

Cosmos and the Curriculum:
Observatory Public Programming and the K-12 School System

by

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Executive Summary

Introduction

This project offers options and recommendations to the Friends of the Dominion Astrophysical Observatory (FDAO) to help meet their goal of improving public science outreach for children at the Dominion Astrophysical Observatory, which is located outside of Victoria, British Columbia (BC). This project identified answers to the following question: in what ways could the FDAO engage with K-12 school aged children at the observatory in alignment with the BC curriculum? It also identified what resources are needed, which options are more challenging than others, which options require less resources than others, and which options should be pursued first.

The primary issue being addressed in this report is that the Victoria Capital Regional District (CRD) schools inconsistently and infrequently visit the Dominion Astrophysical Observatory (DAO) and the Centre of the Universe Visitor Centre (CUVC) since having lost funding in June 2013 and the CUVC closing public access to the facilities. The FDAO nonprofit was established in June 2015 with the goal to reopen and reinvigorate the CUVC and its programming so that it can once again become a resource to the school system (Our journey, 2019).

The findings in this report are a way to assist the FDAO in meeting its mission statement of inspiring “visitors of all ages by expanding their understanding of their place in the universe and making Canada’s historic Dominion Astrophysical Observatory and the Centre of the Universe sites of learning, creativity, and community for all” (Mission and strategic plan, 2019). This endeavor is important because the recommendations in this report are designed to help preserve this National Historic Site of Canada, which is a world-renowned observatory where many scientific discoveries were made (Dominion Astrophysical Observatory national historic site of Canada, 2019).

Methods and Methodology

The project used a community-based research (CBR) methodology, where the research was grounded in and served the interests of community and engaged citizens (Caine & Mill, 2016, p. 14). In this context, community refers both to the larger international community of space science education outreach providers, to the local FDAO, and the community of families and children in the area.

Another methodology used in this research was a smart practices review. Bardach (2012) explains that smart practices require the researcher to consider what kind of solutions have been tried by other organizations (pp. 109-110). He further notes that a smart practice is not necessarily a “solidly confirmed” practice, but rather may be identified as a slightly better practice than other options in a very context sensitive situation (Bardach, 2008, p.30). It is a “cluster of ideas” that can be used in a particular set of circumstances (p.30). The researcher used this methodology in the research method of key informant interviews by identifying successful solutions that have been tried by other organizations.

Data collection for this research project was qualitative with the primary method for data collection being semi-structured interviews. The key informants were sourced in collaboration with the FDAO, in conducting a literature review, and in completing internet searches. The interviews were conducted with four key informants - one was located in Canada and the other three were located in different international locations. Key informants are people with lots of knowledge and/or influence in the topics being researched (Patton, 2015, p. 268). These key informants were especially knowledgeable in K-12 space science education, observatory-based public programming, and/or youth space science community outreach programming.

Key Findings

Five key overlapping themes emerged from the literature review and the research: people, money, programming, logistics, and philosophies. This research project identified ways that the FDAO can re-establish themselves in the following ways:

- To consider and pursue their needs specific to people, money, programming, logistics, and philosophies;
- To consider the background information related to the new BC science curriculum, the new FDAO strategic planning document, and the resulting smart practices.

These resulting smart practices identified are:

- **People:** The smart practice involved in addressing the need for people would be to identify funders and donors, staff, volunteers, and teachers as the key stakeholders. A further smart practice in this regard would be to engage with teachers more comprehensively, including possibly getting their feedback.
- **Money:** The smart practice to address the need for money for public programming would be to utilize a combination of the funding streams, build relationships with funders, aim to have a minimal or no-fee program, and to seek private sponsorships as a way to make this possible.
- **Programming:** The smart practice related to programming would be to build programming that is fun, social, exciting, hands on, and aligned with the BC science curriculum, preferably for grades four and six as a focus.
- **Logistics:** A key smart practice to navigate logistics is to consider having all basic supplies, access to food or snacks, and access to busses for transportation, as well as making sure there is relevant marketing being produced that utilizes different advertising strategies. Furthermore, this smart practice would make sure the programming does not solely focus on content, but gives students a positive and memorable experience.
- **Philosophy:** A smart practice would be to consider the themes that were indicated as “important”, in particular consider the execution of site based historical content and how to address the topic of women in science. Related, a smart practice

would be to carefully consider concerns related to Indigenous knowledge in the space science public programming and to develop recommendations to address the concerns.

Options to Consider and Recommendations

The following are options that the FDAO can consider to implement:

Option 1 – Maintain the status quo: Continue with current projects, practices, systems, and programs using the new FDAO strategic plan as a guide through to 2021 to achieve desired results.

Option 2 – Execute some of the smart practices: Execute some of the smart practices identified in the report. The identified smart practices could be reviewed with the Board of Directors to get consensus and identify those practices that are most important and relevant to move forward with.

Option 3 - Execute all of the smart practices: Execute all of the identified smart practices in the report, include them in a revised version of the FDAO strategic plan, and create a plan for how they will be executed.

The Friends of the Dominion Astrophysical Observatory (FDAO) is **recommended to pursue option 2: Execute some of the smart practices.**

Furthermore, it is recommended that the smart practices identified around **people, money, and Indigenous knowledge are considered as key smart practices** and a primary focus for the FDAO board of directors to consider.

Terminology

Some of the terms used in this report may not be familiar to the reader. For this reason, the following key terms used in this report are defined below:

Curriculum: In the context of this report, curriculum is referring to the government mandated teaching criteria and content. For this report it primarily refers to the science curriculum mandated by the Province of BC (Science, n.d.).

Field Trip: A trip made by students to study something firsthand (Field trip, 2019). For this report field trips include school tours; for example, when a school takes a short trip to a place to view something (Tour, 2019).

First Peoples and Indigenous Knowledge: Indigenous knowledge or known as First Nations or First Peoples knowledge in Canada, is a holistic paradigm that reveals the wealth and richness of Indigenous languages, worldviews, teachings, and experiences, which have been systematically excluded due to Eurocentric knowledge systems (Battiste, 2005, p. 1). It is crucial to both Indigenous and non-Indigenous educators (p.3).

Grey Literature: A type of literature that is not scholarly and does not go through a peer review process. The quality can vary a great deal and for this reason the sources have to be evaluated critically (Grey literature, 2017).

Observatory: A facility where an astronomical telescope or other scientific equipment is located for the study of natural phenomena (Observatory, 2019). The observatories mentioned in this report are all located on naturally occurring mountain tops.

Planetarium: A domed device in which images of stars, planets, and constellations are projected for public entertainment or education. (Planetarium, 2019)

Public Programming: Public programs refer to participatory educational activities that are offered to the visiting public, either free or for a fee, and in this context relate to a museum setting (Keith, n.d. p. 2)

Royal Astronomical Society of Canada (RASC): A nonprofit, membership based society with more than 5,000 members and 28 centers across Canada. The organization supports persons in their quest to learn more about the universe by hosting free public activities such as star parties, astrophotography events, and more (About the RASC, 2017) .

Star Parties: An evening or overnight excursion to a suitable dark sky site where other astronomers attend using telescopes to view the night sky (Star parties, 2017). Star parties at the Dominion Astrophysical Observatory in Victoria BC can also include special presentations, a planetarium experience, a telescope tour, activities for children, and special talks from scheduled speakers (Star parties, 2019).

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1.0 Introduction

1.1 General Problem

In a generation where access to information, education, and technology does not require physically attending an observatory site to learn, the Friends of the Dominion Astrophysical Observatory society (FDAO) seeks to re-establish its physical presence and build relevancy with the local K-12 education system to provide on-site learning at the Dominion Astrophysical Observatory (DAO) and the accompanying Centre of the Universe Visitor Centre (CUVC). The FDAO wishes to update their facilities, permanent and temporary exhibits, and their visitor programming to include timely information and sensory experiences. By doing so, the FDAO wishes to become a sustainable resource to the public with K-12 Victoria Capital Regional District (CRD) students (FDAO board strategic planning meeting day two, February 10, 2018).

The primary issue being addressed in this report is that the CRD schools inconsistently and infrequently visit the Centre of the Universe Visitor Centre (CUVC) compared to previous attendance in the past. The Dominion Astrophysical Observatory is still a fully functioning observatory utilized by the National Research Council (NRC) of Canada's Herzberg Institute of Astrophysics (The Dominion Observatory, 2019) but access for the general public to visit the site and access the CUVC ceased in 2013. In response to stakeholder meetings and working groups that included the NRC president and Saanich Members of the Legislative Assembly, it was decided that a nonprofit organization should be founded to re-establish public programming to the site (Our journey, 2019).

The working groups indicated the need for a nonprofit to be founded to promote scientific literacy in the community and to create a medium for people to appreciate and understand the role astronomy plays in our society. The DAO was identified as a historically significant and currently active place of scientific study to foster science learning, creativity, and community for all (Mission and strategic plan, 2019). Furthermore, space science education and hands-on and experiential learning is a part of the BC science curriculum requirements. The FDAO Board feels that the DAO site is an invaluable tool to serve the community in providing this hands-on experiential learning that could align with the curriculum (FDAO board strategic planning meeting day one, February 3, 2018). Ultimately, in 2015 the FDAO was founded to reinvigorate the CUVC and its public programming (Our journey, 2019).

1.2 Project Client

Dr. Ben Dorman, Board Chair of the FDAO, is the project client. The FDAO is a charity organization run by volunteers who support the programming at the CUVC and the public tours of the DAO (Our journey, 2019). The FDAO is committed to "promoting scientific literacy in the community and creating a culture that emphasizes cooperation with local businesses,

education supplementary to student curriculum, as well as a medium for people to appreciate and understand the role astronomy plays in our society” (Mission and strategic plan, 2019).

The DAO is a National Historic Site of Canada and is a world-renowned facility where many scientific discoveries have been made (Dominion Astrophysical Observatory national historic site of Canada, 2019). Currently, a group of astronomers performs world-class research in astrophysics and cosmology at the DAO as part of the Herzberg astrophysics projects (Herzberg astrophysics, 2019). The National Research Council of Canada runs the DAO. They currently operate the two research telescopes, support international projects, and provide training to the next generation of astronomers for scientific careers (Dominion Astrophysical Observatory research facility, 2019).

As such, the physical site can be a valuable tool to educate local K-12 school groups in the Victoria Capital Regional District (CRD) area in astrophysics, cosmology, and local history. Furthermore, the DAO is situated approximately 200 meters up on Little Saanich Mountain/Observatory Hill, providing unique, picturesque, and panoramic views of the southern tip of Vancouver Island (Dominion Astrophysical Observatory national historic site of Canada, 2019). This adds to the inherent value of the site and appeal to the public to attend the DAO and its accompanying CUVC.

1.3 Project Objectives and Research Questions

The purpose of the research project was to answer the following primary question: What are the ways the FDAO can re-establish the CUVC as a resource to the Victoria CRD K-12 school system? The answers to this initial research question are in part based on the findings from the literature review and also the primary research. The research question is grounded in the context that the recommendations presented to the FDAO will align with the current BC science curriculum.

Secondary questions that supported answering the primary question are:

- What are the ways the FDAO can engage with the K-12 school system in alignment with the Province of BC’s Ministry of Education curriculum?
- What resources are needed?
- Which options are more challenging than others?
- Which options require less resources than others?
- Which options should be pursued first?

The answers to the secondary research questions were explored in the primary research conducted for this project. The research consisted of key informant, semi-structured interviews with international members of the space science education community to provide the most comprehensive knowledge about the issues that the FDAO are interested in knowing about, which are issues that are specific to public programming at observatories. This group of key

informants have knowledge and information that has not been widely shared as was discovered upon doing a literature search on the topic. The interviews were semi-structured, which allowed for open-ended questions and the opportunity for follow-up probing questions.

The project's objectives were to provide 3-5 options to consider as well as 1-2 final recommendations that focus on the most suitable, cost-effective, and least challenging ways the FDAO can engage with Victoria's K-12 school aged children.

1.4 Background

1.4.1 FRIENDS OF THE DOMINION ASTROPHYSICAL OBSERVATORY

The federal government, by way of the National Research Council of Canada (NRC), closed the Centre of the Universe Visitor Centre (CUVC) in 2013 citing costs as the rationale. The CUVC had been previously open to the public and had been a consistent and known resource to the Victoria Capital Regional District K-12 school system by hosting educational events and visits to school groups. After closing in 2013, it ceased to be open to the public, including school groups. The NRC now leases the CUVC to the Friends of the Dominion Astrophysical Observatory. The Friends of the Dominion Astrophysical Observatory (FDAO) was established to reopen and reinvigorate the CUVC and its programming and again become a resource to the school system (Mission and strategic plan, 2019). The board chair of the FDAO is Dr. Ben Dorman, who is the primary contact person for the purposes of this project.

Due to limited funding and resources, there has been minimal programming in recent years as was indicated at the 23 October 2017 FDAO board of directors meeting. Funding streams have been limited to small grants, small fundraising events, and income from public annual memberships and donations. Moreover, the income sources are not supported by a communications plan, committee, or staff person and overall, there is no fundraising or marketing plan. A small committee that has garnered minimal income has planned only small events (FDAO board strategic planning meeting day one, February 3, 2018).

The FDAO created a strategic plan in late 2018 after having completed a two-day strategic planning session with board members in February 2018 (Mission and strategic plan, 2019). The plan includes a new mission statement, aspirations, and goals and is in Appendix A: Friends of the Dominion Astrophysical Observatory: Strategic Plan FY 2019-2021. The goals are themed by governance, organizational development, and programming. Their strategic plan document also identifies secondary goals that are not a current organizational priority. The programming goals include the development of a science organizations engagement plan, a media outreach plan, an action plan for the 16" telescope, the redesign of the planetarium experience, and development of a school and youth engagement program (pp. 13-14). This research focused on the research questions that could provide recommendations geared towards the development of school and youth engagement programs at the DAO.

The researcher attended the FDAO strategic plan development sessions in February 2018, which helped guide the research questions and the framework for the literature review and research. Yet the final strategic plan was not released to the public and reviewed by the researcher until after the literature review and research had been completed. While this created some challenges, it did not hinder the researcher. Dr. Ben Dorman made himself available to any and all questions that the researcher had about the FDAO throughout the research. This proved helpful to the researcher to understand the FDAO's strategic plan, goals, and current state.

1.4.2 BC SCIENCE CURRICULUM

One of the goals of the FDAO outlined in their strategic plan is to “refine and redesign the planetarium experience” at the Centre of the Universe Visitor Centre (Mission and strategic plan, 2019, p. 13). The strategic plan details how the Planetarium software needs to be programmed with topics that align with BC's education curriculum (p. 13). Another goal of the FDAO outlined in the strategic plan is to “develop a school and youth engagement program” (p. 14). The strategic plan indicates that this goal correlates with the new BC science curriculum, since the new curriculum highlights astronomy education (p. 14). These goals in the FDAO strategic plan highlight the importance of reviewing and understanding the current BC science curriculum.

The new BC science curriculum was rolled out for grades K-9 in the fall of 2016, and for grades 10-12 fall 2018 and 2019 respectively. The curriculum indicates specific content that must be taught that K-12 students are then expected to know (Curriculum model, n.d.). Aspects of the curriculum that directly relate to space science are now found in the grade 4, 6, 10, 11, and 12 curriculum content. Specifically, in grade 4, students are expected to know about the Earth's rotation and orbit, as well as First People's perspectives on the sun, moon and earth (Science 4, n.d.). While the grade 4 science curriculum specifically indicates First People's perspectives as a curriculum outcome, it should be noted that it is found elsewhere in the BC Science curriculum such as in the grade 11 earth sciences (Earth sciences 11, n.d.), in the grade 12 geology curriculum (Geology 12, n.d.), and in the grade 12 physics curriculum (Physics 12, n.d.).

In grade 6, students need to know the overall scale, structure, and age of the universe and the components of our solar system (Science 6, n.d.). In grade 10, students must know about the formation of the universe (Science 10, n.d.). In grades 11 and 12 the science curriculum is broken down into different courses based on scientific disciplines. In grade 11, those courses are chemistry, earth sciences, environmental science, life science, physics, and science for citizens (Science 11, n.d.). In grade 12, those courses are anatomy and physiology, chemistry, environmental science, geology, physics, and specialized science (Science 12, n.d.). There are aspects of space science intertwined with most of these science courses, though the studies of physics, chemistry, and earth sciences seem to be where they primarily overlap. Table 1 highlights what the BC science curriculum grades 4, 6, and 10 learning outcomes are for space science related aspects and the available science courses for grades 11 and 12.

Table 1. BC Science Curriculum: Grades 4, 6, 10, 11, & 12 Outcomes & Courses

Grade	Space Science Content - Students are Expected to Know the Following:
4	<ul style="list-style-type: none"> ● Local changes caused by Earth’s axis, rotation, and orbit ● The effects of the relative positions of the sun, moon and earth ● Local First Peoples perspectives.
6	<ul style="list-style-type: none"> ● Force of gravity ● The overall scale, structure, and age of the universe ● The position, motion and components of our solar system in our galaxy
10	<ul style="list-style-type: none"> ● Formation of the universe: big bang theory ● Components of the universe over time ● Astronomical data and collection methods
Grade	Science Courses Offered:
11	<ul style="list-style-type: none"> ● Chemistry ● Earth sciences ● Environmental science ● Life science ● Physics ● Science for citizens
12	<ul style="list-style-type: none"> ● Anatomy and physiology ● Chemistry ● Environmental science ● Geology ● Physics ● Specialized science

1.4.3 BC FIELD TRIPS

Prior to the Centre of the Universe Visitor Centre losing funding from the NRC in 2013, field trips or school tours were regularly hosted at the site (FDAO board strategic planning meeting day two, February 10, 2018). Since establishing themselves as a nonprofit, the FDAO now offers some school tours or field trips for a \$40.00 fee, which is heavily subsidized by the Victoria Foundation (School tours, 2019). Yet these tours are being offered only by request from school teachers and are only offered when the appropriate staffing is available (FDAO board strategic planning meeting day two, February 10, 2018). These school tours are currently only

possible due funding that was secured specifically for school tour programming. This funding allowed for the hiring of a recent University of Victoria graduate student in physics and astrophysics who hosts the tours (School tours, 2019).

The primary research question focuses on the ways the FDAO can re-establish the CUVC as a resource to the Victoria CRD K-12 school system. A secondary question is how this can be done in alignment with the Province of BC's Ministry of Education curriculum. Field trips or school visits are a way that the DAO used to engage with schools (FDAO board strategic planning meeting day two, February 10, 2018). School or field trips are also a type of space science public programming that was indicated in some of the literature as a way that K-12 students engage with that educational content. The new BC curriculum is based on the "know-do-understand" model, where "do" is the demonstration and application of content through learning. Furthermore, the new BC curriculum has a focus on allowing teachers and students to explore more local contexts and place-based learning (Curriculum model, n.d.). The DAO used to engage with schools by hosting field trips and the literature review also discusses field trips. Field trips also align with the new BC curriculum in regard to place-based learning. For these reasons, field trips or school trips are an important aspect to consider in grounding the research.

One piece of grey literature found by the researcher was the BC Field Trips website that contains a comprehensive list of institutions who host field trips, a search option to look for field trips by city, grade, timelines or keywords, and information on transportation (www.bcfieldtrips.ca). An organization is able to be listed on the BC Field Trip website for a \$50 per year fee, which is used for website maintenance and to identify if their programming aligns with the BC curriculum (About us, n.d.). The researcher found this information early on in the search for literature to review and passed it to the FDAO board chair.

