improved to allow for a more developed level of data exchange. Therefore, there is little risk to the defamation of the organisations or individual participants of the study. However, the risk of potential backlash against individual participants for their thoughts and views exists; ensuring anonymity of all parties through as many steps of the data collection period as possible mitigates this risk significantly.

Ensuring anonymity and following strict confidentiality and information security procedures will prevent unauthorised personnel from accessing any information (Denscombe 2010) and minimise the risk of sensitive or confidential information being exposed. The JISC Online Survey tool used for data collection promotes data security as one of their main priorities, following “strict information security standards [with] data [being] processed in compliance with General Data Protection Regulation (GDPR)” (JISC n.d.). Furthermore, using a trusted service “designed specifically for education and research organisations” (JISC n.d.) ensures that the data are safeguarded in the necessary ways to prevent unauthorised access.

The number of participants and the right to withdraw are risks against the study itself. As a smaller-sized study during a global pandemic, response rates were projected to be relatively low following initial contact with several museums across western Canada and ran the risk of insufficient results. Contingency plans were created but were not needed as the survey yielded enough results to keep the study within a Canadian context.

Participants were educated on all aspects of the study, from the intent and focus to individual rights as a participant, via the information and consent page at the beginning of the survey and the email the survey was attached to. The information detailed and reinforced the voluntary nature of participation, expressed the benefit of participating, and detailed contingencies to combat any risk to the participant (Oldendick 2012). Before the participant could proceed to the survey, they were required to confirm consent through a yes/no question.

4.3 Data analysis

Due to the qualitative and quantitative nature of the data gathered from the survey and the intention of the research itself, it was determined that cross-tabulation analysis and simple statistical analysis were the most appropriate data analysis techniques.

By incorporating open and closed-ended questions into the survey, making it more mixed rather than either strictly qualitative or quantitative, the responses aided in interpreting the data as a whole, creating a clearer image of the findings (Suter 2021).

Despite the mixed-method data collection, data analysis was done through IBM's analysis software package. SPSS Statistics v25. SPSS supports the analysis of large data sets and a "top-down, hypothesis testing approach" (IBM n.d.) and can support the requirements for cross-tabulation and statistical analysis, therefore supporting the analysis needs of the study.

4.3.1 Cross-tabulation analysis

The premise of cross-tabulation is to "look at responses to one question in relation to responses to other questions" (Sreejesh, Mohapatra and Anusree 2014 p.174) from data organised into groups to facilitate comparisons. Since a "cross table can be produced on almost all parameters for given survey data" (Sreejesh, Mohapatra and Anusree 2014 p.176), it is the ideal analysis method in the face of the research question.

The use of cross-tabulation analysis aided in drawing conclusions between the data and how they are associated and correlate with each other (Momeni, Pincus and Libien 2018); the analysis aided in drawing connections between responses both in and between the topic sections of the survey.

4.3.2 Statistical analysis

Suter (2021 p.387) describes the goal of statistical analysis as making "an inference about the hypothesis being tested and [reaching] a conclusion about a larger population represented by the sample." However, "such inferences are warranted only when the study is not jeopardised by methodological flaws, such as biased sampling, threats to internal validity, or any other sources of contamination" (Suter 2021 p. 415). Accordingly, steps were made to prevent contamination, as detailed in Sections 4.1.1, 4.1.2, 4.1.4, and 4.4.

While statistical analysis usually ensures a study will go beyond remarks of survey results and make generalisations that represent the population (Suter 2021), the small percentage of respondents prevented the study from being genuinely representative and made it unable to make any generalisations beyond the data set. Several statistical tests for qualitative data can be performed to reject the null hypothesis and prove a relationship between the variables within the targeted population (Suter 2021); however, the focus was on comparing differences.

Within the context of the research topic, content and discourse analysis were deemed inappropriate. Analysing qualitative data involves classifying, coding and finding patterns through inductive strategies to produce "new ways of understanding a complex phenomenon" (Suter 2021 p.408). Instead, open-ended questions were introduced into the survey for explanatory and individual perspective purposes regarding museum systems. Comments and remarks from the respondents aided only in supplementing the statistical data and reinforcing determinations made from the analysis.

4.4 Limitations

Since "higher response rates […] do not necessarily translate into more accurate results" (Krosnick 1999 p.540), the lower number of responses is not necessarily a limitation to the research. As such, while this study is small and can only truly represent the small data set, there is hope that the impact of this study is broader than that of just the organisations that are studied. A study at a much greater scale that

encompasses interoperability at an international level between a variety of museum sizes and specialisations would be one that would have more than a minor impact on the technical museum community.

However, while the survey yielded more than the expected number of results, the data set was too small for the sample to be generalisable. The study was further limited by the single collection method employed; in the face of COVID-19 and its impact on museums, surveys were the only acceptable collection method. Posting the survey on listservs added to the diverse sample and expanded the reach to museums outside the sample to minimise this limitation.

Denscombe (2010) warns of bias through non-contact as an issue for internet-based research. Although the sample, as discussed in Section 4.1.2, was selected to represent the population that the research analyses, lack of contact information or interest to respond contribute to non-contact bias. This bias is mainly a by-product of internet research done through websites, chat rooms, or newsgroups; the respondents represent those online and are interested instead of representative of the targeted population (Denscombe 2010). Therefore, a diverse sample was established to counteract any potential non-contact bias, and multiple methods were used to distribute the survey.

This study complements existing literature on the subject and helps shed light on the inner workings of data exchange between museums.

4.5 Evidencing identification

The literature and evidence used for both the literature review and supporting methodology were located primarily from the following databases:

- Library Literature and Information Science
- Emerald
- Web of Science

A broad to narrow search approach was initially taken. Briefly browsing to better understand the existing literature, incorporating complex searching and utilising chaining methods helped narrow down and locate appropriate supporting evidence.

5. Findings and analysis

5.1 Participant analysis

The survey received 55 responses from museums across Canada (see Figure 1). From those comfortable in supplying their organisation's name, the respondents were varied and diverse, covering large and small, multi-interest and specialised museums (see Figure 2). Size and interest were determined by public information detailing the focus of the museum. Determining the 'size' of the museum was based on the size of the collection. The physical building size is a misleading factor, considering the possibility of small collections of large objects, such as an aerospace or military vehicle museum.

The variety of respondents is beneficial for the pursuit of understanding information and data exchange between Canadian museums. However, due to the small data set, generalisations to the population cannot be made. For this study, the diversity of respondents gives a broad perspective of cataloguing methods and data exchange and is a beneficial starting point for future research in the area.