1.5 Report Outline

This report consists of an introduction, literature review, an overview of methodology and methods which include an ethical review, and identification of project limitations and eliminations, research findings, discussion and analysis, options and recommendations, conclusion, references, and an appendix. The organization of the report reflects the way the FDAO problem was addressed by first addressing background information in the introduction, followed by reviewing relevant literature, which was followed by conducting key informant semi structured interviews as primary research. This is illustrated in Figure 3, the conceptual framework, in section 2.5 of the report. The research findings are in section four which include identified emergent themes. The discussion and analysis section identifies five themes that overlap between the literature findings and the research findings and resulting smart practices. The options and recommendations section identifies three options for the FDAO to consider, provides the recommendation of moving forward with option two, as well as further recommendations in regard to key smart practices to pursue, and a brief implementation strategy.

Finally, the conclusion section provides an overview and summary of the project, followed by appendices.

2.0 Literature Review

2.1 Introduction

The purpose of this literature review is to provide a foundation of analysis for the primary research conducted in this report. The two areas of focus for the literature reviewed are: 1) observatory and planetarium focused public programming and 2) science museums. Within the two areas of focus, three main themes emerged, resources, learning, and collaboration. Resources consisted of three theme subsets, human resources, money, and stakeholders. Learning consisted of four theme subsets, science education, cross disciplinary/cross cultural content, teaching, and public programs/museums. Collaboration had three theme subsets, teachers, Indigenous persons/groups, and other stakeholders. The areas of focus, themes and theme subsets are presented in Figure 1.

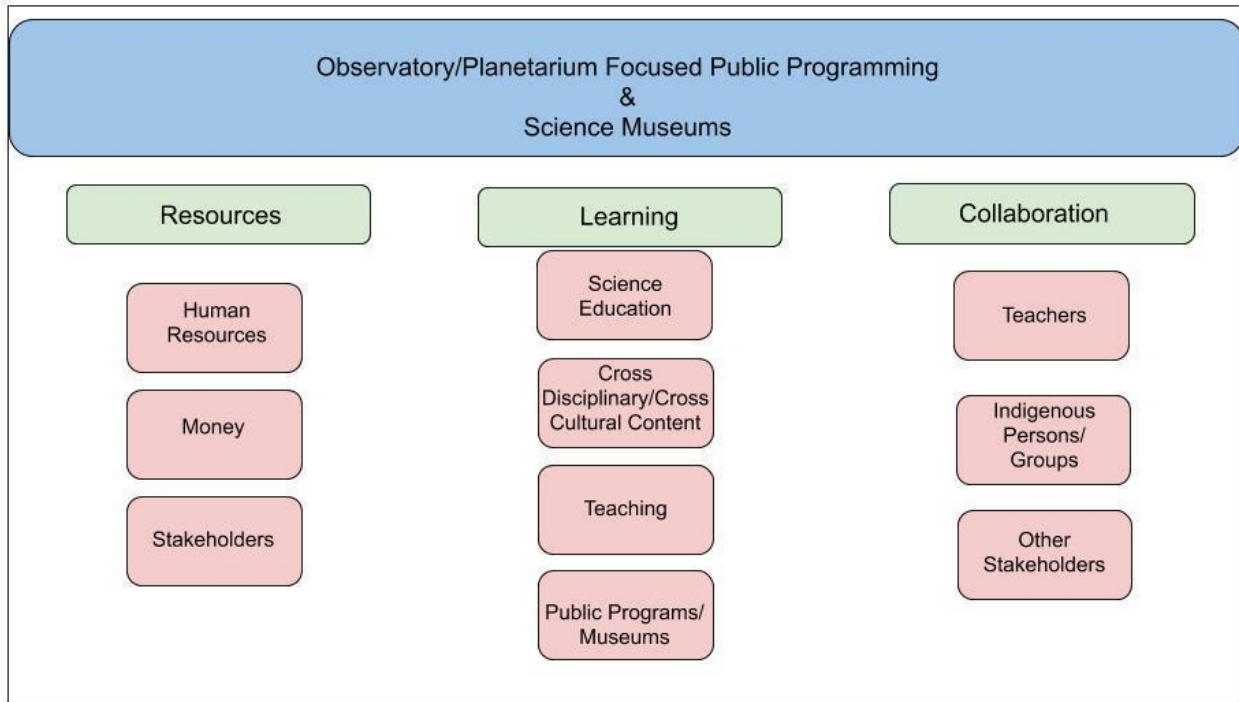


Figure 1. Literature Review: Areas of Focus, Themes, and Theme Subsets.

The area of technology and digital engagement is one that arose in the literature. Since it is not the area of focus for this research it was not pursued as a separate literature topic. The FDAO is already actively providing digital tours and experiences through the Canadian Youth Exploring Space (CanYES) program since the summer of 2018 and were not seeking research in regard to technology and digital engagement by the researcher (Canadian youth exploring space CAN-YES, 2019). Furthermore, a comprehensive, in-depth literature review on the Province of

BC's K-12 Education curriculum was not completed. This is also not the primary focus of the research. For context and consideration, the Province of BC's science curriculum is referred to in the background section and in Appendix B: BC Science Curriculum Grades 4 and 6.

Literature on the topic of observatory based K-12 public programming was found through targeted searches in academic search engines through the University of Victoria libraries database, including Google Scholar and Summons. Initial keywords and terms searched included: Canadian education system, teaching, schools, observatories, curriculum, K-12, and science education. This was followed by keyword searches for the Dominion Astrophysical Observatory (DAO), with a third search that included international sources, and used the keywords and search terms: observatory public programming and astronomy science education. This final search resulted in a more comprehensive list of applicable articles, including Wolfschmidt's (2015) "Learning by Doing: Science Education at the Hamburg Observatory", and Ruddell, Danaia, & McKinnon's (2016) "Indigenous Sky Stories: Reframing How We Introduce Primary School Students to Astronomy - a Type II Case Study of Implementation". The authors of both of these articles were subsequently interviewed as part of the research. The Centre of the Universe Visitor Centre (CUVC) is a form of a science museum. For this reason, a final literature search included books focusing on the topic of public museums.

2.2 Key Theme 1 - Resources

The literature on required resources for the execution of space science public programming had three main recurring themes, resources, learning, and collaboration. The theme of resources consisted of three theme subsets, human resources, money, and stakeholders.

2.2.1 HUMAN RESOURCES

While there are many definitions of human resources, generally it is believed to include all the personnel of an organization whose skills and abilities are a significant asset (Human resources, 2019). Volunteers are persons that work for an organization without being paid (Volunteer, 2019) and therefore, human resources in this context refers to the staff and volunteers whose skills and abilities are required for the organization to function. Kadoyama (2018) coins and defines the term "staff bandwidth" (p. 61), which means that staff have sufficient time and capacity to meet the organization's program needs directly impacting an organization. Ultimately, Kadoyama identified that a lack of staff time and capacity means the organization will need to move more slowly and on a smaller scale (p. 61).

Another human resource to consider are volunteers or docents, which according to Shaffer (2015, p. 95), volunteers or docents are critical to a science museum. This is partly demonstrated by Mace (2018) who wrote in the *Arizona Daily Star* that the Kitt Peak observatory located in Tucson, Arizona, U.S.A., currently has a volunteer staff team of 40, which they hope to increase to 100 in the coming two and a half years. This information from grey literature about the volume of volunteers at the Kitt Peak observatory gives some indication of

the critical requirement for volunteers, or docents to run such programming. Shaffer goes on to say that a volunteer's background can vary greatly and that well-trained volunteers are vital so that they can be good at leading a public program (Shaffer, S., 2015, p. 95). This is further supported by Edson & Dean (2005) who claim that having experts that are specialized and appropriately trained with museum specific skills are essential for an organization to be taken seriously as an educational resource (pp. 192-193).

The Kitt Peak observatory was not the only observatory found to rely on staff and volunteers. The staff and volunteers who support the Hamburg Observatory in Hamburg, Germany, include amateur astronomers, who support the public star gazing events (Wolfschmidt, 2015, p. 59). Other aspects of their programming is staffed by volunteers who are a collection of local high school teachers, amateur astronomers, PhD students, and professional astronomers (pp. 69-70). Percy & Hesser (2008) also identified that in Canada, graduate students and amateur astronomers play an important part in the non-technical lectures and the tours at observatories, many of whom are associated with the Royal Astronomical Society of Canada (p. 32). These types of persons are also identified by Fields (2009) as key staff who support the space camp program at the University of Arizona, including undergraduates, graduate students, post-doctorates, and professionals in astronomy (p. 155).

2.2.2 MONEY

In Germany, the Ministry of Education has funded a half-time position for a local secondary school teacher to organize and teach the Hamburg Observatories' programming (Wolfschmidt, 2015, p. 61). In Canada, it seems to be a bit different in regard to government funding for public science programming which Percy & Hesser (2008) identify. As an example, compared to the U.S., there is little government funding to support science outreach in Canada overall (Percy, J. & Hesser, J., 2008, p. 32). They also identify that there are other sources for funding for public science programming in Canada, including from corporate and private sources (p. 32). A problem identified with this aspect of money is that "astronomers are amateurs in the realms of fundraising" (p. 32).

There are other examples of funding other than from Germany's Ministry of Education. The Kitt Peak telescopes in Arizona recently received 4.5 million dollars in grant money (Mace, 2018). This funding will pay for upcoming renovations, exhibit development, and program design as well as three years of operations for the Kitt Peak telescopes public programming (Mace, 2018). While this is a grant from the U.S., it illustrates how grant money can fund a variety of assets needed to run public science programming. Kitt Peak has also proven their ability to operate under their own revenue through ticket sales after they had their federal funding cut (Mace, 2018). Ultimately, the literature, including grey literature, shows that the money that functions as a funding stream can be sourced from public funding, such as a Ministry of Education, or federal funding; grants that could be from a government body or from a private organization; ticket sales income from charging persons for a service and access to the site; or

sponsored and fundraised dollars. Figure 2 reviews the five streams where money can be sourced for science museum or public science programming based on the literature reviewed.

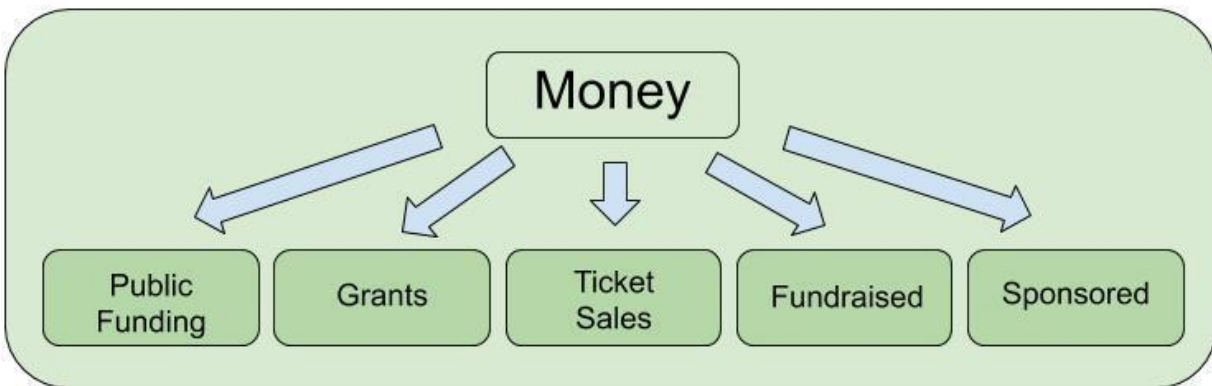


Figure 2. The Five Streams Where Money Can Be Sourced for Science Museums

2.2.3 STAKEHOLDERS

Kadoyama identifies ‘community stakeholder’ to be community members such as community organizations, informal groups, businesses, government bodies, or individuals who care about, have an interest in, or are affected by a certain project (Kadoyama, 2018, p. 10). In this context, the project that the community stakeholders care about or have an interest in would be K-12 public programming at the DAO observatory. Stakeholders include all of those persons mentioned in human resources, including volunteers, staff, high school teachers, grad students, PhD students, amateur astronomers, professional astronomers, and RASC members. Stakeholders also include all of those mentioned in the theme subset of money, including the provincial or federal government, the organizations where grant money comes from, which may or may not be different bodies than the provincial or federal government; businesses or persons who donate money; and those who provide sponsorship. In addition, other stakeholders include members of the public, families, children, and youth. Stakeholders are at their core a person-to-person connection that when nurtured and expanded become person-to-organization and organization-to-organization relationships, which can play out over years and involve various organizations (Kadoyama, 2018, p. 113).

The literature points to a key stakeholder, who are teachers, where there are key relationships to be nurtured and expanded. Some authors note that museum educational programs, including science museums, should view school teachers as allies (Edson, G. & Dean, D., 2005, p. 193) and that it should be a collaborative effort that involves “not only museum personnel but also public administrators, educators for private and public schools, actual and potential museum visitors, and others in the community that can offer insight” (p. 200). This link to teachers is also mentioned or discussed by others in the literature review. For example, Wolfschmidt (2015) identified the dependence on program development and support from at

least one teacher for the programming to function (p. 61); Ruddell, Danaia, & McKinnon (2016) indicated that teachers are required to engage with the students through the development of the programs (p. 171); and Columbo, Aroca, and Silva (2010) identified that teachers are part of the motivations, discussions, and interactivity with the students (p. 6). Another aspect to keep in mind with this key stakeholder is that they often shy away from astronomy because so few of them have a background in astronomy or teaching it (Percy, J. & Hesser, J., 2008, p. 33).

2.3 Key Theme 2 - Learning

2.3.1 SCIENCE EDUCATION

The experience of science education for youth or children was described by the numerous authors. For instance, Fields (2009) describes how space camp for youth is designed for children and young adults to have fun while learning (p. 155); Shaffer (2015) also identifies that a museum, including science museums, should anticipate and embrace opportunities for play and social interaction (p. 86); Jauncey et al., (2017) found that students show their enjoyment in how they interact with scientists who themselves are excited and involved (pp. 284-285); and Basu and Barton (2007) found that when students could choose to engage with science activities that connected to their values, there was a stronger, longer term commitment to pursuing science (p. 487). The literature ultimately found that science education for children or youth should be fun, playful, social, exciting, and connect to their values.

Research in science education has found that teaching science only in school settings is not enough to motivate students (Braund & Reiss 2006, pp. 1385-1386; Columbo, Aroca & Silva, 2010, p. 1). Teaching outside of a school setting was further explored by Basu and Barton (2007) who found that sustained interest in science when taught to young students was best done when the youth experienced “self-motivated science explorations outside the context of the classroom” (p. 469). While Berkovitz (2017) does not indicate that science education should include out of classroom teaching experiences, they do state that it is important that science education “inspires creativity, open-mindedness, critical thinking, and respect for different cultures and conceptions of the world” (p. 42). Berkovitz goes on to say that “any vision for K-12 science education should strive to achieve these goals” (p. 42).

According to Fields, one way that students can access this sort of science education is through informal science learning experiences, such as those outside the classroom at science camp-type of experiences (Fields, 2009, p. 1). Science camp-type experiences provide the students’ access to science professionals outside a classroom setting (pp. 153-155). Fields found that in all cases students experienced an increase interest in science when they could engage with science professionals outside a classroom setting (p. 153). Youth in the science camp-type activities were “drawn into the culture and community of astronomers through the staff who are undergraduates, graduate students, post-doctorates, and professionals in astronomy and related science fields” (p. 155).

2.3.2 CROSS DISCIPLINE AND CULTURE

Educational content at observatories and planetariums that crosses many other education disciplines or cultural boundaries was a theme that arose in the literature. Wolfschmidt (2015) found that science can be understood at the Hamburg Observatory via other areas of interest, such as cultural history, the history of science itself, and the history of astronomy (pp. 57-58). Daniels & Daniels (2011) found that at the Hampstead Observatory there has been much interest from architect design students in the design of the observatory itself (p. 17). Berkowitz (2017) also states that it may be best to complement science education from scientists with that of historians, philosophers, sociologists, and anthropologists of science (p. 42).

Another example of non-science related education at an observatory was identified by Baird (2006) who was taught about local history and aspects of navigation using the night sky as part of their experience at Kitt Peak's amateur astronomer space science "fantasy camps" (p. 1). Basu and Barton (2007) identified an example of a young person whose interest in cartooning and action figures was pulled from their experiences with science (p. 480). The science experiences cross disciplinary boundaries because they were relevant to arts or other interests. They also found "that a strong connection existed between a sustained interest in science and authentic opportunities for students to develop skills that advanced them toward their...personal and professional desires" (p. 479). Shaffer (2015) indicates that this is also something important in the principles of museum education, building on children's existing interests (p. 86). Shaffer elaborated on the other ways that children can be engaged in a museum type of setting, including using theatre techniques, storytelling, and connecting to history (p. 141). This focus on individual interests of the children and youth is also indicated by Lord (2007) as important, and he advises that the museum experience should be "offering learning experiences according to the needs and expectations of each individual visitor" (p. 50). Much of the literature ultimately points to the necessity of having content outside of the science disciplines.

Cross-discipline themes led into finding cross-cultural themes in the literature review. At the Kitt Peak observatory in Tucson, Arizona, U.S.A., art murals created by the Tohono O'odham nation are featured and new informational signage is being added on the site to highlight the cultural history of the Tohono O'odham nation (Mace, 2018). Edson & Dean (2005) explain how these sorts of cultural experiences can be provided by museum administrators and educators to "promote multicultural education and the importance of cultural expression through the exhibits and the programming itself" (p. 199). They go on to explain how "cultural heritage...can serve as a focal point for community participation in exhibits and educational programs (p. 199). This cultural heritage focal point was also identified in a study that found that part of the problem with teaching science materials to students may be that it is not "relevant through the cultural frameworks that guide student experience in science" (Basu, S.J. & Barton, A.C., 2007, p. 469). Shaffer (2015) also identifies this connection between cultural backgrounds and the learning experience, claiming that "when programs make

connections between the cultural background and experiences of diverse young visitors, they are likely to resonate and encourage a stronger connection to the museum” (p. 99).

Ruddell, Danaia, and McKinnon (2016) investigated the impact of a cross-cultural science program on both Indigenous and non-Indigenous students in Australia (p. 171). Part of the reason for this investigation was due to the embedded cultural themes that acknowledge the value of Indigenous knowledge that are now part of the national curriculum in Australia (p. 171). This investigation and literature is relevant to this research project because the new BC K-12 curriculum includes Aboriginal perspectives and knowledge (Aboriginal perspectives and knowledge, n.d.). The research by Ruddell, Danaia, and McKinnon (2016) “was driven by literature that posits local, Indigenous knowledge involving hands-on activities with appropriately modified language and which takes full advantage of existing western knowledge systems, strengthens both non-Indigenous and Indigenous students’ engagement and learning outcomes” (pp. 177-178). This research focused on the impact that recounting of Indigenous sky stories had on students who attended an event at the observatory. It was found that students were intrigued, embraced cultural elements, were motivated and inspired to observe the night sky, and indicated they appreciated listening to a local storyteller (pp. 174-178). Collaboration with Indigenous groups is explored further in the literature theme subset “Indigenous persons/groups”.