Figure 1. Geographical representation of respondents

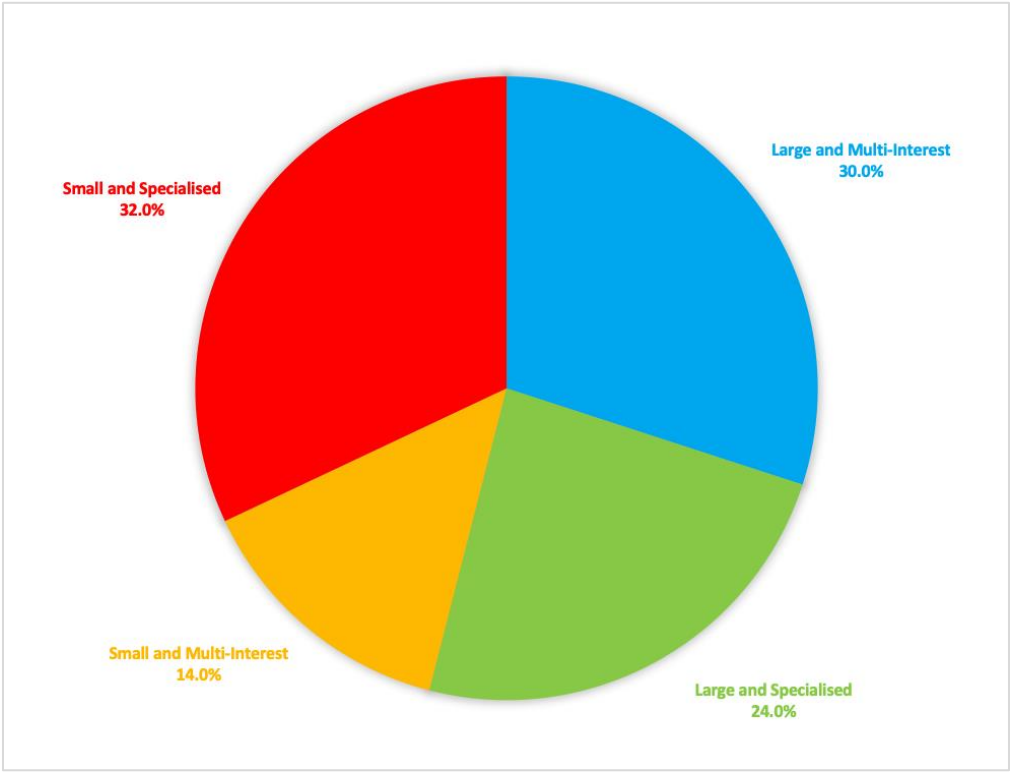

Figure 2. Size and types of museums respondents are from.

Respondents fell into four main departments: (1) Curatorial (16.4%), (2) Collections (56.4%), (3) Administration (18.2%), and (4) All Areas (covering all museum duties, as stated by the respondent) (9.0%). The presence of respondents outside of collection and curatorial departments provide a rounded perspective of how museum employees, in all areas, view and understand cataloguing in theory and practice. Limiting the survey exclusively to those in a defined collection or curatorial role would narrow responses to larger museums with various departments and positions. The more diverse nature of respondents provides a larger data set and a more diverse view of current knowledge and practices.

Primary roles of respondents include Curation at 36.4% and Collections Management at 32.7%. Cataloguing held one of the lowest respondent percentages at 3.6% (see Figure 3 for a complete breakdown of respondents' roles). With cataloguing in museums seen as comparatively sub-par (Zoller and DeMarsh 2013), the low percentage of participants in a defined cataloguing position was not unexpected. Those in the cataloguing role were all from large, multi-interest museums. From the limited data set, it cannot be proposed that a museum's size determines the level of interest and investment in cataloguing; however, it is discernible that museum size impacts the number of roles within organisations, consequently impacting the prioritisation of tasks.

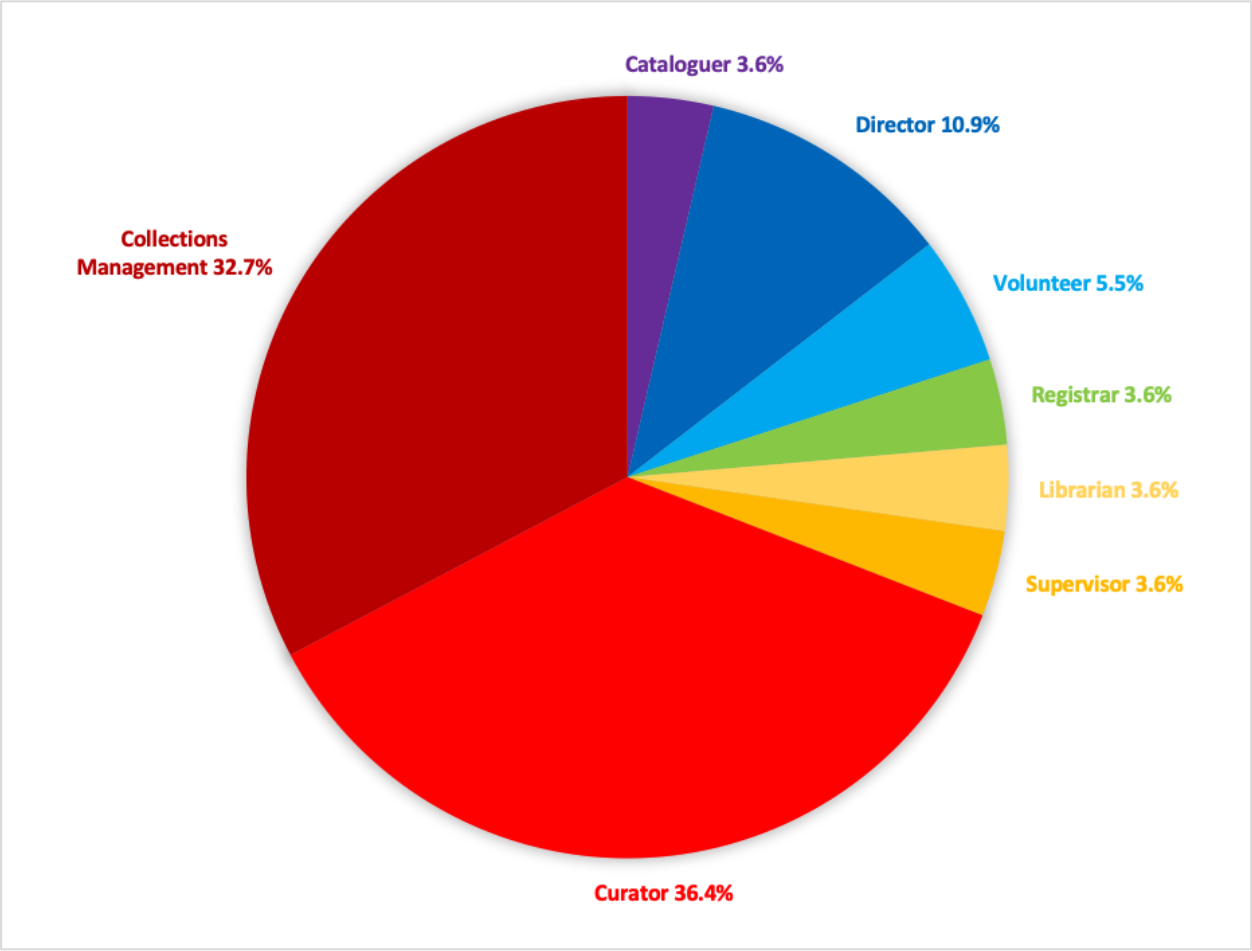

Figure 3. Roles respondents have within their organisation.