2.3.3 TEACHING

The importance of teachers as a stakeholder was reviewed in the resources theme earlier. The act of teaching was a theme subset that also emerged. Berkowitz (2017) points out that the foundations of science taught to students are “instrumental to the development of creative and critical thinking” (p. 44). Ergo the persons who are doing the teaching are ultimately the ones who are instrumental to the development of creative and critical thinking. This is a problem when considering what was mentioned earlier, that teachers often shy away from teaching astronomy because so few of them have a background in astronomy or teaching it (Percy, J. & Hesser, J., 2008, p. 33). This was further identified by Columbo, Aroca and Silva (2010) who found that even though astronomy is part of the school curriculum in Brazil, usually teachers who must teach astronomy have rarely studied it (p. 6). For this reason, they indicate the importance of having science museum guides who know about age appropriate scientific content (p. 6). The museum guides are ultimately expected to take on the role of teaching the content that the teachers are less familiar with.

There are also examples of teachers and students engaging in science learning together and actually participating in scientific exploration together. For example, a classroom can connect remotely or digitally with a telescope to operate it or can engage with astronomers and scientists remotely by way of digital communications. The Goldstone telescope in California, part of NASA’s Deep Space Network, is an example of such a program. It can be operated remotely by teachers and students from the classroom. This unique opportunity encourages students from K-12 to “experience discovery for themselves, in their classrooms, interacting with

other students, scientists, and educators” (Jauncey et. al., 2017, p. 281) using phones and the internet. Another example found in the grey literature is the CAN-Yes program. The FDAO now currently offer this program where students who live in remote areas of Canada can take a virtual field trip to the DAO to speak with astronomers and engineers as part of the CanYES program (Canadian youth exploring space Can-YES, 2019). This form of teaching is considered remote from an observatory’s site and therefore not the focus of the literature review. While this topic is not the focus of this research project, it was an aspect of public programming that the researcher did not want to ignore or omit from the literature review.

2.3.4 PUBLIC PROGRAMS/MUSEUMS

The FDAO has maintained some public access to the Plaskett telescope and the CUVC allowing for the education model introduced by Plaskett himself nearly 100 years ago to continue (Posey, 2016). This model has components of teaching science in informal spaces, like science museums, that have a nice environment, allowing students direct contact with scientific instruments and practices (Columbo, Aroca, & Silva, 2010, p. 1). The Astronomical Observatory of the Center of Scientific and Cultural Dissemination of the University of São Paulo, campus São Carlos, Brazil, offers these informal science teaching spaces at their observatory as part of their mission to promote astronomy education. They host school visits that include a two hour lecture, a short documentary, and a guided visit through the observatory (p. 2). They found that 95% of the students surveyed after these school visits to the observatory claimed they would like to return with their family and friends, clearly showing that the guided visits were interesting enough to encourage students to return (p. 3). Another observatory that offers this public programming in a science museum type of setting and non-classroom setting is at the Hamburg Observatory in Germany, where the students learn by doing with hands on experiences (Wolfschmidt, 2015, p. 69). These experiences of field trips at observatories allow students to garner information and positive memories of the experience itself which can last a long time (Hofstein & Rosenfeld, 1996, p. 96).

With this long lasting and positive experience in mind, the educational and conceptual design of exhibits in these kinds of settings play an important role in how effective the education is (Madden, 1985, p. 2). Shaffer (2015) points to the need for museum professionals to incorporate appropriate strategies when planning museum experiences so that they are geared for the audience of young children (p. 129). Hofstein & Rosenfeld (1996) indicate that research has been done to help answer the questions “how could field trips be designed and implemented to better achieve important learning goals”? and “how might field trips be integrated into the formal science curriculum”? (p. 96). Some ways that these questions have been answered are by Feher (1990) who advises that “exhibits should be designed as teaching/learning devices with four levels: Experiencing, exploring, explaining, and expanding” (Feher, 1990, as cited in Hofstein & Rosenfeld, 1996, p. 104). Edson & Dean (2005) elaborate on this by explaining that “you would want books, objects, documents...and exciting visual aids to excite and stimulate your students (p. 193). Lord (2007) goes on to say that there needs to be curriculum-linked programming with

clear curriculum-related outputs (pp. 79-80). This allows teachers to justify their participation in such site visits and could also show a direct link to improved standardized test scores (pp. 79-80).

The site visits and the experience that students have when coming for such site visits “requires a welcoming environment” which is “now more the norm than at any other time in the past” (Shaffer, 2015, p. 94). Some of the ways that this can be achieved is by presenting young visitors with stickers, special guidebooks, or an invitation to take part in certain events designed for young persons (p. 94). Another key aspect in creating a welcoming space relates to “creating a sense of comfort...places to sit, eat, change diapers” (p. 94). The author further notes that “by creating a culture that respects the needs of the child and [their] family, the museum demonstrates its interest and support for this audience of young museum goers” (p. 94). Shaffer ultimately identifies the following practices for developing museum programs for young persons that would help meet some of these important aspects:

- Demonstrate genuine respect for each and every child
- Design programs that are child-centered
- Value children’s ideas and perspectives
- Make learning relevant and meaningful
- Build on children’s interests and areas of common knowledge
- Create experiences that engage children through their senses
- Plan opportunities that allow exploration and discovery
- Incorporate inquiry within programming
- Anticipate and embrace opportunities for play and social interaction (p. 86)

While Shaffer focuses on the needs of the children in a museum setting, Lord (2007) points out that children do not usually come to museums by themselves; instead, they come with family or schools (p. 49). For this reason, making sure that learning experiences are meeting the needs of all these groups is important. It is also important that the whole organization identifies itself with this objective (p. 50). The first step to do this is for the organization to identify itself as a targeted resource for families and have this “inscribed into their mission and vision” (p. 62). Edson & Dean (2005) also speak to the role of the organization’s identity when they state that an organization “should take every opportunity to develop its role as an education resource” (p. 192). Shaffer (2015) adds that organizations do not need to be doing this alone since “experts have found that museums and schools working in partnership can affect young children and their learning” (p. 147).

2.4 Key Theme 3 - Collaboration

The partnerships that Shaffer (2015) mentions related to the programming in a museum context were a recurring theme in the literature. Edson & Dean (2005) claim that it should be a collaborative effort that involves “not only museum personnel but also public administrators,

educators for private and public schools, actual and potential museum visitors, and others in the community that can offer insight” (p. 200).

2.4.1 TEACHERS

A challenge identified by Lord (2007) is that teachers can often see museum visits as “frills” (p. 78). Yet museums are obliged to see teachers as the key target market, the client that is to be “carefully cultivated and wooed” (p. 78) and this approach is deemed to be necessary to maintain levels of school group visitations (p.78). In this sense, Lord seems to be identifying the teachers as a customer to target the sale of an activity related to the museum. This seems to counter what Edson & Dean (2005) have to say about school teachers, who they consider to be “allies” to a museum organization rather than clients or target markets (p. 193). They go on to state that this relationship should be a “collaborative effort” (p. 200). This collaborative effort is further identified by Columbo, Aroca, and Silva (2010) in their claim that “a solid cooperation between schools and science museums is essential” to improve science education, and because it is up to the teachers to relate the content seen on a school visit to the school classroom content (p. 6). This collaboration with school teachers and museums should also involve other public administrators and educators from the public and private school systems because they can offer insight to the educational adaptation and implementation (Edson & Dean, 2005, p. 200).

2.4.2 INDIGENOUS PERSONS/GROUPS

Ruddell, Danaia & McKinnon (2016) offer reflections on collaboration with Indigenous persons and groups in their case study. They indicate that “having local Indigenous community and its knowledge within the learning space was critical”, and that this served as a type of “middle ground” where optimal engagement was possible (pp. 178-179). This middle ground or “space” is where curriculum development should be done to mediate between Western ways of knowing and traditional knowledge (Rennie, 2006, p. 138). Ruddell, Danaia & McKinnon go on to express how this should be done “respectfully with elders and other Indigenous community members”, and how a key to this engagement was by “developing collaborative relationships with the local Indigenous community to locate and deliver sky stories” (p. 178). Their results found that positive engagement with Indigenous knowledge is possible “when Indigenous knowledge is recognized and given space within the curriculum” (p. 178). They also found that students responded well to “the cultural stories about the night sky” and furthermore that they were then “motivated to seek out both cultural stories and scientific facts to broaden their knowledge” (p. 178). They conclude that further research needs to be done to “investigate the efficacy of the inclusion of such Indigenous perspectives in other educational programs or interventions” (p. 178).

2.4.3 OTHER STAKEHOLDERS

As identified by Columbo, Aroca, and Silva (2010), family members, friends, and colleagues of young students who visit an observatory site are also stakeholders who may

support a return to visit (p. 3). Kadoyama (2018) also indicated the many other persons who are considered community stakeholders including “individuals, community organizations, informal groups, civic organizations, government entities, and businesses” (p. 10). Kadoyama goes on to explain how a big challenge is getting involved with that community of stakeholders to measure qualitative indicators, as well as figuring out which ones you would feel comfortable getting advice from in regard to exhibits or programming (p. 142). Visitors should therefore complete surveys and this data should be compiled and shared with everyone in the organization, helping to articulate the value the museum has in the community (p. 96).

Engagement with other stakeholders is something that Wolfschmidt (2015) from the Hamburg Observatory points out in regard to the requirement for publicity. In order to publicize programming, the observatory needs to engage with stakeholders to do so (p. 69). The Hamburg Observatory utilizes different engagement strategies and publicity platforms including web pages, newspapers, flyers, announcements at public lectures held at the university, and communications with the schools directly (p. 69). The stakeholders in this case then could also include the different organizations, groups and persons involved in all these forms of publicity, including the web support systems, the contacts at the newspapers, the companies who would support the flyer creation or distribution, the schools themselves, and other departments at the university that hold the lectures where the announcements would be made.

2.5 Conceptual Framework

A conceptual framework helps a researcher to make sense of what they are exploring and provides the structure to the researcher’s enquiry (Frey, 2018, p. 2). The conceptual framework for this research was created to outline the intended actions of the researcher and to keep the research on track (p. 3). The researcher’s conceptual framework for this research is structured as a procedural model where a visual model was built to express the processes the research used. This kind of conceptual framework allowed for the researcher to stay on track with the intended purpose of the project. The basis of the conceptual framework started with the main research question: “in what ways could the FDAO engage with K-12 school aged children at the observatory in alignment with the BC curriculum?” With that question in mind, the literature review branched off to focus on two closely related areas: 1) observatory and planetarium focused public programming, and 2) science museums. The literature review identified the majority of the key informants that were interviewed, as some of them authored the literature that was reviewed, and also identified key themes, which was the purpose of the literature review to contextualize the primary research.

The key themes identified were considered to be emergent. Emergent themes are building blocks of qualitative social science research (Williams, 2019, p. 2). Some overarching themes were identified in the literature review including resources, learning, and collaboration. These themes helped the researcher to identify and contextualize the emergent themes in the research. Emergent themes in the research were identified through close analysis of the data (p. 2). Some

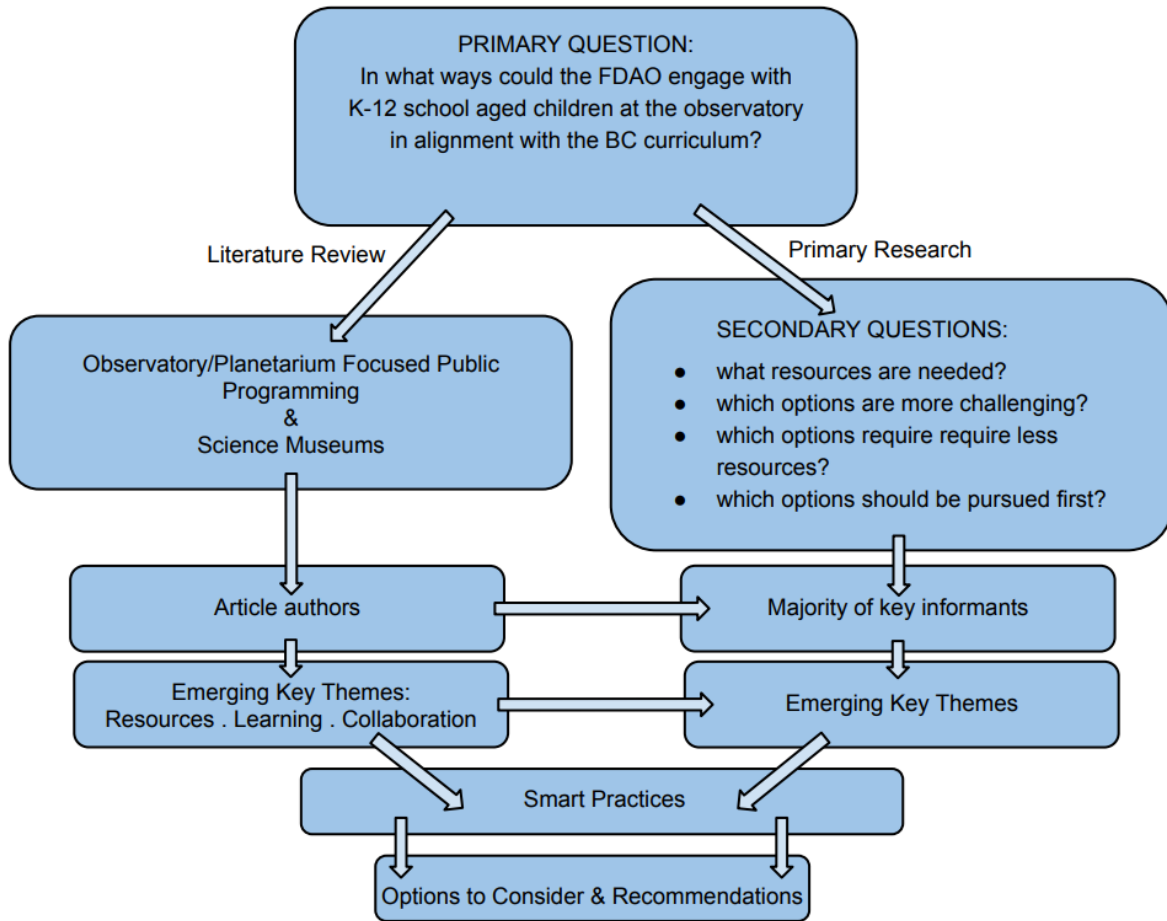
of the themes that emerged from the research were similar to the themes that emerged from the literature review. This was likely to occur because some of the key informants wrote the articles. Since they had written the articles, it made logical sense that their answers to the questions in the interviews resulted in at least some similar themes. Ultimately, the literature informed the initial emerging key themes, which helped provide context for theming the primary research themes, and also helped identify the key informants that were interviewed.

The literature review identified the majority of the key informants which was done due to the assumption that persons writing on the topic of space science public programming and observatory public programming would have valuable knowledge and information that the researcher could garner through key informant interviews. Two of the articles reviewed and one piece of grey literature reviewed were authored by the key informants: Gudrun Wolfschmidt's (2015) "Learning by Doing: Science Education at the Hamburg Observatory"; David McKinnon, who co-authored with Ruddell and Danaia (2016) "Indigenous Sky Stories: Reframing How We Introduce Primary School Students to Astronomy - a Type II Case Study of Implementation"; and Dr. Lisa McIntosh, one of the volunteers and creators of the BC Field Trips webpage (About us, n.d.). After completing the literature review, the researcher contacted several of the authors examined in the literature review, resulting in three of them participating in the research interviews.

The secondary research questions branched off separately in the conceptual framework. The secondary research questions guided the research and ultimately the key informant interview questions. For example, the research question "what resources are needed" informed the interview question "what resources do you believe are required for the K-12 public programming to continue at the organization"? These draft questions were submitted to the University of Victoria's Human Research Ethics Board prior to conducting the literature review or the research, as required by the Ethics Board. The draft questions were utilized in the key informant interviews with only small changes made to be more conversational in style. Ultimately the literature review did not inform the questions asked of the key informants as they were developed by the researcher prior to conducting the literature review.

The themes that emerged from the literature and the themes that emerged from the coded data of the research from the key informant interviews allowed the researcher to identify smart practices. These smart practices, in consideration of the background information related to the new BC science curriculum and the new FDAO strategic planning document, provided the final options to consider and recommendations. Figure 3 outlines the conceptual framework that the researcher used.

Figure 3. Conceptual Framework



2.6 Conclusion

This literature review contextualized the research by garnering information, smart practices, and recommendations for ways that observatories around the world engage with their K-12 school systems, and how museums, including science museums, design their programming. It also served to find the majority of appropriate key informants for the primary research. The challenges with finding comprehensive and relevant peer reviewed literature after completing targeted literature searches demonstrates that this topic requires further academic research.

The literature revealed three overarching themes: resources, learning, and collaboration. Resources includes paid staff as well as volunteers whom need to be properly trained for their roles. Volunteers and staff can include grad students, PhD students, professional astronomers, amateur astronomers, and high school teachers. Volunteers and staff are required in order to conduct all the activities done at the observatory for public programming, including tours of the facility, hosting lectures or talks, and providing telescope demonstrations. The literature highlighted the many avenues for sourcing money, or funding, for the public programming.

These include accessing public funding from a government body, applying and receiving grants, garnering funds from ticket sales, hosting events or activities that result in fundraised dollars, or having sponsors. All of these groups are considered stakeholders while a key stakeholder identified in the literature were teachers.

Learning was another theme that emerged, which directly connects to the theme of teachers. The theme subset of science education addressed the need for teachers to provide education on science outside of a classroom setting. This out-of-classroom learning is deeply connected to and dependent upon the astronomers, grad students, and other persons identified in the human resources theme. The learning is also connected to other disciplines and not just those of space sciences. The content can also have cross cultural aspects as well, especially in regard to Indigenous ways of knowing. This cross disciplinary content and cross cultural content is possible when teachers who teach it are engaged with it.

The museum model can help to inform smart practices for space science public programming, especially in regard to smart practices with exhibits, curriculum-based learning, hands-on learning, their ability to create a welcoming environment for all, and their requirement for collaborating with schools. Collaboration, another major theme that emerged from the literature, looped back to the necessity to work with teachers, Indigenous persons and groups, and all other stakeholders.

3.0 Methodology and Methods

The methodologies used in this research were a community-based research approach and a smart practices approach. The methods used were semi-structured interviews with key informants from the space sciences education community. This research received ethics approval from the University of Victoria's Human Research Ethics Board on October 17, 2018 and the certificate number is 18-1023. The documents in the ethics approval included:

- Consent form for participants
- Third party recruitment letter template
- Project overview letter
- Pre-screening questionnaire
- Draft interview questions
- Recruitment email template

3.1 Methodology

The project used a community-based research (CBR) methodology, where the research was grounded in and served the interests of community and engaged citizens (Caine & Mill, 2016, p. 14). In the context of this report, community refers to the larger international community of space science education outreach providers, the FDAO, and families and children in the area. Space science education outreach providers include local and international teachers, graduate students, and organizations that support public programming outreach, including the DAO and other observatories or space science centers around the world.

The following key elements of a community-based research approach were the focus as they related to the research questions:

- capacity building
- collaboration/authentic engagement
- knowledge relevant to the community (Caine & Mill, 2016, p. 24, table 2.1).

The CBR approach has the combined goals of learning and social change that include “reciprocal learning” (Polanyi & Cockburn, 2003, p. 17). By focusing on a CBR research approach, the researcher has been able to be part of reciprocal learning with the FDAO and other research stakeholders.