Respondents in the cataloguing role additionally stated that they were unaware if they held certification in information management (or the equivalent). Lack of certification does not necessarily determine lack of knowledge or skill in cataloguing, nor does certification mean possession of knowledge and skill; however, cataloguing skills learned and information management knowledge gained in the workplace were not considered in the data analysis. For this study, certification was a measurable gauge in which to determine skills and knowledge. There was no effective standardised way to measure learned skills through practical work experience to allow for comparison and cross-tabulation analysis. While lack of certification does not negate understanding and knowledge, the study approached this factor as a with/without binary.

Despite the low percentage of respondents certified in information management or the equivalent at 41.8%, 89.1% of respondents stated they frequently interact with data, with 78.2% additionally working with data systems frequently. Of those that either stated that they did not have certification or did not know if they had certification in information management, 59.4% found that they experience issues with current cataloguing standards and practices. However, compared against common interoperability issues, respondents with no certification experienced them less frequently than those with certification. On a frequency scale, uncertified respondents reported 'never' at 91.7% for data redundancy, 72.2% for problems with sharing services and functionality, 76.5% for lack of interconnectivity, 77.3% for lack of interdepartmental coordination, 76.9% for lack of data integrity and quality, and 52.4% for high operational and maintenance costs.

Aside from those stated above, there are few variables that are distinguished by certified or uncertified respondents. The academic standing of respondents does not impact perceived weaknesses in internal or external information and data exchange, nor cataloguing practice.

Despite the literature expressing lack of certification and limited cataloguing priorities in museums as primary reasons for problems within data (Zoller and DeMarsh 2013), the survey responses suggest the lack of individuals with official certification in the field does not directly correlate to problems museums face in cataloguing.

5.2 Controlled vocabularies

Without the use of subject headings, approximately one-third of records would be lost and unretrievable in cataloguing systems (Gross, Taylor and Joudrey 2014). Despite this statistic and the influence of library cataloguing methods on museum practices (Zoller and DeMarsh 2013), only 86.7% of the survey respondents know of and utilise a controlled vocabulary while cataloguing objects in their organisation. Of that 86.7%, 43.8% of respondents stated they use universal vocabularies without internal alterations of any kind, 54.2% use a personalised vocabulary (this includes the creation of one by an organisation or the altering a universal vocabulary to their needs and requirements), and only one respondent uses both. The approaches to personalised vocabularies vary. Respondent 28 stated: "We use local common use words and have followed no established system." Respondent 5 shared: "We try to be exact. For example, location of artefacts can be impacted by such think [sic] as capitalisation i.e. box 10 or Box 10."

Among those using a universal vocabulary who shared which specific one it was, Nomenclature for Museum Cataloguing 4.0 (Nomenclature 2021) was the most popular, with 10 respondents preferring its use. Using a universal vocabulary does not necessarily mean it will be followed without deviation, as evidenced by Table 1, but deviations are far less common. Respondent 41, using Nomenclature for

Museum Cataloguing, found that it helped maintain consistency: “While the nomenclature rules are strict, they are very helpful for minimising cataloguing discreapancies [sic] between staff members.”

Table 1. Comparing the type of controlled vocabulary used within Canadian museums against whether the cataloguers make deviations.

		Controlled Vocabulary Deviation			
		Yes	No	Don't Know	Total
Type of Controlled Vocabulary	A vocabulary set that was published online for universal use	6	14	1	21
	Created or manipulated within the organization (i.e. personalized or changed in any way)	14	11	1	26
	Both	0	1	0	1
Total		20	26	2	48

In theory, universal vocabularies are easier to use and ensure consistency because of their pre-existing standards and rules for use. However, that does not discount the use or need of individualised controlled vocabularies; they are helpful in the cataloguing of specialised collections and objects that require more specific terms than what universal vocabularies may offer (Smith 2021). Respondents who use an unaltered universal vocabulary have found this to be a reason for deviation:

> **R26:** We are not very strict but try to maintain consistency. We deviate when a term doesn't exist for a particular item and would rather not use a broad generic terminology.
> **R46:** Chenall's [sic] nomenclature is in standard use and our collections management system has it built in. We can add an item if it is missing but that happens very rarely.
> **R49:** There are limitations within the standard set of rules. Some terms don't exist in the controlled vocabulary.

The control of the vocabulary ensures consistency in its use and helps prevent the scattering of related subjects under different headings (Azuara, González and Ruggia 2013). However, deviations can disrupt the unambiguous understanding required in cataloguing, and in moving away from that level of standardisation, interoperability effectiveness decreases (Azuara, González and Ruggia 2013). The creation and use of a personalised vocabulary can work to combat these issues.

In creating a vocabulary or authority, Harpring (2010) emphasises the importance of following standards and construction methods. Vocabularies are used in indexing to “encourage the greatest possible consistency among cataloguers by limiting choices of terminology according to the scope of the collection and the focus of the field being indexed” (Harpring 2010 p.134). Without the necessary standards and rules outlining how the vocabulary is used, indexing becomes convoluted, retrieval and information exchange problematic. Creating and using a vocabulary that does not follow standard construction methods significantly decreases its worth and will not be an appropriate alternative to deviations from universal vocabularies.

From the data set, the use of personalised or universal vocabularies does not have much of an impact on how strictly they are followed (see Table 2). However, a slightly higher number of respondents using personalised vocabularies reported a weaker application; weaker in the sense that the vocabulary is deviated from more frequently than those followed more strictly.

Table 2. Level of controlled vocabulary application based on the type used.

		Controlled Vocabulary Application				
		Very Strict	Average	Not Strict	N/A	Total
Type of Controlled Vocabulary	A vocabulary set that was published online for universal use	6	6	8	1	21
	Created or manipulated within the organization (i.e. personalized or changed in any way)	6	5	12	3	26
	Both	1	0	0	0	1
Total		13	11	20	4	48

Sharing personalised controlled vocabularies is necessary to universal, or at the very least, multi-organisational understanding. Personalised vocabularies are equally as effective as universal vocabularies when there are few deviations, and any made are recorded with the vocabulary republished. 41.8% of respondents reported deviating from their controlled vocabulary. From that percentage, only 58.3% make changes to their vocabularies and standards to align with deviations that are considered the new norm. Without the documentation of permanent changes, cataloguing practice becomes negatively impacted twofold. Firstly, the new method will not be consistently applied to cataloguing practice without updated guidelines; therefore, inconsistency will affect record creation from that point on. Secondly, lack of documentation will lead to an increase in human intervention in data retrieval and exchange due to the inconsistencies. Ultimately, not documenting changes to cataloguing practices diminishes the compatibility of vocabularies and standards, and indexing accuracy significantly decreases.