The conversations and communications with Dr. Ben Dorman and with the FDAO Board of Directors arose from the fundamental community-based research methodology of establishing authentic partnerships with the community members who were part of the research (Stoecker, 1999, p. 852). These community members initially included the members of the FDAO Board of Directors and with other persons in the space science community, including astrophysicists in Hawaii. As the project progressed, these authentic partnerships included the interviewees themselves. The partnerships were authentic by way of the researcher remaining transparent with

the FDAO board members. The FDAO was open and honest about their values and intentions; the researcher in return was open and honest about their values to the FDAO. The intentions of the researcher were of the pursuit of supporting the space sciences and organizations who share that value and mandate. The intentions of the FDAO were to be supportive of the researcher's research, while allowing the researcher to have autonomy with the research as it pertained to their Masters in Community Development. It was also an authentic partnership by engaging with the board in a way that demonstrated "mutual respect and trust, capacity building, empowerment, and accountability" (Cargo & Mercer, 2008, p. 336).

Authentic partnerships have also been established by the researcher by way of communications with other observatories in North America. This included email communications and a skype call with Callie Crowder November 4th - 20th, 2017, from the Canada France Hawaii Telescope (CFHT) on Mauna Kea, Hawaii, and email communications, as well as an in-person site visit with Thomas Lowe from November 7th - 12th, 2017 and December 9th, 2017, from the PAN-STARRS facility in Maui, Hawaii. These connections and external networks with persons outside the FDAO board are defined as authentic partnerships within the confines of this research project. The participants provided information, resources, and strategies for the researcher to move forward, which Auspos & Cabaj (2014) indicate are key aspects of authentic partnerships in community based research (p. 48); They were authentic in that the researcher also considered these persons to be personal acquaintances and at times, friends. These relationships and authentic partnerships are positionality relevant to the research. Derry (2017) blogged about the importance of a researcher considering their positionality to become aware of their "beliefs, value systems, and moral stances" and how they are "fundamentally present and inseparable from the research process" (Derry, 2017).

Another methodology used in this research was a smart practices review. A smart practices review is different than "SMART goals" where SMART is an acronym for specific, measurable, attainable, realistic, and timely (Williams, C., 2012). The SMART goals framework was utilized by the FDAO board of directors when building their strategic plan. The methodology used for this research, smart practices, is explained by Bardach (2012) as practices that require the researcher to consider what kind of solutions have been tried by other organizations (pp. 109-110). A practice is a behaviour based on an idea that works to solve a problem (p.110). The ideas that are "particularly clever" are called "smart practices" (p. 110). To find these smart practices, it requires a researcher to look for what worked well, as well as understanding how and why (p. 109). A smart practice is not necessarily a "solidly confirmed" practice, but rather may be identified as a slightly better practice than other options in a very context sensitive situation (Bardach, 2008, p. 30). It is a "cluster of ideas" that can be used in a particular set of circumstances (p. 30). The researcher used this methodology in the research method of key informant interviews by finding out what solutions have been tried by other organizations. This was done by asking the key informants to describe their current and past relevant experiences and provide their relevant opinions and recommendations in an open ended

question format. Based on the responses the researcher was able to then assess what worked well, how, and why. This methodology was also utilized in the literature review to identify smart practices that are being used by other similar organizations, such as museums.

Bardach (2012) goes on to explain how a researcher must be rigorous in distinguishing between the functions versus the features of a smart practice (p. 116). The functions are the basis of the smart practice, whereas the features are the details that are more likely to vary (p. 116). A smart practice is based on a verb-like noun, such as “creating” or “instilling”, is generic, flexible, not prescriptive, and not overly precise, is complex, context-sensitive, and capable of being used by different parties to pursue slightly different bundles of goals (pp. 116-117). This methodology requires the researcher to carefully consider the definition of the smart practices of interest and define which ones are most important under the circumstances (p. 119).

A limitation of a smart practices review is that it will rarely leave a researcher with an actual best practice, but rather a good practice based on the parameters of the circumstances (Bardach, 2012, p. 110). Another limitation the researcher must consider is if a smart practice will work well enough in a particular context to justify trying it (pp. 120-121). This means considering the reasonable risks and costs of the smart practice (p. 121). Another limitation of smart practices is that they can be adopted with excessive, unwarranted enthusiasm before having their worth tested (p. 123). It is therefore important to treat a smart practice as comparable to other approaches (p. 123). The researcher used this methodology to guide them by considering the risks and costs of the smart practices on the Friends of the Dominion Astrophysical Observatory (FDAO). The researcher has also advised the FDAO that the smart practices identified that are the basis of the options and recommendations should not be accepted with any more enthusiasm than other suggestions might garner.

3.2 Methods

Data collection for this research project was qualitative. The primary method for data collection was semi-structured interviews (Given, 2008). The purpose of interviewing was to allow the researcher to see another person's perspective (Patton, 2015, p. 426) and this allowed for open-ended questions and the opportunity for follow up probing questions, which built rapport between the interviewer and interviewee (Given, p. 2). Another purpose of interviewing was to align with the methodology of smart practices research, which would garner information that would result in identifying smart practices that are used by other persons in the field of space science public education programming.

Draft interview questions were developed in advanced but the exact wording was not set prior to the interviews which allowed the interviews to be somewhat conversational, but still had the ability to garner systematic data (Given, 2008, p. 2). A possible weakness in this approach was that significantly different responses could have been garnered if the interviewer framed the questions differently each time (Patton, 2015, pp. 437-439). A structured interview format that

uses closed questions would have resulted in a fixed range of responses (Given, 2008, p. 2). The semi-structured approach also allowed for more control than unstructured interviews (p. 2). The semi-structured interview approach appears to have been best suited for this particular research project. The responses given by the interviewees contained emergent themes, including Indigenous knowledge, which demonstrated the suitability of the semi-structured approach.

The interviewees were part of “purposeful sampling”, where information-rich persons were strategically selected to research (Patton, 2015, p. 265). The purposeful sampling strategy means that key informants were deliberately sourced, which required the researcher to identify people with lots of knowledge and/or influence in the topics being researched (p. 268). They were especially knowledgeable in K-12 space science education, observatory-based public programming, and/or youth space science community outreach programming. The key informants were sourced in consultation with the FDAO, through conducting a literature review, and completing internet searches. The interviews were conducted with four key informants - one was located in Canada and the other three were located in different international locations:

- Dr. Lisa McIntosh, Vancouver B.C., Canada;
- Mary Beth Laychak, Hawaii, Hawaii, U.S.A;
- Dr. David H. McKinnon, New South Wales, Australia;
- Dr. Gudrun Wolfschmidt, Hamburg, Germany.

The number of key informants is low due to challenges the researcher faced in regards to the accessibility and availability of key informants for research purposes. A total of 17 key informants from around the globe were contacted; four out of 17 agreed to be interviewed as part of this research.

3.3 Project Ethical Review and Trust

3.3.1 ETHICAL REVIEW

An application was made to the University of Victoria’s Human Research Ethics Board, and received approval for conducting interviews for the purpose of this research project. The application included pre-screening questionnaires for proposed interviewees, draft email communications, and draft questions for the interviews. Data collected from the interviews did not protect the interviewees’ confidentiality in that interviewees are identified in the report. All data collected was kept in an appropriately secure manner on a password protected cloud drive. Participants were advised in advance and in writing that the information they provided would be used to inform the FDAO on how to re-establish the CUVC as a resource to the Victoria CRD K-12 school system, and doing so in a way that aligns with the current K-12 Province of BC’s Ministry of Education curriculum, and the FDAO’s vision, mission, and values. The interviewees were also contacted again after the interviews to confirm that they were comfortable with being identified by name in the report, and to request their preferred personal pronouns.

3.3.2 PROJECT TRUST

Permission to complete the interviews required agreement from the FDAO board chair as well as the interviewees. This agreement assumed that the interviewees participated to the best of their ability. If any interviewee did not wish to participate, this was respected by the researcher. When due to logistical or scheduling reasons interviewees could not participate in an interview, everything was done within reason to accommodate.

The researcher is a former registered member of the FDAO, a supporter of the causes that the FDAO board of directors is working towards, a social acquaintance of Dr. Ben Dorman, FDAO board chair, and of Mr. Bob McDonald, FDAO board advisor. Furthermore, one of the interviewees is an acquaintance of Dr. Ben Dorman. The researcher recognizes that these facts allowed for a development of trust with the organization and client. This was an ethical consideration that was mitigated by considering the status of power the researcher had as an individual, researcher, and representative of the university, by being honest about the power held and “unmasking” that power (Wallerstein, 1999, p. 49). This unmasking and being honest was done by the researcher by being transparent about their relationships, values, and backgrounds within the context of the research, and throughout the research. These relationships and this unmasking are aspects of positionality relevant to the research (Derry, 2017).

3.4 Data Analysis

The research was done with grounded theory. This allowed for codes and ultimately themes to emerge from qualitative research data inductively. The data had been collected through interviews conducted over Skype, a telecommunications application, where both an audio recording and a video recording were made. The researcher then used the video to transcribe the data. The audio recordings had been done as a backup, in case data was lost or there were any technical issues with the video files.

A transcription program was used in part to aid in the process of transcription. The transcription program was not very effective due to two of the interviewees having accents. This proved a challenge for the transcription program to analyze the content of the interviews. The researcher ultimately transcribed by hand approximately 70% of the data, with the remaining 30% of the data being transcribed by the transcription program. After transcription the researcher organized the data into 10 separate response categories. Each response category related to the 10 pre-determined interview questions. Any additional information garnered by additional questions asked by the researcher or by the interviewees offering the information were still organized within the context of the 10 pre-determined interview questions. Each interviewee was given a colour code in order to keep the content clear and organized for the researcher to analyze.

After all the transcribed content was organized into the 10 pre-determined interview question categories and colour coded, each sentence of content was reviewed and given a thematic category. These categories were tracked in a separate excel document. The categories

were also organized by the 10 primary questions. The total number of initial theme categories was 59. Each of these 59 initial theme categories were then charted in an excel document. Each theme was given a total number of times that it had been mentioned thematically in the data. This was an approximation due to these being themes and not how many times a specific word was quantifiably mentioned. Of those themes, 27 were coded as having been indicated only one time. Of the theme categories 32 were indicated at least twice throughout the research. Those 32 were then funneled down to six primary themes. This is demonstrated in the excel file in Appendix C: Secondary Code Categories and Final Code Categories.

Any instance where the interviewee indicated that something they were saying was “important” or “key”, this was highlighted separately by the researcher in red colour. Since the key informants were indicating that the content in question was important, the researcher decided that this should be captured. This was done so as to capture in the analysis the gravity that the informants were attempting to convey with the use of the word “important”. One of the key informants frequently used the term “important” in the answers to their questions. Due to this heavy use of the term, the researcher had to make some interpretations and assumptions to pinpoint what the interviewee was considering to be “important”. Table 2 lists the themes that the key informants had indicated were “important” in their opinion.

Table 2. List of Themes Key Informants Indicated as “Important”

Indicated as “important” by key informant:
Emotional Impact of Educators
Cultural Sensitivity
Cross Content
Site Historical Content
Women in Science & Astronomy
Regular (consistent) programming
Include Teachers
Computer usage
Flexibility
Human resources
Funding
Scientific Instruments
Approach
Resources
Cultural/Indigenous aspects

3.5 Project Limitations and Delimitations

3.5.1 LIMITATIONS

There were some limitations with accessing peer-reviewed articles specific to observatory programming due to an apparent lack of comprehensive articles on this topic. Another challenge was a lack of interest or capacity for potential interviewees to participate in interviews. To mitigate this, the researcher attempted to build relationships with other observatories that have public programming prior to conducting the research. This was done by communicating over emails, Skype, and in person to establish authentic partnerships of trust and mutual respect (Stoecker, 1999, p. 852). This attempt to build relationships had challenges due to primarily happening over email with strangers who were the potential key informants. The email

communications with strangers resulted in a lack of interest from some key informants to participate in the interviews. One potential key informant emailed the researcher and specifically mentioned their lack of interest in participating.

There were seventeen people considered appropriate persons to contact for possible interviewing or to possibly direct the research to others who could be interviewed. Out of that 17, five never replied to the researchers emails at all; one replied and indicated a strong desire to not participate; two responded but indicated they were not an appropriate interview candidate and had no one else to forward the request to; one responded but indicated they were not an appropriate interview candidate and did forward the request, but this did not lead to any other interview candidates; four answered but were required to get permission from their superiors, a process which took many weeks, and after gaining permission, then requested to have several more weeks before interviewing due to their schedules or capacity.

These delays were not something that the researcher was able to reasonably accommodate as it pushed back the research timelines by many weeks. The researcher initially sent out invitations over email for possible interviews on January 3, 2019. Subsequent follow up emails were sent out through February. Interviewees had until March 15th to complete the interviews. Any desire from the interviewees to have their interview done after March 15th had to be denied due to the timelines that the researcher had decided were necessary to complete the project in a timely way. Ultimately four key informants were willing and able to complete an interview for the research within the timelines that the researcher had indicated.

Another limitation the researcher faced was that the Friends of the Dominion Astrophysical Observatory (FDA) have proven to be an active and fast-moving organization. The board members and organization as a whole were making progress faster than the researcher could conduct the academic research. Since the researcher initially approached the FDAO about working together on an academic project for Master's in Community Development in the fall of 2017, the client has completed many projects and goals. Some of those projects and goals include: conducted strategic planning meetings, and created and posted a strategic planning document; created, funded, and launched a virtual field trip experience; applied for and been successful in a grant allowing them to hire a part time staff person for their summer season, for both the 2018 and 2019 summers; offer class field trips upon request; and have sourced funding and launched a new website.

3.5.2 DELIMITATIONS

The scope of the research, including the literature review and interviews, were originally going to be from Canadian or United States sources. This was to maintain appropriate context that is relevant to the Dominion Astrophysical Observatory (DAO), the Centre of the Universe Visitor Centre (CUVC), and the FDAO located in Victoria, BC, Canada, and to manage the scope of the project. Due to a lack of relevant literature, this scope was expanded to include international observatories and space science organizations that have public programming.

The research project did not seek to prove the relevance or need for public programming at observatories. It is a background assumption that there is a need for public programming at observatories. The project instead sought to identify key recommendations for how to reinvigorate K-12 public programming at the CUVC and at the DAO. The researcher also recognized that one piece of the literature review was written by a member of the FDAO. The article “Communicating Canadian astronomy on the eve of the international year of astronomy 2009”, was written in part by Jim Hesser (2008), Emeritus Director of the DAO, and advisor to the FDAO board of directors (Directors and advisors, 2019). This is noted to indicate transparency around the source materials and an awareness of potential conflicts of interest with use of certain publications in the research.

4.0 Findings

This section reviews the findings from the semi-formal interviews conducted with the four key informants. Interviews were conducted between January 31st, 2019 and March 1st, 2019. The purpose of the key informant interviews was to see the perspective of other persons who are working in and leading programming in the space science public programming field, as well as to learn about smart practices in the field.

Interviewees were asked ten primary questions that were followed up with at least one other additional question that arose from the semi-formal interview structure. The amount of time for each interview took between 30 and 90 minutes. The findings were structured into a thematic analysis based on grouping various questions asked of the respondents.

4.1 Background Information on Key Informants

Each key informant was contacted after the research to enquire their preferred pronoun to be used and how they would like to be named during the research findings section. They were also given a final opportunity to indicate if they did not wish to be identified. All the key informants replied and indicated the following way they wished to be referred: Dr. Gudrun Wolfschmidt; Ms. Mary Beth Laychak (and/or “she”); Dr. Lisa McIntosh; Dr. David H. McKinnon (and/or “he”). The researcher’s personal values and therefore positionality in regards to personal pronouns is that they are important and to be respected. For this reason, the researcher made a point of making sure the pronoun preferences were correctly used throughout this report.

4.2 Interview Questions

Table 3 indicates what the ten primary interview questions were. The ten primary questions were created to align with the secondary research questions of:

- What resources are needed?
- Which options are more challenging?
- Which options require less resources?
- Which options should be pursued first?

Ten Primary Interview Questions
1. How would you describe the K-12 public programming that the organization you work for currently has?
2. How would you describe the K-12 public programming that the organization you work for previously had?
3. What resources do you believe are required for the K-12 public programming to continue at the organization?
4. What resources do you feel are optional for the K-12 public programming that your organization provides?
5. What resources would you consider of greatest significance for the K-12 public programming to continue at the organization?
6. In your opinion, what are the challenges for the K-12 public programming at your organization?
7. In your opinion, what are the best ways in which an organization can engage with K-12 schools?
8. In your opinion, what are the best ways in which an organization can encourage K-12 schools to visit an observatory, the location of public programming?
9. In your opinion, what would you recommend that a new organization do as a first step to having K-12 public programming at an observatory?
10. If you are more familiar with the FDAO programming, or the DAO site, what recommendations would you make for them to pursue public programming for K-12 schools?

Table 3. Ten Primary Interview Questions

During the first interview with Dr. David H. McKinnon, there were several times when aspects of Indigenous knowledge were mentioned. This is likely due to the title of the article that the researcher had reviewed that Dr. McKinnon had co-written as part of the literature review titled “Indigenous sky stories: Reframing how we introduce primary school students to astronomy - a type II case study of implementation” (2016). The mentioning of Indigenous knowledge and culture triggered the researcher to ask a further open ended question in regards to McKinnon’s thoughts around engaging with the local Indigenous community. Two of the remaining three subsequent interviews also consisted of the interviewees mentioning a topic

around Indigenous culture or knowledge. The researcher therefore asked the other two interviewees a non-leading question in regards to Indigenous culture, or knowledge.

One of the interviewees, Dr. Lisa McIntosh, provided a significant amount more information on this topic after being asked the follow up question. The researcher took great care in regards to allowing the topic of Indigenous knowledge and culture to emerge on its own without asking any probing questions. When the topic emerged on its own, the researcher then took great care in making sure that the emerging question was asked in a way that was open ended, and not leading. This was done due to the researcher's awareness of their positionality in regards to their personal values around Indigenous culture, knowledge, and ways of knowing.

Question four, "what resources do you feel are optional for the K-12 public programming that your organization provides", garnered minimal responses from the interviewees. It was the only question asked that did not result in significant amounts of data or information. The researcher asked this question in an attempt to capture information about resources that an organization could possibly omit from their initial programming. This was considered to be a question that would align well with the secondary research questions of what resources are needed? Which options are more challenging? Which options require less resources? And which options should be pursued first? One of the interviewees answered question four with "I don't have anything that I would say is optional". Ultimately, the interviewees didn't have a significant amount to contribute to this question.

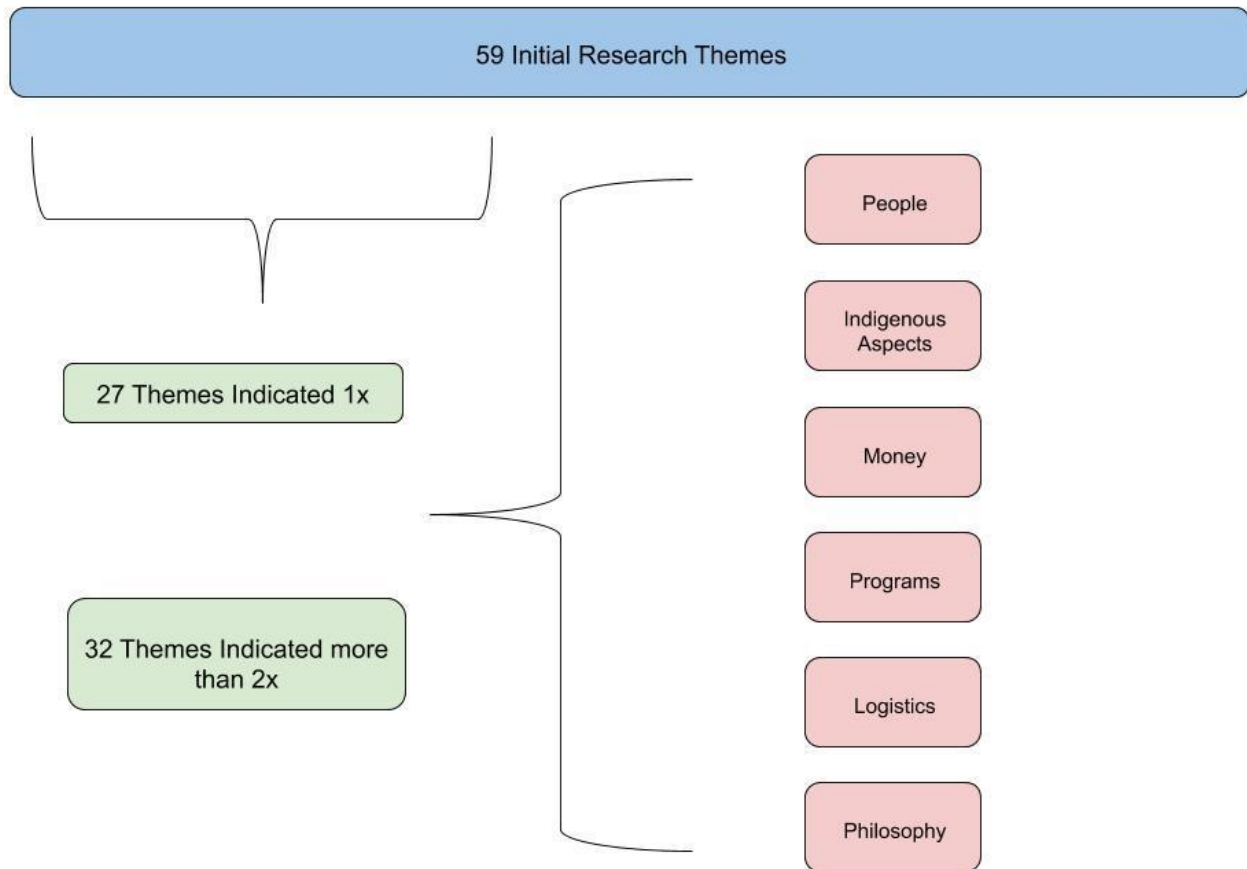
4.3 Initial Themes

After all the transcribed content was organized into the 10 pre-determined interview question categories and colour-coded, each sentence of content was reviewed and given a thematic category. These categories were tracked in a separate excel document. The categories were also organized by the 10 primary questions. The total number of initial theme categories was 59. The 59 categories of themes were separated out by how frequently they were mentioned. This was an approximation due to these being themes and not how many times a specific word was quantifiably mentioned. Of those themes, 27 were noted only one time. Of the theme categories, 32 were indicated at least twice throughout the research. Those 32 were then funneled down to six primary themes, which can be seen in Appendix C: Secondary Code Categories and Final Code Categories.

The six primary themes are people, Indigenous aspects, money, programs, logistics and philosophy. It should be noted that all the other 27 themes noted only once still fit well into the final 6 categories. This is also noted in Appendix C: Secondary Code Categories and Final Code Categories. Some of the initial themes repeated a significant amount of times: human resources/staff/volunteers, at least 23 times; Teachers, at least 13 times; Funding/budgets/money, at least 11 times; Program design, at least 11 times; and activities, public programming, and

curriculum, each at least 10 times. Figure 4 outlines the primary themes that emerged from the research.

Figure 4. Primary Themes That Emerged From the Research



4.4 Primary Themes

4.4.1 PEOPLE

The themes of human resources, staff, and volunteers were indicated at least 23 times throughout the data. When all the themes relating to “people” were tallied up, they were indicated at least 47 times. The primary theme of “people” includes the themes of human resources, staff, volunteers, teachers, and the capacity of persons, relationships, collaborations, and training. All interviewees indicated that there is a dependence on either volunteers or staff, or a combination thereof, in order to make space science public programming possible at either an observatory or a space centre. Dr. Gudrun Wolfschmidt indicated that they are dependent on a part time staff member, who is also a high school teacher that is funded by the government to organize all the astronomy workshops for classes that come to the observatory in Hamburg. Dr. Gudrun Wolfschmidt also stated that finding enough instructors for their public programming

was a primary problem, or challenge, and that they are heavily dependent on volunteers or “freelancers” who “want to help the observatory” (G. Wolfschmidt, personal communications, March 1, 2019). Dr. Lisa McIntosh also indicated that the H.R. Macmillan Space Centre has paid staff that facilitates its programs. When asked what resources are considered of greatest significance for the K-12 public programming to continue at the H.R. Macmillan Space Centre, Dr. McIntosh replied that “it’s the people” (L. McIntosh, personal communications, February 6th, 2019). Ms. Mary Beth Laychak elaborated on this in her response to the same question stating that “if you have multiple staff members who are doing outreach and community engagement they need to report to somebody...that is looking at what is ‘our’ vision” (M. Laychak, personal communications, February 20, 2019). Dr. McKinnon also pinpointed that a very first step in regards to people and these relationships is to “identify a small group of teachers who can work with the personnel astronomers at the observatory” (D. McKinnon, personal communications, January 31, 2019).

All the interviewees brought up the role that teachers play in space science public programming, though teachers are not mentioned specifically anywhere in the research questions, or interview questions. Dr. McKinnon stated that in his experience, both primary school teachers and high school teachers “don’t have a great degree of knowledge about astronomy” (D. McKinnon, personal communications, January 31, 2019). In regards to the perspective and lens of the teachers, Dr. McIntosh asks that the organization consider the perspective of the teacher by “figuring out what you as an organization can do that you as a teacher cannot do in a classroom” (L. McIntosh, personal communications, February 6th, 2019). Ms. Mary Beth Laychak works directly with teachers in her role with the Canada France Hawaii Telescope public programming and explained her relationship with teachers. She stated that “you have to be someone that the schools know that they can count on” and that “we’re giving them something that teachers can’t give” (M. Laychak, personal communications, February 20, 2019). Ms. Laychak serves on two school and community councils, allowing her to interact with the teachers and administrators “on a closer level” (M. Laychak, personal communications, February 20, 2019). She added that larger, more systemic public programs “require a personal relationship with the administration and teachers” (M. Laychak, personal communications, February 20, 2019).

Volunteers and their significance were also mentioned by all the interviewees. Ms. Laychak has coworkers that volunteer for classroom visits, summit tours, and community events and as such are a significant part of the “people” who work with and support her with community engagement. She also mentioned that high school students could possibly serve as a good resource of volunteers to provide support at weekend events, such as Star Parties (M. Laychak, personal communications, February 20, 2019). Dr. McIntosh specifically brought up the importance of well-trained volunteers who are “great educators” and “great science communicators” (L. McIntosh, personal communications, February 6th, 2019). Dr. Wolfschmidt indicated that the Hamburg Observatory considers its volunteers to be persons who do “support work” and these include the real astronomers at the observatory, the University students, and

PhD students. Dr. Wolfschmidt also mentioned the challenge of relying on these persons for support due to the fact that they often leave the observatory, and then new members have to be found who are interested in providing this sort of support at the observatory (G. Wolfschmidt, personal communications, March 1, 2019).

4.4.2 INDIGENOUS ASPECTS

The theme of “Indigenous aspects” was indicated by three of the interviewees, Dr. David McKinnon, Ms. Mary Beth Laychak, and Dr. Lisa McIntosh, as a very important issue. It is also a key aspect to BC’s new curriculum. The researcher decided to pull it out separately from the other themes to draw further attention to it and discuss it in greater depth. For these reasons, it was not included in the “people” or “philosophy” themes. Ms. Mary Beth Laychak stated that there is a “cultural component to the program [and] it’s really important to us that this program is rooted in a sense of place and acknowledges the local Indigenous culture and knowledge”; This includes “modern and ancient ways of navigating the Universe, and so it focuses on Hawaiian voyaging and wayfinding...from a mathematical, scientific, and cultural point of view” (M. Laychak, personal communications, February 20, 2019).

Dr. Lisa McIntosh stated that “including Indigenous content in programming like this is challenging on many levels” and “if you’re doing it right, it is an Indigenous person from the nation who is facilitating it”. Dr. McIntosh also indicated that even the H.R. Macmillan Space Centre is not at that point yet itself (L. McIntosh, personal communications, February 6th, 2019). Dr. Lisa McIntosh went on to explain that “teachers are really looking for [Indigenous content] because Indigenous perspectives are much more ingrained and filtered through all of the curriculum and there are not a lot of resources out there, so it’s a challenge for teachers”. The H.R. Macmillan Space Centre is “integrating it in slowly” and is currently utilizing a “good story that kind of fits, that we integrate in different ways into grade 1 and 4” called “The 13 Moons of WSANAC” (<http://www.racerocks.com/racerock/firstnations/13moons/13moons.htm>) (L. McIntosh, personal communications, February 6th, 2019).

Dr. Lisa McIntosh went on to explain that “one of the challenges around first nations content is...of focusing on place, so from a west coast, Squamish, or broader Coast Salish, there are not many, if any, stories out there that I’m comfortable with their authenticity, and whether they are stories that are then allowed to be shared publicly”, and then “actually accessing” those materials (L. McIntosh, personal communications, February 6th, 2019). Dr. Lisa McIntosh explained how the H.R. Macmillan Space Centre “in 2008...did look at Indigenous perspectives of the night skies, and had an Indigenous educator working with us on and one of the things that she was trying to do was to find stories that we could share; she kept running into roadblocks because either they weren’t there or they were not ready to be shared” (L. McIntosh, personal communications, February 6th, 2019).

Another challenge identified was that “there are Indigenous stories out there publicly that are accessible but they tend to be from more of the central North American area”, and therefore

does not talk “about any of the First Nations who live here”. It would be preferred to “work with someone locally where we could tell local stories; but we’re just not there yet other than The 13 Moons” (L. McIntosh, personal communications, February 6th, 2019). Dr. Lisa McIntosh offered that the FDAO may have access to resources that have been collected on a “padlet,” which is an online tool with resources that serves “to bring together a number of Indigenous night sky resources” (<https://padlet.com/learning11/v6a8o6m2zk1d>). Dr. Lisa McIntosh also provided the advice to the FDAO that “having someone from the local First Nation on your board might not be a bad idea” (L. McIntosh, personal communications, February 6, 2019).

The Indigenous sky stories project that Dr. David McKinnon is part of includes working with Indigenous persons and groups. He stated that “one of the key issues is respect...total utter respect for the First Nations peoples and their use of the sky” (D. McKinnon, personal communications, January 31, 2019). He states that “judgement has to be totally suspended until you can walk in their shoes” and “that cultural respect, cultural awareness, is only the first step”. He went on to explain how the astronomer has to take a step back and hear and “appreciate the stories for what it is, from their perspective” (D. McKinnon, personal communications, January 31, 2019). He goes on to provide the advice that “there is an invitation to the local people...any elders who know some sky stories that they would be prepared to share with visitors to the observatory”. He advised to “work with” them and also to pay them for their time, stating that to ask them to volunteer their time is not appropriate, as they are sharing their culture. Dr. McKinnon gives the specific example that for the Indigenous sky stories project that he is part of, the elders “come and sit around the campfire and share their stories with school groups who come to visit” (D. McKinnon, personal communications, January 31, 2019).

4.4.3 MONEY

Money and themes that related to it, like funding, budgets, costs, fees, and free programming were mentioned at least 17 times throughout the data. Dr. McKinnon brought up the theme of money by discussing funding for the programming and indicated that an organization should consider seeking sponsorship from businesses that could, in exchange for financial support, have their logo featured in some way, such as printed materials. When asked about the required resources needed for K-12 public programming, he stated that “collaboration between astronomers, teachers, and whoever else” requires time, and “time costs money”. He also mentioned the opportunity to charge visitors a small amount of money, a fee, to support program funding (D. McKinnon, personal communications, January 31, 2019). The opportunity for sponsorship is something that Dr. Gudrun Wolfschmidt stated was not something available in Germany in the way it is available in Canada; that it is not traditionally how things are done in Germany for program funding; The sense is that “the state should do it”, and as it stands now, that is their source of funding for the one staff person that they have part time. In regards to raising funds, Dr. Gudrun Wolfschmidt went on to state that “it’s very difficult to raise money for...things [such as] restoration” for items such as their large refractor telescope, and that “this is

extremely complicated” to even raise just “two thousand [dollars]” (G. Wolfschmidt, personal communications, March 1, 2019).

The cost of having students attend the Canada France Hawaii Telescope is a big issue. For example, one respondent noted that “it’s just too expensive” for some members of the community to pay for the busses required to visit the site (M. Laychak, personal communications, February 20, 2019). The cost of bussing was mentioned also by Dr. Lisa McIntosh, who indicated that the bus costs are a cost that the schools are left to pay for even if the cost of the program is free. The programming offered at the H.R. Macmillan Space Centre is not free; the fee that the schools pay to attend the site helps to pay for the cost to have staff deliver the programming and to pay for other resources. They do also have some programming that is funded by a private corporate sponsor (L. McIntosh, personal communications, February 6, 2019). The programming offered at the Canada France Hawaii Telescope has received additional funding by way of grants that were written to garner further funding than what CFHT already has from varying sources (M. Laychak, personal communications, February 20, 2019).

When asked about the best way to engage with K-12 schools, Dr. Lisa McIntosh immediately stated “if you can do a free program for them, they would love you.” Removing the cost of taking a bus to the site is also something that Lisa McIntosh brought up; in the programming they offer, they can do this by offering virtual trips using video Skype (L. McIntosh, personal communications, February 6, 2019). Money was one of the two things that Ms. Laychak indicated was a challenge for K-12 programming, the other being staffing. She stated that “I’m a department of one, so there are things that I can’t do” and that “if we had more money, I would spend more money” (M. Laychak, personal communications, February 20, 2019).

4.4.4 PROGRAMS

The theme of programs or programming and everything related to it, such as program design, activities, curriculum, grade levels, site features, and cross discipline content, were mentioned at least 47 times. Two of the four interviewees discussed that their programming is a combination of the students coming to them at their site and the staff going to the students at their schools. The other two interviewees discussed that the students attend the observatory for the educational programming, and did not mention if they have staff or volunteers who go into the classrooms for the programming. One of the interviewees who has programming where the staff go into the schools to host the space science education explained this is in part done because younger students are not permitted to attend the observatory site due to the age restrictions to be at a high elevation (M. Laychak, personal communication, February 20, 2019). The other interviewee who also has programming where the staff go into the schools to host the space science education explained that they do so in order to engage with schools who are outside of their geographic area. They conduct the in-school programming with the support of a private, corporate sponsor, and by having a staff person travel to the school with their portable

planetarium (L. McIntosh, personal communications, February 6, 2019). In both instances, the in-classroom visits from the science education staff are done by specific and direct requests from the schools.

Dr. Lisa McIntosh states that it is not as important to sit the students in a lecture hall and lecture them because that can bore them, but rather the focus should be on the experience (L. McIntosh, personal communications, February 6, 2019). Dr. Gudrun Wolfschmidt elaborates on this by indicating “touching, hands on experiments...are very motivating for the children...and they like it more than listening to a lecture”. Wolfschmidt clarifies that they do offer a lecture hour at the Hamburg Observatory with an astronomer where the children can ask questions and “the real astronomers answer these questions”, which is exciting for the students because it is a “real astronomer” that they get to “see and to touch” (G.Wolfschmidt, personal communications, March 1, 2019). Dr. Lisa McIntosh also indicated that they offer programming designed with a “Q&A” portion with an astronomer for the older students “because they often have some good, hard questions” (L. McIntosh, personal communications, February 6, 2019).

Ms. Laychak, Dr. McIntosh, and Dr. McKinnon all addressed the fact that it is in grade four that students learn about the phases of the moon and that this is a curriculum and education aspect that teachers are often looking for support with from their organizations. Ms. Laychak suggests focusing “on a single grade level...perhaps a grade level in elementary school and a program for high schoolers”. She goes on to explain about the program that her organization offers “where we’re either giving the students something that is expanding on something they’re learning at school or we’re giving them something that teachers can’t give”. She also stated that she thinks that “somewhere like the Centre of the Universe, the expectation is it’s going to be aligned with or augment the curriculum” (M. Laychak, personal communications, February 20, 2019). This focus on the curriculum is something that all of the interviewees mentioned, and ultimately agree upon: that at least some of the programming should align with the curriculum, or at least compliment it. Dr. Lisa McIntosh indicated that with the changes to the BC curriculum, specifically moving much of the science content from grade three into the grade four curriculum, teachers were initially resistant to this change, and they had a drop in field trips for this grade and age group. They seem to have now adjusted to these curriculum changes, at least for the grades three and four (L. McIntosh, personal communications, February 6, 2019). While Dr. Gudrun Wolfschmidt indicates the importance of linking to the curriculum, Wolfschmidt also stated that “you can [also] offer additional things which are not in the curriculum” and that “the students like to do such things”. Dr. David McKinnon also added to the theme of program design by stating that “the quality of the material that you have developed has to be really high quality” (D. McKinnon, personal communications, January 31, 2019).

Dr. McKinnon pointed out that the DAO site has history, “a very impressive dome with a beautiful shield on the front of it”, a large sized telescope, and real working astronomers that can all be used to attract people to the facility. He also encourages that there are social events held at the site to attract interest from the community (D. McKinnon, personal communications, January

31, 2019). Dr. McIntosh also points out that an aspect is “helping teachers understand what a unique resource it is” and recommends the option of “actually do[ing] a teacher pro-D workshop at the site, so you get the teachers on the site, you help them understand how unique it is, and even walk them through the programming options” (L. McIntosh, personal communications, February 6, 2019). This engagement with local teachers is also mentioned by Dr. Gudrun Wolfschmidt who indicates that teachers from the local University Education department could be engaged with so that they are aware of the sort of field trip related educational programming is offered at the observatory (G. Wolfschmidt, personal communications, March 1, 2019).

Dr. Gudrun Wolfschmidt also discussed how the Hamburg Observatory has historical significance in regards to the history of navigation and particular scientific instrumentation, which is embedded into the educational programming provided at the site, including access to the historical instrumentation at the site. Dr. Gudrun Wolfschmidt specifically indicated that the observatory’s historical significance in regards to certain aspects of astronomy can help to explain where we are with modern science and is therefore embedded into the educational programming provided at the site for school aged students. In this way, “the student can follow the development”. Dr. Gudrun Wolfschmidt also indicated how there is an opportunity for cross discipline experiences, including things like “art exhibitions”, “literature evenings” as well as connecting to other science disciplines like geography, mathematics, or biology (G. Wolfschmidt, personal communications, March 1, 2019). Dr. Lisa McIntosh also indicated that at the H.R. MacMillan Space Centre they offer more English language arts and humanities type of programming such as storytelling and mythology in regards to constellations (L. McIntosh, personal communications, February 6, 2019).

The theme of age appropriate and curriculum-linked programming came up with all the interviewees. In order to build age appropriate and curriculum linked programming Dr. Lisa McIntosh gives the advice to “take a look at the grade four curriculum...and then grade six” due to their relevance to the BC space science curriculum requirements. She also indicated that grade one is a common age group to attend the programming offered at the H.R. MacMillan Space Centre. She stated that “it could be a really fun grade one field trip” but also stated that such a young age can be more challenging and that volunteers would be required that have an appropriate level of comfort with working with children that young. She stated that hosting high school students has some logistical challenges in regards to how their schedules and timetables work, and for this reason, it may be best to focus on the elementary school grades, to start as a target (L. McIntosh, personal communications, February 6, 2019).