The appropriate use of a universal or personalised vocabulary, so long as it is applied via a structured schema, will not negatively impact interoperability. However, when deviations are made and cataloguing is approached intrinsically, issues of missing objects, incomplete entries, and redundancy, as expressed by Respondent 10, will appear:

> In terms of our collections [our] database has had many users over the time, all of which had different views on cataloguing, which has created significant problems with the data. For instance, skeletal data which does little in identifying an object or its location, missing items, missing data, duplicate records, and an overall convoluted database.

These issues are not limited to organisations that have personalised vocabularies. Respondent 35 uses a universal vocabulary and has stated that they do not deviate from it in any way. However, they still experience issues with users adhering to the vocabulary rules: “The greatest weakness is consistency of

data entry, especially when some staff people, interns, contract workers, students follow the rules differently."

It is unlikely that effective and logical cataloguing will advance to a stage where human intervention is not required (Lancaster 2003; Keyser 2012). From the responses to the survey, it is primarily this factor that is negatively impacting controlled vocabulary application, and therefore cataloguing as a whole within museums.

5.2.1 Controlled vocabulary application

Standardisation of rules is one of the key facilitators to interoperability, with using and following established metadata schema being vital to successful data exchange (Hider 2004). Park and Tosaka (2010 p.105) further express that "successful resource access and sharing in the networked environment demands semantic interoperability based on accurate, complete and consistent resource description." In addition to common metadata schemata for museum cataloguing (e.g. Rules for Archival Description (RAD), Canadian Heritage Information Network (CHIN), Cataloguing Cultural Objects (CCO)), like personalised controlled vocabularies, there exists personalised standards. Like personalised controlled vocabularies, as discussed in the section above (5.2), it is not the creation or use of a personalised standard that could negatively impact cataloguing and data exchange, but the *access* to the schema that makes that determination.

Of the 55 respondents, only 72.7% stated that they use a schema in indexing. Of that 72.7%, 63.2% use a universal schema but only 43.5% leave it unaltered. Personalised standards and rules from collections management software make up the remaining 36.8%. Lack of schema adherence altogether prevents any sort of effective data exchange with limited human intervention, suggesting those not using metadata schemata either do not exchange data or their processes are done exclusively through human intervention. With 73.3% of the respondents who do not use a schema exchanging external information and data, the latter is more probable. Reasons for not using schemata vary from not knowing of them to not having the time or the staff to introduce them, but the results are the same:

> **R29:** Unaware of cataloguing systems. Have developed some key words [sic] for retrieval of special items but no system has been developed.
> **R36:** Frequent changing of databases, non-standard systems throughouth [sic] the province/country/museum industry.
> **R54:** Since there is no standard procedure our records are very messy. there are so many fields that each person uses differently. no one has the time (its [sic] not a priority) to write up a procedural manual to assist with training. some of out [sic] object have very little to no information about them, often this is left out. I have started including this information in the records so future staff don't re-do my research to find nothing. our 'good enough attitude' works but leaves lots of holes where I feel wastes time when people have to double check the old paper records or cant [sic] find thing because location descriptions are unclear.

The lack of schemata is detrimental to effectively cataloguing items, affecting future retrieval and data transfers to other internal departments or external organisations. While lack of certification in respondents does not necessarily equate to lack of schema usage in organisations, like Respondent 54, who has certification but uses no schema and maintains a 'good enough attitude', the percentage of respondents without certification in information management that do not follow a metadata schema is 60.0%.

Compared against perceived weaknesses in cataloguing, 63.2% of respondents found issues with the use of current schema; those with personalised schema and no perceived cataloguing weaknesses made up 10.5%. Despite the literature discussing the importance of standardisation as a way to ensure accuracy and prevent redundancies and lack of data integrity (Shreeves et al. 2005; Dibakar et al. 2011; Smith 2021), on a frequency scale, respondents using personalised schema were found to experience the issues at a lower-than-expected rate (averaging 'never' at 70.0% and 'always' at 20%). The comparison of schema usage against data issues drew similar results: those not using metadata schemata experience issues of data redundancy, problems with sharing services and functionality, lack of application interconnectivity, lack of interdepartmental coordination, high operational and maintenance costs, and problems with data integrity and quality being less than expected. Due to the limited data selection and lack of further investigation into respondents' understanding of cataloguing and information management, more of a hypothesis cannot be drawn from these results. However, the existing literature on the importance of standardisation and schema usage (Shreeves et al. 2005; Dibakar et al. 2011; Smith 2021) in correlation with the survey results suggests that participants who do not use a metadata schema and additionally do not experience data exchange issues either do not exchange data within the parameters of interoperability, or they do not understand the concept of interoperability. From the responses on how information and data are exchanged between museums currently, and without any further investigation into perceptions, it is safe to say the former is most accurate. Email, hardcopy, and verbal exchanges of information (Figure 4) do not fall within the parameters of interoperable data exchange. The level of human intervention in exchanging information through these methods substantiates the relationship between lack of schemata usage and lack of data issues respondents reported.