Dr. Gudrun Wolfschmidt explains that normally the children visit by way of the teachers. The observatory advises teachers through different marketing means that they offer free programming where you can “just come with your class and we do the rest”. The activities that are then offered are many and varied and include spaceflight activities, making rockets, a planet walk for the small kids to experience the solar system, making small models of the planets, using computers to do computer simulations of galaxy collisions, spectroscopy experiments and more

(G. Wolfschmidt, personal communications, March 1, 2019). In regards to developing this sort of programming and activities, Dr. McKinnon recommends “you get a few teachers... to work with the astronomers to develop the activities”, which gives the organization the ability to market the programs as having been developed with and by teachers (D. McKinnon, personal communications, January 31, 2019).

4.4.5 LOGISTICS

The themes that related to that of logistics were indicated at least 19 times, including aspects around advertising, bussing, communications, accessibility of a space, access to technology, and scientific instruments. The logistics of attending an in-class presentation was mentioned by Mary Beth Laychak in regards to the work that goes into emailing and coordinating the school visits off-site. She also mentioned the necessity of bringing supplies with her to the in-class presentations, which requires coordination and access to a budget for supplies, including stickers, bookmarks, crayons, and scissors. When she hosts other community events, such as the “engineering bash” at the local library, she also requires supplies for alka seltzer rocket demonstrations (M. Laychak, personal communications, February 20, 2019). Ms. Laychak also mentioned that her and her volunteer teams also attend community events, such as the “engineering bash” at the local library, Astro Bash, and Journey Through the Universe astronomy blitz (M. Laychak, personal communications, February 20, 2019). Mary Beth Laychak also spoke about the logistics of going to the observatory site of the Canada France Hawaii Telescope. She discussed some of the challenges with buses and also with making sure that the students receive a snack or lunch item. This was due to the fact that if students haven’t eaten before climbing the high altitude, they could get sick (M. Laychak, personal communications, February 20, 2019).

Dr. Lisa McIntosh spoke about the programming that has been offered in other cities outside of the Vancouver H.R. MacMillan Space Centre, including Prince George, Kitimat and Fort St. John. This program requires the coordination of staff to visit the cities who have requested it, as well as the portable planetarium to be transported (L. McIntosh, personal communications, February 6, 2019). When discussing the programs offered at the H. R. Macmillan Space Centre, Dr. McIntosh mentioned the logistics of managing 50-60 kids at the site. She stated that having a busload of two classes attending at one time is a more likely way to book the busses due to logistics. Lisa McIntosh also spoke about the logistics that can be required to make “your program accessible for learners of different kinds”, including having the students working together to support the kids with different abilities. Dr. McIntosh gave a specific example of a request from a teacher who had a student that was visually impaired. It was explained that the programming offered is primarily visually based, which can prove a challenge with such requests, as well as with requests for students who are “English language learners” due to the amount of new vocabulary (L. McIntosh, personal communications, February 6, 2019).

Ms. Laychak spoke about the necessity of having all the logistical resources, such as staffing, to meet the expectations that are being put out to the community. She spoke about this by giving the example of a popular children's book called *If you give a mouse a cookie*: "if you give a mouse a cookie..." and elaborated that "if you start opening stuff up and you don't have the staffing" to support it with, then you cannot maintain the quality of the programming the way it is or should be (M. Laychak, personal communications, February 20, 2019). Dr. David McKinnon also indicates the organization needs to be "delivering all of the things" that are being promised as an organization (D. McKinnon, personal communications, January 31, 2019).

Dr. Wolfschmidt, Dr. McKinnon, and Dr. McIntosh all mentioned the requirement for marketing and advertising in order to communicate to the population the programming that is available at the observatory. They indicated a combination of tools including newspapers, journals, the internet and web pages, and mail outs of printed marketing materials. "It's important that people can come and visit...and know that there is something going on here" and also that "we tell the schools that.... the observatory is a valuable outside the classroom learning place". Dr. Wolfschmidt specifically indicated "that people [should] always know... there is something going on" at the site, such as lectures being offered on a regular basis, events on the weekends, and regular guided tours (G. Wolfschmidt, personal communications, March 1, 2019). Dr. Lisa McIntosh asked the question "how do you market to the right teachers?" and offered information about the opportunity to pay for an ad in the website BC Field Trips.ca, an opportunity for advertising to teachers about field trips available in BC (L. McIntosh, personal communications, February 6, 2019) The researcher discussed this website in the background section, since it was found by the researcher prior to conducting the interviews.

Dr. David McKinnon spoke in detail about his experience of offering materials to teachers before and after the actual visit to the observatory. This is something that he indicates requires planning, as the materials must be developed in advanced, organized in advanced to be sent to the teachers, and managed after the visit. The materials offered before the visits include the opportunity to receive pre-visit questions from the students that he then organized into categories and addressed and answered during the school visit. Dr. McKinnon also indicated that the logistics of this are labor intensive, and provided the example that it took many hours of work to organize all the students' questions that were received in advance. He also mentioned the logistics that are involved on the part of the schools, including how the teachers have to coordinate with the parents around having the field trip taking place, and consider that teachers and parents will "undertake the risk analysis" of even going through with the field trip (D. McKinnon, personal communications, January 31, 2019).

4.4.6 PHILOSOPHY

The theme of philosophy was derived based on the recurring themes that came up around 'big questions' and 'big goals'. This included themes such as emotional impact, knowledge, community, and organizational vision. Some of the 'big questions' were addressed by Ms.

Laychak who stated that the FDAO needs to consider their plan, and figure out what their priorities are, rather than trying to accomplish too many things at once. She warned against trying to “do everything” and to instead recommend that the FDAO stay focused on “what programs you can create or participate that allows you to reach the group that you specifically want to reach”. She suggested that the following questions be considered: “what is your goal? What do you want to impart to these students? Do you want them to learn about space? Do you want them to be empowered in some way shape or form? Do you want them to have a fun experience? Do you want to complement their education in school? Do you want to do something that augments their education in the school? Do you want to provide enrichment? Are you working with students that are high achievers, average students, everybody, medial achievers? Do you have specific programming for special education?” She goes on to suggest that after a clear idea has been established, the organization can then figure out how to execute it (M. Laychak, personal communications, February 20, 2019).

The theme of ‘big goals’ came up in regards to the experience of the space science programming that is not related to content or garnering knowledge. Dr. Lisa McIntosh stated that “one of the biggest take home messages...in general, is that content is not king, it is about the experience and it is about the effective components that your site and the passion of your educators can convey”. Dr. McIntosh went on to elaborate about the goals of the H. R. Macmillan Space Centre by stating that “the goals of our programming, ‘our big goals’, are focused really around wonder and curiosity and joy...the content is just a vehicle to help get us there” (L. McIntosh, personal communications, February 6, 2019).

The theme around the idea that there is an emotional impact or unique experience that arises from the visits to the observatories or space centres is one that recurred as well. Dr. Lisa McIntosh articulated that it is not just about the knowledge you are imparting on the children, but that “it’s the experience you’re giving them” (L. McIntosh, personal communications, February 6, 2019). Dr. David McKinnon also brought up the emotions and transformations that can occur to both the teachers and the students, and claimed that “suddenly you see the teacher’s views being transformed when the kids get excited about something and that engagement leads to real learning”. He stated that while there is learning going on, it is also “providing a motivating experience for students” when they are able to have an experience with an astronomer. He also described how there is a special impact “that really enthuses [the students] when they get to experience looking through a telescope and seeing “the surface of the moon, or the rings of Saturn” with their own eyes. McKinnon also specified how the use of “images are really powerful messages that kids take away with them”, that last on an emotional level beyond their visit at the observatory (D. McKinnon, personal communications, January 31, 2019).

4.5 Themes Indicated as “Important”

The instances where the interviewees indicated that something they were saying was “important” or “key” were noted and coded thematically. This resulted in the identification of the

following themes: emotional impact of educators, cultural sensitivity, cross content [discipline], site based historical content, women in science and astronomy, regular or consistent programming, inclusion of teachers, computer usage, flexibility, human resources, funding, scientific instruments, approach, resources, cultural/Indigenous aspects. The theme that emerged around Indigenous and cultural aspects were discussed more thoroughly in the findings as this was indicated as something “important” but also was something discussed thoroughly by two of the interviewees. Since it is also a key aspect of the new BC curriculum, the researcher chose to also pull that theme out of the “important” list to report on those findings separately. As noted earlier, Table 2 is indicated again to list the themes that the key informants had indicated were “important” in their opinion.

Indicated as “Important” by Key Informants
Emotional Impact of Educators
Cultural Sensitivity
Cross Content
Site Historical Content
Women in Science & Astronomy
Regular (consistent) programming
Include Teachers
Computer usage
Flexibility
Human resources
Funding
Scientific Instruments
Approach
Resources
Cultural/Indigenous aspects

Table 2. List of Themes Key Informants Indicated as “Important”

4.6 Summary of Findings

The findings from the four key informant semi-structured interviews provided the perspective of other persons who are working in and leading programming at three international observatories and one Canadian space centre. The interviewees were asked 10 primary questions that were followed up with at least one other additional question that arose from the semi-formal interview structure. A question that arose that was asked of most of the interviewees was in regards to elaborating on the topic of Indigenous knowledge. The answers to these questions resulted in certain themes emerging, those of: people, Indigenous aspects, money, programs, logistics, and philosophy. At no time did any of the interviewees answer questions that directly conflicted with answers to another interviewee answer. In this way, there was nothing that the key informants seemed to disagree with each other on.

The following discussion and analysis will address smart practices, other themes, and other ideas that emerged from the findings and relate them to the literature review. This will ultimately allow the researcher to suggest ways that the Friends of the Dominion Astrophysical Observatory can engage with the K-12 school system in alignment with the BC curriculum. It will also allow the researcher to answer the secondary research questions of: What resources are needed? Which options are more challenging? Which options require less resources? Which options should be pursued first?

5.0 Discussion and Analysis

Five key themes emerged from both the literature review and the research to potentially answer the research questions: people, money, programs, logistics, and philosophy. The purpose of the following section is to discuss how these themes from the literature review and the research, linked with the background section, will develop into the smart practices. Two other topics will also be addressed, the first being the emergence of the theme of Indigenous aspects. The second topic to be addressed are the themes that the key informants indicated as “important”. The exploration of these themes and smart practices will help to answer the research questions and to inform the options and recommendations. A summary of the smart practices identified in this discussion and analysis can be seen in Table 4.

5.1 Literature Review and Primary Research - Overlapping Themes

The research questions can begin to be answered by looking at the literary themes and the primary research themes and noting where they overlap. The literature themes of resources, learning, and collaboration, expanded into the themes of human resources, money, stakeholders, science education, cross disciplinary/cross cultural content, teaching, and public programs/museums. The primary research resulted in the themes of people, Indigenous aspects, money, programs, logistics, and philosophy. The themes that emerged from the literature review and the themes that emerged from the research were very similar to each other; in some cases, they were identical and they often overlapped. This alignment with the literature review and the research allowed the researcher to highlight smart practices and ultimately make recommendations.

The primary research question of what are the ways the FDAO can re-establish the CUVC as a resource to the Victoria CRD K-12 school system can begin to be answered when considering the overlapping themes and resulting smart practices. The ways that they can re-establish themselves is to consider and pursue their needs in regards to people, money, programming, logistics, and philosophies.

5.1.1 PEOPLE

The theme of people, including human resources, stakeholders, and teachers was a significant theme throughout the literature review. The theme of human resources was also identified by the key informants as being “important”. This theme highlighted the significance of both staff and volunteers to an organization’s capacity. Kadoyama (2018) pinpointed that a lack of staff bandwidth will result in a slower moving and smaller scale organization (p. 61), which can be interpreted to mean that an increase in staff bandwidth would result in a faster moving and larger scale organization. Since volunteers are persons that work for an organization without pay, Kadoyama’s description of staff bandwidth could also include volunteer bandwidth, especially for organizations that are heavily, or entirely dependent on volunteers as their human resource.

This dependence on staff and volunteers was echoed by all interviewees. Dr. McIntosh's statement that "it's the people" who are the most important resource (L. McIntosh, personal communications, February 6th, 2019) gives credence to this idea. Stakeholders are another group of persons that were significant in both the literature review and the research. These stakeholders include persons and organizations who provide financial support and funding, such as funders and donors. Teachers were identified as a key group of stakeholders. All the interviewees brought up the role that teachers play in space science public programming, even though they were not prompted to do so anywhere in the research questions or interview questions. Dr. Gudrun Wolfschmidt explained that normally children visit the Hamburg Observatory by way of the teachers (G. Wolfschmidt, personal communications, March 1, 2019), and all four of the interviewees identified teachers as key persons to engage with in regards to getting schools to visit their space science education sites. Teachers must be convinced that a museum is not a "frill" (Lorde, 2007, p. 78) while simultaneously being an "ally" and worked with collaboratively (Edson & Dean, 2005, pp. 193-200). This was echoed by Mary Beth Laychak when she stated that you "have to be someone that the schools know that they can count on"; "we're giving them something that teachers can't give"; and that "requires a personal relationship with the administration and teachers" (M. Laychak, personal communications, February 20, 2019). Varying financial stakeholders, staff, volunteers, and teachers were ultimately the key persons identified by both the literature and the research. A smart practice for an organization that hosts observatory public programming would be to identify funders and donors, staff, volunteers, and teachers as the key stakeholders. A further smart practice in this regard would be to engage with teachers more comprehensively, including possibly getting their feedback.

5.1.2 MONEY

The theme of money was also significant and overlapped through the literature review and the research. It was more predominantly mentioned throughout the research than in the literature review. The literature and the research both showed that funding to support the space science education programming can be sourced from government bodies, grants, ticket sales, sponsorship, or fundraising. Dr. McKinnon indicated that an organization should consider seeking sponsorship from businesses (D. McKinnon, personal communications, January 31, 2019), something not always accessible to other organizations outside of Canada (G. Wolfschmidt, personal communications, March 1, 2019). Dr. McIntosh provided the example of how private sponsorships were possible in conjunction with funds garnered from admission fees (L. McIntosh, personal communications, February 6th, 2019). Dr. Lisa McIntosh also indicated that a free program for students would be greatly appreciated and desired: "they would love you" (L. McIntosh, personal communications, February 6, 2019). The challenges of creating a program that is cost-effective for students, schools and teachers was addressed by all the interviewees. There appears to be a challenge and conflict in sourcing funding that will meet the needs of the programming while making sure the visitors still "love you". This ties into the theme of people, as persons are required to finance and fund programming through all five of the

funding streams. A smart practice for a space science organization to meet the financial needs of public programming would be to utilize a combination of the funding streams, build relationships with funder stakeholders, aim to have a minimal or no-fee program, and to seek private sponsorships as a way to make this possible.

5.1.3 PROGRAMS

The theme of programs, or programming, and everything related to it, such as program design, activities, curriculum, grade levels, site features, and cross discipline content, were mentioned at least 47 times in the research. These themes overlapped with those in the literature review in regards to museums, programming, and science education practices. The literature found that science education for children, or youth, should be fun, playful, social, and exciting. These findings were echoed in the research: Dr. Gudrun Wolfschmidt explained that the “hands on experiments...are very motivating for the children..., they like it more than listening to a lecture” and students get excited by having questions that “the real astronomers answer” (G.Wolfschmidt, personal communications, March 1, 2019). Dr. Lisa McIntosh also echoed this by pointing out how older students were able to often ask good hard questions to astronomers (L. McIntosh, personal communications, February 6, 2019).

The literature also found that museums must have experiences that are geared for their young audience (Shaffer, 2015, p. 129), that they should be designed and implemented to achieve specific learning goals, and integrate the formal science curriculum (Hofstein & Rosenfeld, 1996, p. 96). This was echoed by three of the key informants, Ms. Laychak, Dr. McIntosh, and Dr. McKinnon, who all discussed the grade four science curriculum and its required curriculum content of the phases of the moon. Dr. McIntosh also identified the importance of aligning programming with the grade six BC science curriculum due to its relevant space science content. The background section provides further details on the grade four and six BC science curriculum. Ms. Laychak explained that students are either expanding on their school learnings, or are being given something that teachers cannot give. She also specifically mentioned that at the CUVC the expectation from teachers is going to be that the content will align with or augment the curriculum (M. Laychak, personal communications, February 20, 2019). This alignment with the curriculum is something that all of the interviewees mentioned, and ultimately agree upon. A smart practice would be to make sure that programming at the observatory is fun, social, exciting, hands on and aligned with the BC science curriculum specifications. In particular, it could be considered a smart practice to be sure that the curriculum specifications of grades four and six were focused on.

5.1.4 LOGISTICS

The literature indicated that there are logistical considerations to take into account regarding observatory based public programming. Those included access to remote operations of telescopes and aspects around marketing. As noted earlier, remote engagement with the telescope is something that the FDAO have already begun to offer as a program option as their funding

allows. The themes that emerged from the research that related to logistics were much more comprehensive than in the literature review. They were indicated at least 19 times, including aspects around advertising, bussing, communications, accessibility of a space, access to technology, and scientific instruments. Detailed logistics to consider included bringing supplies to in-class presentations and at community events, and having lunches or snacks provided to students who attend programming at an observatory (M. Laychak, personal communications, February 20, 2019). Another logistical detail that was identified by two of the interviewees was taking, paying for, and booking busses for field trip transportation to attend the observatory. To visit the DAO and the CUVC, students would have to be on a rented bus as it is not practical to access it on foot or by public transit. These kinds of logistical considerations were not discussed in the literature, however, the researcher considered this information to be relevant and valuable to the FDAO. Considering and addressing logistical details such as providing basic supplies, access to food or snacks, and access to busses for transportation are a key smart practice to consider with observatory public programming.

The aspect of marketing was also addressed in the literature review by Dr. Wolfschmidt (2014) from the Hamburg Observatory. Dr. Wolfschmidt pointed out the requirement for publicity in order to publicize programming and pointed to web pages, newspapers, flyers, announcements at the university, and informing the schools directly as options to do so (p. 69). Dr. Wolfschmidt elaborated during their interview that it is important that the public and the schools are aware of the activities happening at the observatory (G. Wolfschmidt, personal communications, March 1, 2019). Dr. McKinnon and Dr. McIntosh also mentioned the requirement for marketing and advertising in order to communicate to the population that the programming is available at the observatory and pointed to newspapers, journals, websites, and mail outs of printed marketing materials. Dr. Lisa McIntosh asked the question “how do you market to the right teachers?” (L. McIntosh, personal communications, February 6, 2019), a question that could be considered by the FDAO. Another key smart practice would be to make sure that the organization is marketing itself to relevant communities and persons, and to do so utilizing different advertising strategies.