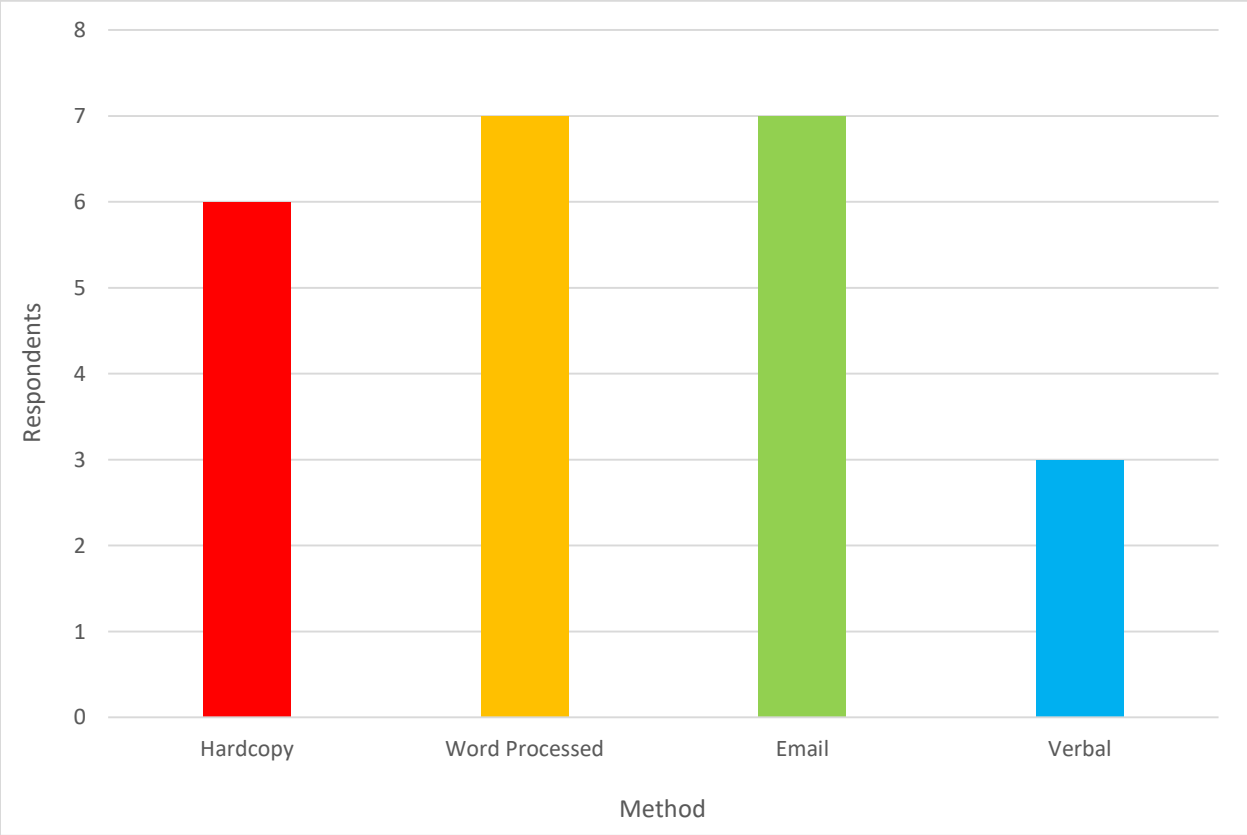

Figure 4. Methods of data and information sharing.

Of the 43.5% of respondents that do not use universal metadata schemata for indexing, only two respondents make their schema available. The remaining respondents neither share their schema or standards nor consider universal standards in creating their own. Dibakar et al. (2011 p.120) state that "standards should be open, scalable and secure and should support interoperability." The lack of sharing and consideration of universal standards does not necessarily negate the ability for personalised schemata to allow interoperability; however, it does limit the potential for success. In comparing whether individualised schema guidelines are shared against potential cataloguing weaknesses, those who do not share their guidelines also experience issues with their current schema. With the continued development of the web and information access methods such as linked data expanding, challenges to accessing data from external sources arise when metadata practices are not standardised (Turp et al. 2020). It is clear that not sharing guidelines for personalised schema negatively impacts cataloguing within museums. Deviations from either or both the controlled vocabulary or its schema that go unchecked affect consistency, retrieval, and the ability to exchange data (Harpring 2010; Diallo et al. 2011; Smith 2021).

5.3 Approaches to cataloguing

5.3.1 Creation of museum records

From the respondents, only 49.1% use subject headings in cataloguing. Across the sizes and types of museums, the respondents using subject headings were approximately equal, save for small multi-interest organisations (at 12.5%); small specialized made up 33.3%, large specialised 29.2%, and large multi-interest 25.0%. The use of subject headings is more telling once examined against formal education of museum indexers, with the majority of those using subject headings having confirmed certification in the field at 51.9% (respondents without certification make up 33.3% and those unsure at 14.8%).

Subject headings enhance object cataloguing and retrieval, enhance usability, link objects through the controlled terms, and remove ambiguity (Hodge 2014; Azuara, González and Ruggia 2013). The absence of subject headings does not mean that the object entirely is unretrievable; other modes of identification exist (e.g. title, accession number, classification, provenance). However, the lack of such a crucial indexing element limits the object's ability to be retrieved if specific details are unknown. Furthermore, without subject headings, an object's precision and recall ability decrease (Fenton 2010). Respondents using subject headings found internal interoperability could be improved at approximately the same rate they found it satisfactory, at 47.4% and 52.6%, respectively. The same cannot be said for perceptions of external interoperability strength, with 59.3% of respondents finding it too weak despite subject heading usage. The approaches to sharing information and data, discussed in Section 5.4, bring into question the validity of interoperability practice in participating museums, and therefore the ability to accurately correlate subject heading usage with interoperability within this data set.

More common fields used by the respondents in cataloguing are accession number (96.4%), acquisition date (96.4%) and source (90.9%), title (85.5%), provenance (85.5%), material (81.8%), and classification (70.9%), with ten other fields (including 'other') falling below 50.0% in use by respondents. It is clear there is an effort to create rich indexing records for museum objects; however, intention does not always equate to successful execution, as is the case with Respondent 9: "We attempt to record as much information as possible, but it is frequently not available to us, so the only required field is the accession number." Further responses from Respondent 9 show that should they have the information, additional fields would be included in the record, suggesting incomplete records are the result of more than just human error and that other factors, such as access to the correct or enough information, impact cataloguing. More frequently than lack of information is the impact of staff contributing to poor and incomplete records. In equal measure, there are remarks on not having enough individuals to create sufficient records, leaving

what is created as bare-boned as possible, or there being too many staff impacting consistency of records across individuals.
Zoller and DeMarsh (2013 p.58) express documentation as a vital step in acquisition, stating that data are almost as important as the objects they document, where "the ability to use a collection is governed not only by the museum's control of the overall conditions of the exhibition and collections maintenance but also by adequate collections management." Roberts and Light (1980) discuss how adequate documentation of objects and cultural heritage is necessary for proper understanding. Unfortunately, this perspective is not widely practiced across the survey respondents, with only 52.7% adhering to their controlled vocabularies and their rules of use. Respondent 54 went so far as to say: "are [sic] moto is better to have 100 objects in the system with crap records than 10 objects with excellent records." Comparatively, some respondents fully grasp the importance of accurate and detailed records, such as Respondent 15 discussing how and why they follow their controlled vocabulary: "Very strict. It is the only way to ensure useful, searchable data."
All respondents consistently use at least one field in object indexing. Of those respondents, 55.8% are from large museums, with the remaining 44.2% from small museums. Furthermore, 39.6% have some form of formal education or certification in cataloguing, 46.1% without, and 14.3% stating they did not know if they had certification or education in the field. Disregarding the 14.3% unsure of their academic qualifications, the closeness of the variables in both size and certification suggests that these are not determining factors in the level of completion in cataloguing records, and poor cataloguing exists regardless of the museum's size or the cataloguer's education.

Zoller and DeMarsh's (2013) conclusions on museum cataloguing are reinforced through these findings. While more research should be done into the perspectives of museum staff who catalogue objects, the lack of correlation between museum size or staff certification and poor record creation supports the postulation that regardless of such factors, museum cataloguing is not at the level of skill of other institutions and comparatively seen as not as important, therefore universally impacting museum cataloguing approaches and integrity.