5.1.5 PHILOSOPHY

The theme of philosophy was not a theme that specifically arose in the literature. The researcher utilized the term philosophy to capture themes that related to the ‘big questions’ that arose in the literature and the research, such as organizational goals, emotional impacts, and the nature of students learning. The nature of the students learning experiences at an observatory or public science program should be how the organization identifies itself and should meet the needs of all persons and visitors (Lord, 2007, p. 50). This should be embedded into the mission and vision of the organization (p. 62). This concept was also identified in the research and was verbalized by Mary Beth Laychak when she stated that there needs to be organizational leadership that is focused on the organization’s “vision” (M. Laychak, personal communications, February 20, 2019). She went on to recommend that the FDAO have a plan, figure out their

priorities, stay focused on creating programs to reach certain groups and consider what the goals are, what you want students to take away from the experience, and what you want that experience to be like. She went on to suggest that after a clear idea has been established, the organization can then figure out how to execute it (M. Laychak, personal communications, February 20, 2019). A smart practice would be for the FDAO to create a strategic plan and pursue taking action on the highest priorities of those strategies in the plan.

The literature identified that science education should inspire creativity, “open-mindedness, critical thinking, and respect for different cultures and conceptions of the world” (Berkovitz, 2017, p. 42). The connection to different disciplines and cultural boundaries was also identified in the literature and the research, including connections to history, arts, music, sociology, anthropology, storytelling, and theatre. This diverse experience of science education was reiterated by Dr. Lisa McIntosh who identified that the focus must be on the experience itself and the passion of the educators. Dr. McIntosh went on to elaborate about the big goals of the H.R. Macmillan Space Centre, a focus on wonder, curiosity, and joy (L. McIntosh, personal communications, February 6, 2019). Dr. David McKinnon also brought up the emotions and transformations that can occur to both the teachers and the students and the power that this has (D. McKinnon, personal communications, January 31, 2019). Another smart practice would be to make sure and to take great care in having programming that does not solely focus on content, but rather also takes into consideration that the students have a positive and memorable experience.

The smart practices identified in this discussion and analysis have been summarized below in Table 4.

Table 4. Identified Smart Practices

Theme	Identified Smart Practices
People	Identify funders and donors, staff, volunteers, and teachers as the key stakeholders. A further smart practice in this regard would be to engage with teachers more comprehensively, including possibly getting their feedback.
Money	Utilize a combination of the funding streams, build relationships with funders, aim to have a minimal or no-fee program, and to seek private sponsorships as a way to make this possible.
Programming	Build programming that is fun, social, exciting, hands on, and aligned with the BC science curriculum, preferably for grades four and six as a focus.
Logistics	Consider having all basic supplies, access to food or snacks, and access to busses for transportation, as well as making sure there is relevant marketing being produced that utilizes different advertising strategies. Furthermore, this smart practice would make sure the programming does not solely focus on content, but gives students a positive and memorable experience.
Philosophy	Consider the themes that were indicated as “important”, in particular consider the execution of site based historical content and how to address the topic of women in science. Related, a smart practice would be to carefully consider concerns related to Indigenous knowledge in the space science public programming and to develop recommendations to address the concerns.

5.2 Other Themes

The theme of Indigenous knowledge and engaging with Indigenous populations emerged from the literature and the research. The researcher chose to separate this theme from the others due to the way it emerged from the research without prompting and due to the fact that three of the interviewees indicated it is an important theme to address. Another aspect that arose was the themes indicated as “important” by the interviewees. Two of the themes that the interviewees indicated as “important” have not yet been addressed, site based historical content, and women in science. These themes that were indicated as “important” will be explored.

5.2.1 INDIGENOUS KNOWLEDGE

The researcher was aware of the potential importance of this theme in the realms of BC space science curriculum due to the recent inclusion of First People’s knowledge and perspectives into the curriculum (Appendix B). The researcher was also aware of their own positionality in regards to their personal values relating to the inclusion of Indigenous culture, knowledge, and ways of knowing.

The literature identified the significance, relevance, and importance of multicultural and cultural heritage aspects in science education. Ruddell, Danaia, and McKinnon (2016) found that students were intrigued, embraced cultural elements, were motivated and inspired to observe the night sky, and indicated they appreciated listening to a local storyteller (pp. 174-178). In the interview with Dr. McKinnon he stated that “that cultural respect, cultural awareness, is only the first step” (D. McKinnon, personal communications, January 31, 2019). If this is the first step, and the BC science curriculum includes the requirement to include First People’s knowledge and perspectives, then that first the step towards cultural respect and awareness must be taken by an organization that hopes to have BC science curriculum aligned programming.

Dr. Lisa McIntosh provided relevant local information in regards to the current state and challenges of including Indigenous perspectives into the space science public programming in BC, something that is now required by the new BC curriculum. Both the Dominion Astrophysical Observatory and the H.R. MacMillan Space Centre are located on the south west coast of BC, which is traditional unceded Indigenous land belonging to the people now known as Coast Salish (Indian land, 2008). This makes the information and experiences of Dr. Lisa McIntosh in regards to Indigenous content in space science public programming particularly relevant to the FDAO. A recommendation would be to carefully consider and review Dr. Lisa McIntosh’s concerns, and to move forward with Dr. McIntosh’s recommendations due to their relevance to the FDAO. Specifically, the 13 Moons of WSÁNEĆ can be included into the FDAO programming (<http://www.racerocks.com/racerock/firstnations/13moons/13moons.htm>), the FDOA can review the “padlet” Dr. Lisa McIntosh has shared (<https://padlet.com/learning11/v6a8o6m2zk1d>), and Dr. Lisa McIntosh could be contacted to further discuss solutions and advice on this topic.

5.2.2 THEMES INDICATED AS “IMPORTANT”

The themes that were noted as “important” by the interviewees included the emotional impact of educators, cultural sensitivity, cross discipline content, site based historical content, women in science and astronomy, regular or consistent programming, inclusion of teachers, computer usage, flexibility, human resources, funding, scientific instruments, approach, resources, and cultural/Indigenous aspects. While most of these themes have already been explored in the discussion and analysis, the researcher would like to draw further attention to those not yet discussed, site based historical content and women in science. These two themes were each only indicated by one interviewee and were not identified specifically in the literature reviewed. These remaining themes could possibly have further relevance to the FDAO and for this reason the researcher wanted to address them here.

It is also possible that these themes may have been indicated by other interviewees as being important or significant if the researcher had prompted the interviewees to provide their thoughts or feedback on them in follow up questions. An example of this would be the theme of women in science. If this theme had arisen early on by the first interviewee, similarly to the

Indigenous perspectives, this theme may have been explored further. The mentioning by one of the interviewees about Indigenous knowledge and culture triggered the researcher to ask a further open ended question in regards to this topic. If the researcher had considered follow up questions with other themes, the results could be different. For this reason, the researcher wanted to bring attention to the themes that were indicated as “important”, other than the Indigenous knowledge theme.

The theme of women in science was mentioned at the February 10, 2018 FDAO board strategic planning day two meeting. The researcher attended this session and took note that the FDAO board members brought up this topic. The researcher’s positionality in regards to feminist perspectives is likely why the researcher took note of this. The FDAO have also indicated in their strategic plan that one of their aspirations is the “enhancement of interest in astronomy and related sciences in groups underrepresented and underserved in the sciences such as girls and women” (Appendix A: Friends of the Dominion Astrophysical Observatory Society: Strategic Plan FY 2019-2021, p. 6). The alignment between this pinpointed aspiration of the FDAO and the theme that was indicated as “important” by a key informant is poignant. A smart practice would be for the FDAO to consider how they can make this “important” aspiration a reality.

The other theme identified as “important” was the historical significance of the site. This theme was raised by one of the interviewees in relation to the historical significance that an observatory site such as the DAO has in regards to its impact on Canadian space science accomplishments. Embedded within the mission statement of the FDAO is reference to the site being a historic Canadian site. The first aspiration listed in the FDAO strategic plan also references their aspiration to create further awareness of the DAO (Appendix A: Friends of the Dominion Astrophysical Observatory Society: Strategic Plan FY 2019-2021, p. 6). This alignment between the aspirations of the FDAO, their mission statement, and this theme that was listed as “important” is noteworthy. A smart practice would be for the FDAO to consider how they can accomplish this aspiration which was considered to be important by at least one interviewee.

5.3 Further Research

Limited literature was found on this topic and due to this further research could be done on the general topic of observatory public programming. Conducting further research could prove to be helpful to further understand this topic. Further research could continue to focus on the nonprofit organizations that support observatory based public programming. The researcher has identified four research opportunities that would support further exploration on this topic. One way this could be done is by surveying organizations that are similar to the FDAO in North America to gain further relevant insight into smart practices. Another research opportunity would be to conduct focus groups with local teachers to identify opportunities and challenges. This research could possibly be conducted informally by the FDAO organization themselves in order

to garner further knowledge and information about the local teachers who may visit the Centre of the Universe Visitor Centre with their students.

A third identified research opportunity would be to conduct community-based research with the local First Nations populations to identify the best ways to engage Indigenous perspectives with observatory based K-12 public programming. This is an identified research opportunity since this has been identified as an emergent theme in the research and is a significant aspect to space science education in British Columbia. A fourth identified opportunity for further research would be to expand on the key informant interviews with other international key informants. The researcher was limited with time and capacity to conduct more than four interviews with four international key informants. This created a small scope for the research. A more robust analysis could be completed by sourcing more key informants to interview.

6.0 Options to Consider and Recommendations

6.1 Introduction

The project's objectives were to provide three to five options to consider as well as one to two final recommendations for the FDAO. These options and recommendations focus on the most suitable, cost-effective, and least challenging ways the FDAO can engage with Victoria's K-12 school system in a way that aligns with the current BC science curriculum. Since the FDAO have recently developed their first strategic plan, these recommendations have also been formed in alignment with that new strategic plan. The options to consider rely heavily on the smart practices that were identified within the five key themes that emerged. These five key themes are people, money, programming, logistics, and philosophies. The sixth identified key theme of Indigenous knowledge has been included within the theme of philosophies. The smart practices identified from the report are listed below within the options to consider. This section also briefly identifies an implementation strategy.

6.2 Options to Consider

Option 1 – Maintain the status quo: Continue with current projects, practices, systems, and programs, using the new FDAO strategic plan as a guide through to 2021, to achieve desired results.

Option 2 – Execute some of the smart practices: Execute some of the smart practices identified in the report that the FDAO board of directors will approve to move forward with. The identified smart practices could be reviewed with the board of directors to get consensus and identify those that are most important and relevant to move forward with.

Option 3 - Execute all of the smart practices: Execute all of the identified smart practices in the report, include them in a revised version of the FDAO strategic plan, and create a plan for how they will be executed. The identified smart practices from the report include:

People: The smart practice involved in addressing the need for people would be to identify funders and donors, staff, volunteers, and teachers as the key stakeholders. A further smart practice in this regard would be to engage with teachers more comprehensively, including possibly getting their feedback.

Money: The smart practice to address the need for money for public programming would be to utilize a combination of the funding streams, build relationships with funders, aim to have a minimal or no-fee program, and to seek private sponsorships as a way to make this possible.

Programming: The smart practice related to programming would be to build programming that is fun, social, exciting, hands on, and aligned with the BC science curriculum, preferably for grades four and six as a focus.

Logistics: A key smart practice to navigate logistics is to consider having all basic supplies, access to food or snacks, and access to busses for transportation, as well as making sure there is relevant marketing being produced that utilizes different advertising strategies. Furthermore, this smart practice would make sure the programming does not solely focus on content, but gives students a positive and memorable experience.

Philosophy: A smart practice would be to consider the themes that were indicated as “important”, in particular consider the execution of site based historical content and how to address the topic of women in science. Related, a smart practice would be to carefully consider concerns related to Indigenous knowledge in the space science public programming and to develop recommendations to address the concerns.

6.3 Recommendations

The following recommendations were identified in consideration of the FDAO’s mission, to inspire visitors, expand their understanding of their place in the universe, and make the DAO a place of learning, creativity, and community for all. This can in part be achieved by engaging with the K-12 school system in ways that align with the FDAO strategic plan and with the findings from this report. The recommendations below also take into consideration the limitations that the FDAO currently face as a new charity with limited funding and resources.

6.3.1 OPTION 2

Pursuing option two would allow for the FDAO to identify the most important and relevant smart practices to move forward with and would allow the FDAO board to get consensus on these choices, making sure that they align with the FDAO’s goals and strategic plan priorities. The researcher has also provided further recommendations below that align with the FDAO strategic plan priorities and the research findings.

6.3.2 FURTHER RECOMMENDATIONS – PEOPLE, MONEY, AND INDIGENOUS KNOWLEDGE

It is recommended that a key and primary focus for the FDAO to consider is the smart practice identified around the need for people, specifically to identify funders and donors, staff, volunteers, and teachers as the organization’s key stakeholders. A further smart practice in this regard would be to engage with teachers more comprehensively, including possibly getting their feedback. The research identified that increasing staff and volunteer capacity would allow for an organization to function at a larger scale, ultimately allowing it to be more likely that it can meet its strategic plan’s goals. To increase staff and volunteer capacity, further financial stability would be required, and for this reason it is recommended that the FDAO also consider focusing

on the need to identify funders and donors. By focusing on these key stakeholders and on increasing the funding to support key stakeholders, there is a greater likelihood that the FDAO can accomplish goal 6.1.3, improving board governance that suffers challenges due to a lack of full-time paid staff; 6.2.2 and 6.2.3, creating an intentional plan and policies to engage volunteers; and 6.3.5, developing a school and youth engagement program. Furthermore, by increasing staff and volunteer capacity, and the funding to make that possible, engagement with and a focus on teachers could be achieved. The smart practice to address the need for money for public programming requires pursuing a combination of the five possible funding streams. This aligns with the FDAO strategic goals 6.2.4, to improve operations of the gift shop located in the Centre of the Universe Visitor Centre (CUVC), and 6.2.5, to develop a fundraising and grant plan. By pursuing the five possible funding streams, the FDAO can then in turn increase staff and volunteer capacity, improve the gift shop operations, and implement a more comprehensive fundraising and grant plan so that the funding cycle can continue.

A final recommendation is to take into consideration the importance and significance of engaging with Indigenous knowledge with the FDAO's public programming. This has been identified as an important topic by nearly all of the key informants. It is also identified as a new key expectation to the BC science curriculum that is challenging for teachers to currently meet on their own. This theme is also in line with the FDAO's strategic plan aspiration of "enhancement of interest in astronomy and related sciences in groups underrepresented and underserved in the sciences such as...Indigenous individuals and First Nations communities" (Appendix A: Friends of the Dominion Astrophysical Observatory Society: Strategic Plan FY 2019-2021, p. 5).

The researcher therefore recommends carefully considering and reviewing Dr. Lisa McIntosh's concerns in regards to Indigenous knowledge in space science public programming, and to move forward with Dr. Lisa McIntosh's recommendations due to their relevance to the FDAO. Specifically, the 13 Moons of WSÁNEĆ can be included into the FDAO programming (<http://www.racerocks.com/racerock/firstnations/13moons/13moons.htm>); the FDOA can review the "padlet" Dr. Lisa McIntosh has shared (<https://padlet.com/learning11/v6a8o6m2zk1d>); and Dr. Lisa McIntosh could be contacted to further discuss solutions and advice on this topic.

6.4 Implementation Strategy

This section identifies ways that the FDAO could begin to implement the above recommendations. While the recommendations differ in scale, they all have the capacity to have a significant impact on the goals of the FDAO and on the outcomes of the local K-12 science education experiences of students. Some ways that these recommendations could be implemented are listed below:

- The FDAO board of directors could host a meeting dedicated to deciding on the smart practices that the board of directors agrees should be a priority moving forward.

- The FDAO could create a revised FDAO strategic plan that includes the new smart practices and recommendations to further solidify them as goals and strategies to be implemented.
- The FDAO board could establish a strategy, such as a working sub-committee, to focus on creating and implementing a funding strategy that utilizes all five possible funding streams.
- The FDAO could establish a strategy, such as sourcing a volunteer administrator or community development professional, to increase the FDAO staff and volunteer capacity, and engagement with teachers.
- The FDAO board could contact Dr. Lisa McIntosh and begin building relationships to address the mutual challenges and opportunities around engagement with Coast Salish communities and the Indigenous knowledge sharing of space sciences.
- The FDAO could create an action plan and a sub-committee to implement moving forward on the FDAO's aspirations to enhance interest in astronomy and related sciences with First Nations communities. These communities could include Coast Salish communities on WSÁNEĆ Territory, including the Pauquachin, Tsartlip, Tsawout, and Tseycum First Peoples (Press Release: WSA NEC chief oppose Malahat LNG, 2016).

7.0 Conclusion

This project was completed for the Friends of the Dominion Astrophysical Observatory (FDAO) board of directors and was proposed to address some of the challenges the newly formed nonprofit was facing. The primary research question was developed to provide recommendations to the FDAO to help manage the challenges in regards to public science outreach activities with school aged children in the Victoria BC area. The secondary research questions were developed to identify ways that were aligned with the BC science curriculum, addressed the required resources, the inherent challenges, and the recommendations that should be pursued first.

The literature review contextualized the research and focused on two main areas, observatory and planetarium focused public programming, and science museums. These two main areas ultimately resulted in identifying three main themes in the literature, resources, learning, and collaboration. There was limited literature available on the topic of observatory and planetarium focused public programming, causing some challenges and limitations for the researcher.

The methodology of community-based research (CBR) allowed for reciprocal learning and authentic partnerships to be established. The methodology of smart practices allowed the research to be grounded in identifying what worked well at other organizations in order to make recommendations on how to help solve the problem. The research method of speaking to key informants over Skype in semi-structured interviews allowed the researcher to see the perspective of those considered experts in the area of space science public programming. Having a set of draft questions to use during the interview allowed for the interviews to be somewhat conversational and still allowed for emergent themes to arise.

While the research only consisted of four interviews, a wealth of knowledge and information was garnered about smart practices in the space science public education sector. Furthermore, there were no conflicting results garnered by the research. The research identified the themes of people, Indigenous aspects, money, programs, logistics, and philosophy. These themes aligned well with those in the literature review. This allowed for the options and recommendations to align with all the literature and the interviews without conflict. The themes were also analyzed while simultaneously considering the FDAO's strategic plan and the new BC science curriculum. This allowed for the options and recommendations to align with the strategic plan and the specifications in the new BC science curriculum.

The options and recommendations took into consideration the priorities and limitations of the FDAO, as they are a new charity. The recommendations, if pursued, could have a significant impact on the organization allowing it to possibly meet some of its goals outlined in its strategic plan. Furthermore, the recommendations, if pursued, could also have a significant impact on teachers, students, and Indigenous populations in the Victoria BC area. While it is the hope that

the FDAO will move forward with the recommendations provided in the report, it is noted that this will require that the FDAO overcome varying challenges and obstacles. The FDAO have proven their ability to overcome varying challenges and obstacles, as well as to accomplish varying tasks and goals since their journey began in 2013 (Our journey, 2019). For this reason, the researcher has identified recommendations that are believed to be possible to achieve.

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9.0 Appendices

Appendix A: Friends of the Dominion Astrophysical Observatory Society: Strategic Plan FY 2019-2021

https://www.observatoryhill.org/docs/FriendsoftheDAO_StrategicPlan_2018-2021

Friends of the Dominion Astrophysical Observatory Society



Strategic Plan FY 2019-2021

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1. Introduction

The Board of the Friends of the DAO Society met on February 3rd and 10th, 2018 to provide input into this strategic planning document which will guide the organization for the next 3 years. Present were Board members and stakeholders from the community. The sessions were facilitated by a consultant, Steven Jones, with deep experience in strategic planning. Participants were asked to provide opinions about what visitors should both see and feel when they came on site and discussed also what they thought was most important about the observatory and visitors' experiences. The sessions ended with the participants creating a set of goals for the future and a first cut at prioritizing these goals.