5.3.2 Deviation and how it is managed

Controlled vocabularies are used to "improve the precision and recall of searches, and to therefore improve the speed, accuracy and specificity of searching" (Fenton 2010 p.189). Therefore, deviating from a vocabulary decreases these benefits to searching and retrieval and while not wholly inhibiting interoperability, the necessity for human intervention increases.

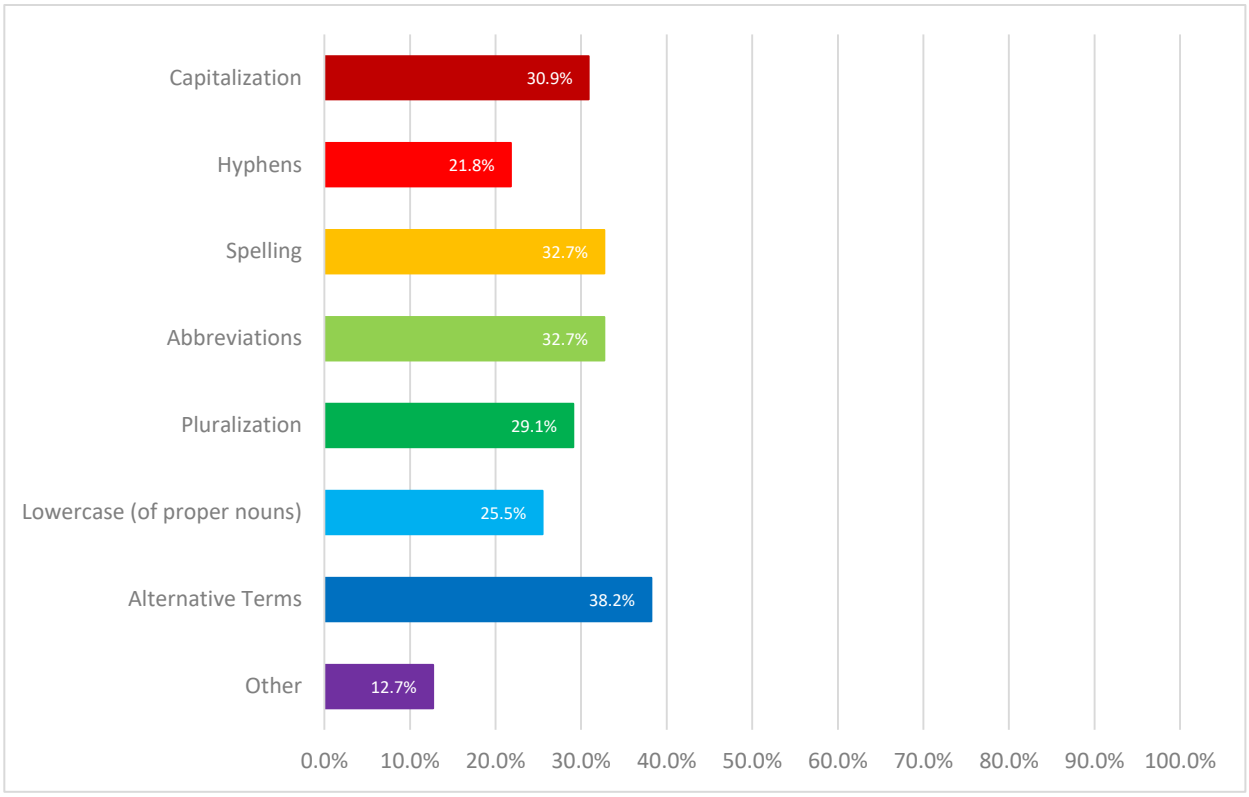

Figure 5. Forms of deviation.

Of the 55 respondents, 41.8% confirmed deviating from their controlled vocabulary in some way. Three additional respondents selected 'I don't know,' with responses to further questions showing forms of deviation; they are then considered within the confirmed group, the combination of the two then making up 47.3%. Of the most common forms of deviation, capitalisation of terms that are not proper nouns, use of hyphens where not necessary, spelling mistakes or alternative spellings (i.e. Canadian versus the United Kingdom or American), use of abbreviations or acronyms, using plural over singular nouns, leaving proper nouns lowercase, and using alternate terms instead of the preferred term, averaged a response rate of 28.7% (Figure 5).

The use of 'other' yielded 12.7% and responses fell into categories of (1) addition of a term in a language other than English, (2) addition of a term not found in the controlled vocabulary, and (3) term with multiple variations. Despite Canada's bilingualism (English and French are the national languages), the use of French as a cataloguing language is only mentioned once, with all other instances of an alternative language being the addition of Indigenous languages.

Completeness, accuracy, accessibility, conformance to expectations and logical consistency and coherence are general characteristics of quality metadata (Shreeves et al. 2005). The high level of deviation, while not necessarily expressing incompleteness of records, does impact the ability of the records to be accurate, accessible, and consistent. In responses to deviations of vocabularies, 46.2% of respondents state that the deviation is considered the new norm, with 58.3% of those respondents going so far as to change old entries that no longer conform, much like Respondent 1:

> Our database as [sic] spent a fair amount of time as the wild west of indexing so we are working to improving that. Having fewer people with the ability to change controls has mean [sic] that our indexing system has many inconsistencies to fix.

The respondents who do not currently or intend to change old records in the future explain that lack of time and staff are the most significant preventative factors. As Respondent 36 so eloquently puts it: “Ain't nobody got time for that.”

Examined against the types of museums, those from large museums deviate more frequently (at a rate of 44.8%) than those from smaller museums. Furthermore, uncertified cataloguers deviate 11.9% more frequently than certified cataloguers, regardless of museum type or size. While these results cannot be generalisable, within the sample it would be acceptable to determine that the lack of standardised education in the field does play a part in how strictly controlled vocabularies are followed in cataloguing within an organisation.

While there is an effort to fix old entries to conform to the new approaches to cataloguing that deviations may establish, only 50.0% of those using personalised standards update deviations that are considered the new norm. 71.4% of those updating vocabulary deviations use a personalised vocabulary (with universal vocabulary users making up the remaining 28.6%); the data corroborate Smith’s (2021) argument that personalised vocabularies are more accurate, current, and stable than larger, universal vocabularies. The updating process of personalised vocabularies is quicker and more efficient than universal vocabularies, affecting fewer users over a shorter period.

No matter the size of the museum and the number of individuals interacting with the data, having rules for the use of vocabularies and metadata schemata is vital to ensuring consistency in their application. Not updating standards once they become the new norm will lead to the situations Respondents 1 and 10 (Section 5.2) found themselves in, with inconsistent records due to differing perceptions of local cataloguing and cataloguing practices. In addition, for the success of resource access and sharing, there must be consistency in resource description (Park and Tosaka 2010). Consistency is met when changes to a vocabulary or its rules are updated, and schema standards are followed as expected rather than how a cataloguer may interpret them.

Deviation from vocabularies and standards is one of the primary reasons for increased human intervention during data exchange, more so when changes are not updated in the guidelines. Even the most minor deviations to vocabulary, through factors such as spelling or punctuation, can hinder attempts at data alignment, preventing local or wider interoperability (Binding and Tudhope 2016). The high percentage of respondents who deviate from their vocabularies and standards, and the general lack of follow-up (reassessing and updating rules or changing older entries), marks the first step against efficient cataloguing in museums and effective data exchange between them.

5.3.3 Weaknesses in museum cataloguing

When cross-examined against responses to perceptions of weaknesses in cataloguing, the claims of Zoller and DeMarsh (2013), Roberts and Light (1980), and Shreeves et al. (2005) that inconsistencies, undocumented deviations, and alterations cause inaccuracy, accessibility weaknesses, and inadequate documentation are confirmed. Responses to whether perceived weaknesses were impacting the success of indexing and retrieval fell into five categories: (1) yes – unspecified (3.7%), (2) issues with current standards (55.6%), (3) multiple standards in use (3.7%), (4) no standards in use (14.8%), and (5) no weaknesses (22.2%). Respondents expanded on their perceptions of cataloguing weaknesses in their

organisation, stating limited personnel and the various ways information is created and data is stored. Differing approaches to cataloguing impacted them the most:

> **R3:** The guidelines require a bit of subjectivity which cause a lot of confusion between departments and through the generations of workers.
> **R7:** Many objects have the bare minimum of 'tombstone' data and aren't fully filled out.
> **R19:** We don't have the resources to do rich cataloguing and are therefore limited to data that is required for operational needs.
> **R22:** Our biggest issue is insuring [sic] the standards are followed with the limited resources available to us
> **R29:** Unaware of cataloguing systems. Have developed some key words for retrieval of special items but no system has been developed.
> **R39:** The library program and inventory program is [sic] Excel and this is limited.
> **R55:** Curator is only full time during the summer so when things are moved it is not recorded or changed in all the places that the references are recorded.

Museum cataloguing, specifically within this data set, is more complex than simple deviations from controlled vocabularies and standards. The factors presented by the respondents suggest there is a significant disconnect between how cataloguing is currently approached and how it should be.

Despite standardisation being an effective and well-recognised way to achieve interoperability (Azuara, González and Ruggia 2013; Hider 2004), 27.3% of the survey respondents do not follow cataloguing standards or metadata schemata while indexing objects. Lack of standardisation negatively impacts records consistency, therefore impacting records retrieval and information exchange. Furthermore, the lack of standards or adhering to a metadata schema prevents museum staff from remaining consistent in cataloguing, creating significant inconsistencies and inaccuracies between records.

5.4 Approaches to sharing data and information

40.0% of respondents exchange data with external sources, be it sending, receiving, or both. Data and information shared primarily include object information and documentation. Additional information such as conservation logs, item care, and set up instructions for exhibit pieces on loan was reported, but much less frequently. Of the 40.0%, 59.1% found data and information exchange to be executable with ease.

Methods of data sharing were limited and required more human intervention than expected. Those that shared their methods fell into four categories: (1) exchange of hardcopy documents, (2) use of word processing software (such as Microsoft Word or Excel and Adobe PDF), (3) via email, or in a small number of cases, (4) verbally (Figure 4); the most basic methods of exchange possible.

The methods contribute to an enlightening first look at how data exchange is currently approached in Canadian museums but bring the validity of interoperability practice into question. While differing approaches to cataloguing affect information exchange regardless of the method of exchange (Hider 2004; Smith 2021), from the methods used by the respondents, it is not possible to determine if how controlled vocabularies are used impacts interoperability between various museums.

Following the exchange of data and information, it is subsequently apparent that the actual process of interoperability, i.e. "the ability of two or more systems or components to exchange information and to use the information that has been exchanged" (Hellberg and Grönlund 2013 p.155), is not being executed.

Respondent 9 explains their end process to exhibition objects information sharing by stating: “It depends on the exhibition but information is generally processed manually.” Thus, while information is shared, the process has not advanced enough to be considered interoperable.

The responses to how the information and data are shared allow for two conclusions: (1) there is limited understanding of the concept of interoperability, or (2) the limitations to current cataloguing within museums only allow for the current practices of information sharing.

Without further research into the level and depth of information management and cataloguing knowledge museum indexers have, it would be rash to assume it is one or the other. However, from the survey results, it can be postulated that it is more so the lack of resources than the lack of understanding. In comparing respondents with information management certification against the ease of information transfer, regardless of certification, information was considered more easily transferrable than not (Table 3).

Table 3. Comparison of cataloguer certification against perceptions of information transfer.

		Is Information Easily Transferrable?			
		Yes	No	Don't Know	Total
Certification	Yes	5	2	1	8
	No	8	3	3	14
Total		13	5	4	22

5.5 Roadblocks to interoperability

As Carlisle and Lee put it, “In a climate of economic austerity, there is an increasing need for inexpensive, reliable, standards-based software which allows for the interchange of data not only between national and local data sets, but also increasingly between these and community-led projects, many of which are often undertaken by volunteers” (Carlisle and Lee 2016 p.133). In an environment that does not prioritise cataloguing or support the presence of cataloguers, at least to the level of libraries (Zoller and DeMarsh 2013), this is even more necessary.

Of the respondents, 16.4% are in a multi-role capacity in their organisation, covering all areas within their museum, and further showcasing the limited staffing abilities of, at the very least, the smaller museums (with 80.0% of the respondents working in all areas belonging to a smaller sized museum). Limited staffing and lack of priority on embracing strict cataloguing standards in museums prevent successful data exchanges that require little human intervention. Furthermore, as a by-product of limited staff and educated professionals in museum cataloguing roles, poorly created records become accepted over a smaller number of complete and precise records (such is the case with Respondent 54). Small organisations with one or a small number of individuals interacting with records may not recognise or understand the impact of maintaining poor records without the influence of data and information exchange to highlight inadequacies. Individualistic cataloguing practices and records management, lack of standardisation and consistent information exchange, and isolation from other organisations are factors that share in holding responsibility for non-conforming records.

Respondents experiencing inconsistent record creation and issues with data exchange express the desire for a more interconnected community that allows for the sharing and access of information across organisations:

> **R20:** If I could access their information, and they could access mine, everyone's work would be better: more comprehensive and less hunting for answers.
> **R27:** Every organisation uses a different database system and terminology. There is major difference between approaches and expertise of database systems and collections terminology. This is a huge barrier to collaboration and moving forward together in a good way.

These responses highlight the absence of intercommunication and information exchange, proving that there is an awareness of the possibilities of interoperability should museums advance to a stage where it is possible, but also an awareness of the limitations that museums face when it comes to achieving interoperability.

Human intervention with data exchange is expected, helping combat problems with data export and import and inconsistencies in terminology and standards (Carlisle and Lee 2016). The lack of sufficient human intervention with museum data limits the effectiveness of information exchange, with 52.7% of respondents stating that external interoperability could be stronger. There are six primary categories of causation for weakness with external interoperability: (1) limited staff, (2) incompatible systems and technology, (3) different indexing methods and needs, (4) use of hardcopy records instead of digital, (5) lack of organisation with data exchange, and (6) different terms used for indexing. Human intervention is a common denominator within the six categories, and specifically, cataloguing-knowledge-based human intervention. Higher human intervention with interoperability is not exclusively limited to small or large museums, as could be postulated with an expectation that larger, provincial museums would be more advanced. Instead, there is a consensus that external interoperability could be stronger with those who participate in external data exchange across all sizes and types of museums (Table 4).

Table 4. Perception of external interoperability strength by organisation size and type.

		Could External Interoperability Be Stronger?				
		Yes	No	Don't Know	N/A	Total
Organization	Large & Multi-Interest	7	4	1	3	15
	Large & Specialized	4	3	2	3	12
	Small & Multi-Interest	6	1	0	0	7
	Small & Specialized	8	7	1	0	16
Total		25	15	4	6	50

Internal interoperability within the responding organisations faces many of the same barriers that external interoperability does. System usage, consistency of cataloguing, and human error act as deterrents to successful information exchange within the 43.6% of respondents who require such practices. Of the 29.1% of respondents experiencing no weaknesses with internal interoperability, six reported using only one computer system within the organisation, further solidifying the postulation of a misunderstanding or misinterpretation of the concept of interoperability.

In parallel with the postulation of organisation size impacting the quality of record creation and keeping and methods usage, internal interoperability is not a problem for those organisations that follow a set standard and schema and manage deviations appropriately and efficiently.

Regardless of the weaknesses human intervention may cause (e.g. inconsistencies, incomplete records), it is more a benefit than a detriment to museum indexing. The lack of human intervention is more of a roadblock to interoperability than its presence. Binding and Tudhope (2016) express its importance by highlighting humans' ability to determine connections, relationships, and differences between synonyms when comparing external and internal data—abilities which computers lack.

The most vital element in determining interoperability strength and practice within museums is ascertaining respondents' understanding of the concept and how they execute information and data exchange. Unfortunately, this remains the most significant roadblock to the success of interoperability, both internal and external, in museums currently.

6. Conclusions and recommendations

The intricate nature of museums and their vast collections of artefacts, objects, and exhibitions require a definite and standardised method of organisation for effective record creation, storage, and retrieval. In an age of digital information and the introduction of linked data and shared data, it is necessary to move away from old cataloguing methods and toward a system that promotes and establishes information and data sharing on a larger scale than local levels.

However, interoperability is limited within Canadian organisations, and the cataloguing practices impact its current and future ability. Basic elements of cataloguing are executed; controlled vocabularies and metadata schemata are used, though not universally, but are plagued with deviations or approached with a 'good enough' attitude. Inconsistent use of cataloguing tools with high deviation percentages significantly impacts the ability for records to be retrievable with any accuracy or precision. Furthermore, inconsistent records prevent successful interoperability with as limited human intervention as possible.

Regardless of the type of controlled vocabulary used by the museums, if any, the lack of standardisation and adherence to application rules have decreased the ability for current records to be effectively or efficiently exchangeable between organisations, no matter the exchange method.

Furthermore, Canadian museums' primary information and data exchange methods are basic, ranging from email to verbal communication, thus requiring the most human intervention. The use of these methods limits the ability to correlate a relationship between controlled vocabulary usage and interoperability, suggesting there is both limited understanding of interoperability and the limited practice of such.

The findings confirm Zoller and DeMarsh's (2013) statement: museum cataloguing practices are far removed from other institutions. The correct use of controlled vocabularies on records will not reverse poor cataloguing methods and manual data exchange practices.

It was the hope of this study to examine the relationship between controlled vocabularies and interoperability, and perhaps in the future, when there is more of an effort toward introducing certified information management professionals into museums and the resources to execute a more in-depth study, more of a direct relationship can be drawn.

6.1 Recommendations

More of a focus on cataloguing is required in museums for positive change to happen. However, the current approaches by respondents show there is little complete understanding of the concept of interoperability and its execution on a larger scale with limited human intervention. This is primarily due to the lack of formal training in cataloguing and the lack of cataloguing priority in museums.

The recommendation here is not to have museum cataloguing be immediately on par with library standards; instead, a re-evaluation of museum cataloguing needs to occur, and steps to develop it into a more structured and standardised practice are necessary. Moreover, this is necessary at a larger scale than exclusively at individual locations. The practice of borrowing exhibits, sharing information, or simply new ownership of an object makes museums interconnected, perhaps not to the extent of libraries, but more so than if they were completely isolated from one another. Examining cataloguing methods, metadata schemata usage, and the use of controlled vocabularies not just in the context of a singular museum but in the context of all museums will aid in successful interoperability in the future. Overcoming linguistic, terminological and verbal differences is the primary way to achieve interoperability (de Almeida Campos, Campos and Barbosa 2020); therefore, considering cataloguing methods and standards of external organisations will help overcome these differences.

In considering museum cataloguing as a whole, it is recommended that controlled vocabularies and standards modified for individual use are made available. Turp et al. (2020) express the lack of standardisation as a detriment to interoperability. It is not expected, nor is it recommended, that all museums adhere to the same cataloguing standards or use the same vocabularies; the diversity of museums in size, interest and collection type is far too vast for that level of conformity. Following a metadata schema and making personalised schema available will help systems will be able to exchange information with limited human intervention.

6.1.1 Future research

It is recommended that further research be done on the impact of controlled vocabularies on interoperability in museums. The research conducted in this study was approached from a metadata standpoint, assessing the application of controlled vocabularies and the effect on information and data exchange. Determining the type, whether and how personalised controlled vocabularies are shared, and whether and how standards and methods are followed within the construction of vocabularies are not addressed in this research but would benefit future studies.

Future research is recommended to assess and determine the expectations of roles in museums for a more in-depth understanding of how museums approach cataloguing. Understanding the level and depth of education and knowledge of information management museum indexers have would provide more context to how interoperability is approached as a concept and in practice.

Finally, it is recommended that further research be done on a broader scale to ensure the possibility for generalisation. The study was simply too small to make such claims, and with limited research on the subject, it is necessary to approach it with a broader sample. Expanding the geographical exchange and assessing if national borders impact the interoperability of museum data would enrich current findings on the topic. Approaching future research with a narrower viewpoint, by looking exclusively at small or large, specialised or multi-interest museums would be beneficial in understanding whether those factors have an impact on cataloguing methods and data exchange.

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