This document presents the goals that were selected as high priority. It describes the goals, the current state of the issue identified in each goal, and the desired state. The document outlines a set of steps needed to achieve the desired state and an overall plan.

2. A Brief History of the Friends of the DAO

The Friends of the DAO was created after the Government of Canada decided in 2013 to cease funding the public outreach efforts conducted from the Centre of the Universe. This affected all public activities including the Saturday Night public viewing that had taken place almost every year since the Dominion Astrophysical Observatory opened in May 1918. Amongst other activities in protest of this decision an online petition was started by Don Moffatt (now Friends of the DAO Vice-Chair) who had worked in public outreach at the Observatory in the 1990s. The public outcry eventually attracted the attention of NRC officials in Ottawa who came out to visit and listen to the public in the summer of 2013.

Later that year in a meeting of individuals interested both in the restoration of public outreach activities and in the potential of the DAO site for education of students, citizens, and visitors, it was agreed that there was a short-term need to restore public viewing as soon as possible. It was also felt that in the longer term the programs of the Visitors' Centre - particularly for schools - should be restored, and further, that the facility could be developed into an attraction for tourist and local citizens alike.

At the same time the management of the National Research Council (NRC) in Victoria expressed the desire for a citizen organization to be responsible for public outreach activities and suggested that the government would be open to giving a fair amount of autonomy to such an organization, allowing it to undertake activities that were previously constrained by the government-funded public outreach organization.

Eventually in early 2015, after a summer in which the Royal Astronomical Society of Canada opened the observatory to restore the Saturday Night public program and the Science Venture organization of the University of Victoria Engineering Department offered children's camps, efforts were made to restart the activities desired for the 'long term'.

Meetings between DAO personnel and interested members of the public led to the incorporation of the Friends of the DAO in June 2015 with 3 founding board members which grew to 8 by the following summer. In the fall of 2015 the Friends of DAO entered into discussions with the National Research Council which led to the signing of the Licence to Occupy in May 2016. This agreement licensed FDAO to use the Visitors Centre and the Plaskett Dome itself for public outreach purposes. That summer the FDAO took over the running of the Saturday night star parties in partnership with the RASC; started making the facilities available to science outreach groups in Victoria; and conducted several pilot tours for schools and community groups.

3. About This Document

This document presents a mission statement; a brief history of the Society; and a set of aspirational statements which were extracted from the Society's original statement of purposes. It then presents the goals identified at the meetings mentioned above that were given high priority. Priority was partly based on need and partly on feasibility. In the Appendix other identified goals are listed. These goals have lower priority, however are still part of the overall strategic plan and will be addressed as opportunities arise.

4. Mission Statement

Option 3) The Friends of the Dominion Astrophysical Observatory inspires visitors of all ages by expanding their understanding of their place in the universe, and making Canada's historic Dominion Astrophysical Observatory and the Centre of the Universe sites of learning, creativity, and community for all.

5. Aspirations

The Friends of the DAO aspires to promote the following concepts and actions:

- Awareness of the Canadian Dominion Astrophysical Observatory (DAO), and of astronomy and related science, technology, engineering and mathematics;
- Public Access to the Dominion Astrophysical Observatory including its Visitors' Centre, *The Centre of the Universe*;
- Science literacy through evidence-based approach to natural phenomena;
- Fellowship and the exchange of information between individuals and organizations who have a common interest in astronomy and related sciences;
- Enhancement of interest in astronomy and related sciences in groups underrepresented and underserved in the sciences such as girls and women, Indigenous individuals and First Nations communities, and persons with disabilities;
- Working partnerships for science outreach with
 - community organizations, businesses and government
 - universities, museums, non-profit organizations, and private foundations
 - the local arts community.

6. Goals

The goals outlined in this document fall under 3 major themes – governance, organizational development, and programming — that together aim to 1) expand opportunities for students, residents and visitors to visit the DAO and an enhanced Centre of the Universe, and 2) develop a sustainable organization to promote science outreach and education into the future.

These are the goals that were identified as highest priorities in the meetings, and therefore execution of the strategic plan focuses in the first place on achieving these. For each objective within the three headings, a sponsor, being either a board member or a committed volunteer is responsible for leading the effort. That individual will create a plan with the assistance of the officers of the society to execute the objective. For items that require funding they will seek approval from the board for use of existing budget line items or seek amendments to the budget as necessary.

Other goals that were identified in the meetings are considered secondary. The intention is not to disallow any attempts to accomplish these goals but instead to act upon them on a more opportunistic basis. A good example is business partnerships. These may arise based on unplanned contacts from businesses in town who have decided to get in touch with FDAO for their own reasons; clearly the board will act in the best interests of the society to exploit such opportunities if and when they arise. A second example is in the goal of enhancing the user experience at the CU. In this case opportunities such as the VR equipment provided by the NRC in the summer of 2018 was certainly a welcome step toward this goal.

Depending on the progress of the organization to deliver on the prioritized goals the intention is to take up some of these secondary goals as time and budget permits. Potentially the largest initiative that the group identified lie in updating the CU displays (“storytelling” and “user experience” goals); these are likely to require significant funding, and therefore were not prioritized partly for practical reasons.



6.1. Governance

GOAL: FDAO will exemplify excellence in its governance

Strategy	Current State	Future State	Sponsor	Target Date
6.1.1 Develop a protocol for board nominations	There is currently no explicit protocol to nominate individuals to the Board of Directors. Offers are made to interested persons based on interview with board chair and officers.	FDAO has a systematic way of recruiting new board members to strengthen the current board's ability to maintain the society and to add expertise, connections, and experience in areas identified as needed by the organization.	Don Moffatt	March 2019
6.1.2 Develop a succession plan	There is currently no succession plan in place. Current Society officers are term-limited in 2020, requiring further commitment by Officers and bylaw amendments to allow them to remain and/or an intentional approach to recruiting new Officers and staggering Board member terms.	FDAO is a sustainable organization that identifies and trains its future leadership ready to take over when the current leadership steps down. <ul style="list-style-type: none"> • Future Officers of the society are identified for some period not less than XXX months before current officers are due to step down. • The chair of the organization is identified and undergoes a period of training before taking office. 	Catriona Johnson	Spring 2020
6.1.3 Improve governance practices	FDAO is in its development phase and currently has a "working board" due to a lack of full-time paid staff. The Board has some policy (i.e. Conflict of Interest) but practices typically evolve organically. Due its current developmental stage, there has been limited opportunity to assess systematically and improve its governance practices.	The FDAO has Board policies in place to govern its practices and reviews these policies on a regular basis.	Catriona Johnson and Nelson Walker	2019
6.1.4 Increase	The FDAO currently has X paid memberships and	FDAO will have an increased number of members supported by membership policies and procedures	Amy	2019

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Strategy	Current State	Future State	Sponsor	Target Date
organizational membership and engagement	a database of X individuals. Membership policies and procedures have not been firmly developed, though research on similar organizations and broad recommendations have been presented to and approved by the Board. These recommendations have yet to be formalized and implemented.	that: <ul style="list-style-type: none"> • Defines membership • Assign costs and benefits to membership • Allows for easy membership acquisition and renewal • Encourages membership for children and youth and individuals from groups underrepresented in the sciences. 	Archer	



6.2. Organizational Development

GOAL: FDAO WILL GROW AND IMPROVE ITS ORGANIZATIONAL INFRASTRUCTURE

Strategy	Current State	Future State	Sponsor	Target Date
6.2.1 Maintain and evolve the License to Occupy the facilities at the Observatory	<p>FDAO benefits heavily from the License To Occupy agreement with the NRC. The 3-year agreement was signed in May 2016 and so is up for renegotiation in FY2019:</p> <ul style="list-style-type: none"> • There are currently limits on FDAO board members and employees in acting under Volunteer Visitor Status to operate the telescope. • A small number of persons allowed on the hill on behalf of FDAO without prior consent, technically means consent is required to hold activities as small as board meetings. 	<p>FDAO will have a renewed 5-year Licence to Occupy agreement that:</p> <ul style="list-style-type: none"> • Allows for all who pass training to operate the Plaskett Telescope and the 16" Observatory at the Centre of the Universe • Adjusts minimum number of persons allowed for FDAO functions outside of business hours without prior NRC consent upward from 10 to 20 • Clarifies naming rights for Centre of the Universe • Other issues 	Ben Dorman	28/2/2019
6.2.2 Develop a volunteer engagement and training program	<p>FDAO has many enthusiastic volunteers but needs to fulfill an ever wider variety of roles particularly on Saturday nights. Volunteers are vital to the organization and its ability to provide public programming. Training opportunities are created approximately bi-annually. A volunteer communication system is used, through signup.com, however there is a need for an intentional plan to engage volunteers.</p>	<p>FDAO has a systematic recruitment, training, communication, and acknowledgement program that improves volunteer recruitment and retention as well as delivering quality experiences to visitors. The program:</p> <ol style="list-style-type: none"> a) includes clearly articulated volunteer role descriptions b) communicates consistently with volunteers c) keeps records of volunteer skills and also of contact events 	Amy Archer	Rough draft June 2019



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		<p>d) recruits a wide range of volunteers of all ages and with diverse skill sets</p> <p>e) develops standardized and recurring training opportunities</p>		
6.2.3 Develop policies for volunteers	FDAO relies on volunteers for staffing Saturday night activities and observatory tours. There is no explicit policy regarding volunteers and approximately bi-annual training for volunteers. There is no documentation provided formally about expected activities or conduct.	FDAO volunteers are properly oriented, trained, meet reasonable guidelines concerning behaviour in public and towards observatory visitors. FDAO appropriately appreciates its volunteers and: <ul style="list-style-type: none"> a) acknowledges volunteers' efforts b) retains volunteers in a measurable way 	Don Moffatt	April 2019
6.2.4 Develop a Stock and Merchandise Plan for the Gift Store	FDAO operates the gift store in the CU building whenever possible when the site is open to the public. Currently the Board has allocated a budget at the beginning of the summer for new stock purchases and ordering merchandising materials has started however a long-term vision and plan for the gift store have not been developed.	The FDAO has a gift store that augments the education and public outreach goals of the organization and generates increasing income for the organization's science education and outreach activities. <ul style="list-style-type: none"> • The gift store inventory is replenished with suitable materials in a systematic way to attract purchases. • A stock and merchandise plan address the restocking of inventory including branded merchandise. 	Amy Archer	February 2109
6.2.5 Develop a fundraising and grant plan	The FDAO has received several grants and donations to support educational programming however grant-writing has been opportunistic and limited due to the time it has taken to gain charity status. Likewise, FDAO has held an annual fundraiser over each of the last 3 years	The FDAO has a strategic fundraising and grant plan in order to support other strategic priorities. By 2021, the FDAO has a part-time employee with dedicated time to research available grant offerings using available technology, creates a calendar for submissions, and asks for assistance to appropriate resources (e.g. educators, astronomers) within the	Catriona Johnson	2021

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	that have been successful yet dependent on a small group of volunteer organizers.	organization.		
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6.3. Programming

GOAL: FDAO will expand and enhance its outreach and education programming

Strategy	Current State	Future State	Sponsor	Target Date
6.3.1 Develop a Science Organization Engagement Plan	FDAO has partnered with the NRC, the RASC, Science Venture and the Royal BC Museum, and the FIRST Robotics organization for a number of activities at its events. Science Venture in particular has held camps at the CU and may do so again in future. The Canada-Hawaii France Telescope (CFHT) and the East Asia Observatory have been supportive of FDAO efforts. Outreach to local schools and to public and private schools across the country is taking place as part of the CAN-Yes project, but it is not currently designed as a permanent program to support organizational relationships.	As a science outreach organization which is a peer to other such entities in North America, including science museums and observatory public outreach departments, FDAO is a full member or participant in associations such as the Canadian Association of Science Centres, the BC Science Teachers Association, and the Association of Science Technology Centers based in the US. FDAO supports the education of students and teachers at the local, provincial and national levels.	Lauri Roche	2020
6.3.2 Develop a Media Outreach Plan	There are no fully developed communications plans for FDAO initiatives. Any activities that require communications components are developed ad hoc. There is no clear chain of responsibility for determining outreach opportunities. FDAO has a list of media contacts, but it needs to be updated.	FDAO identifies and develops communications plans for all initiatives that require internal and/or external outreach. Each plan outlines the goal, objectives, strategies, tactics and people responsible for each component.	Jesse Grigor Board liaisons - Don Moffatt and Ben Dorman	March 2019



Strategy	Current State	Future State	Sponsor	Target Date
	FDAO also utilizes Facebook, but sometimes it does not give information regarding Society activities in a timely fashion.			
6.3.3 Develop an action plan for the 16" telescope	The 16' telescope is a popular and important feature of the Centre of the Universe allowing hands-on use of a telescope for viewing planets and stars. It is therefore desirable to keep it well-maintained and enhance its capabilities for public viewing. The 16" observatory has not been upgraded since its building in 2001 and has begun to show its age. The dome motion and exterior shows noticeable corrosion sometimes affecting its motion. The telescope itself lacks electronic guidance and some maintenance is required on the existing drive.	FDAO has in place a stakeholder group that is responsible for overseeing the maintenance and enhancement of the 16" telescope. This group: <ul style="list-style-type: none"> a) Assesses the telescope status and make recommendations, b) determines priorities, feasibility and the cost of recommendations, c) takes steps to upgrade and improves the 16" telescope, related mechanical and facility requirements d) determines ways to fund the telescope improvements. 	Ben Dorman	2021
6.3.4 Refine and Redesign the Planetarium Experience	The Centre of the Universe Planetarium has the potential to offer unlimited educational experiences to students, groups, and the public. The planetarium is one of the showcase offerings of all public tours. The current software, a 6-year old version of Nightshade Legacy, is no longer	The Planetarium software and hardware is upgraded in order to harness the potential of the planetarium. Programming topics are expanded to provide consistent offerings aligned with BC's education curriculum, astronomy discoveries throughout the world but with a specific focus on Canadian discoveries,	Ben Dorman	2020



Strategy	Current State	Future State	Sponsor	Target Date
	state of the art. All programming in the planetarium is delivered based on manual operation of the software and provides no consistency between operators.	and the history of astronomy among different cultures, etc.		
6.3.5 Develop a school and youth engagement program	School students have very limited access to the Centre of the Universe despite changes in the BC science curriculum that highlight astronomy education. FDAO accepts request for school tours on a case by case basis dependent on the availability of volunteers to deliver the tours.	<p>FDAO operates:</p> <ol style="list-style-type: none"> 1) a school and youth engagement program that provides area classrooms access to educational programming at the Centre of the Universe throughout the school year, and 2) a student engagement program that provides interested students with access to astronomy data and opportunities to dialogue with astronomers. <ul style="list-style-type: none"> • Both programs make astronomy inclusive to youth underrepresented in the sciences (girls, Indigenous youth, youth with disabilities, etc). • The Centre of the Universe is staffed by a roster of employees and volunteers organized by a paid staffer. • FDAO advertises the availability of school tours to school districts in BC as field trip opportunities. • The Centre of the Universe is open for visitors in business hours. Tours for small groups are given by staff on an ad hoc basis: larger groups are accommodated on a fee basis to be determined administratively. 	Don Moffatt and Lauri Roche	2021



Strategy	Current State	Future State	Sponsor	Target Date
		<ul style="list-style-type: none"> • Tours out of hours are accommodated on a fee basis to be determined administratively 		



7. Appendix

Additional Strategies

The following

1. Develop Partnerships with Downtown Business Community
2. Develop a User Experience Plan¹
3. Provide Explicit Support for visitor groups
4. Provide a responsive changing series of hands-on activities for visitors²
5. Redesign Exhibits to support Storytelling²
6. Refine and Redesign the Plaskett Telescope Visitor Experience¹
7. Develop targeted programming for underserved populations¹



BIG IDEAS

All living things sense and respond to their environment.

Matter has mass, takes up space, and can change phase.

Energy can be transformed.

The motions of Earth and the moon cause observable patterns that affect living and non-living systems.

Learning Standards

Curricular Competencies	Content
<p><i>Students are expected to be able to do the following:</i></p> <p>Questioning and predicting</p> <ul style="list-style-type: none"> • Demonstrate curiosity about the natural world • Observe objects and events in familiar contexts • Identify questions about familiar objects and events that can be investigated scientifically • Make predictions based on prior knowledge <p>Planning and conducting</p> <ul style="list-style-type: none"> • Suggest ways to plan and conduct an inquiry to find answers to their questions • Consider ethical responsibilities when deciding how to conduct an experiment • Safely use appropriate tools to make observations and measurements, using formal measurements and digital technology as appropriate • Make observations about living and non-living things in the local environment • Collect simple data <p>Processing and analyzing data and information</p> <ul style="list-style-type: none"> • Experience and interpret the local environment • Identify First Peoples perspectives and knowledge as sources of information • Sort and classify data and information using drawings or provided tables • Use tables, simple bar graphs, or other formats to represent data and show simple patterns and trends • Compare results with predictions, suggesting possible reasons for findings 	<p><i>Students are expected to know the following:</i></p> <ul style="list-style-type: none"> • sensing and responding: <ul style="list-style-type: none"> – humans – other animals – plants • biomes as large regions with similar environmental features • phases of matter • the effect of temperature on particle movement • energy: <ul style="list-style-type: none"> – has various forms – is conserved • devices that transform energy • local changes caused by Earth's axis, rotation, and orbit • the effects of the relative positions of the sun, moon, and Earth including local First Peoples perspectives



Learning Standards (continued)

Curricular Competencies	Content
<p>Evaluating</p> <ul style="list-style-type: none"> • Make simple inferences based on their results and prior knowledge • Reflect on whether an investigation was a fair test • Demonstrate an understanding and appreciation of evidence • Identify some simple environmental implications of their and others' actions <p>Applying and innovating</p> <ul style="list-style-type: none"> • Contribute to care for self, others, school, and neighbourhood through individual or collaborative approaches • Co-operatively design projects • Transfer and apply learning to new situations • Generate and introduce new or refined ideas when problem solving <p>Communicating</p> <ul style="list-style-type: none"> • Represent and communicate ideas and findings in a variety of ways, such as diagrams and simple reports, using digital technologies as appropriate • Express and reflect on personal or shared experiences of place 	



BIG IDEAS

Multicellular organisms rely on internal systems to survive, reproduce, and interact with their environment.

Everyday materials are often mixtures.

Newton's three laws of motion describe the relationship between force and motion.

The solar system is part of the Milky Way, which is one of billions of galaxies.

Learning Standards

Curricular Competencies	Content
<p><i>Students are expected to be able to do the following:</i></p> <p>Questioning and predicting</p> <ul style="list-style-type: none"> • Demonstrate a sustained curiosity about a scientific topic or problem of personal interest • Make observations in familiar or unfamiliar contexts • Identify questions to answer or problems to solve through scientific inquiry • Make predictions about the findings of their inquiry <p>Planning and conducting</p> <ul style="list-style-type: none"> • With support, plan appropriate investigations to answer their questions or solve problems they have identified • Decide which variable should be changed and measured for a fair test • Choose appropriate data to collect to answer their questions • Observe, measure, and record data, using appropriate tools, including digital technologies • Use equipment and materials safely, identifying potential risks <p>Processing and analyzing data and information</p> <ul style="list-style-type: none"> • Experience and interpret the local environment • Identify First Peoples perspectives and knowledge as sources of information • Construct and use a variety of methods, including tables, graphs, and digital technologies, as appropriate, to represent patterns or relationships in data • Identify patterns and connections in data • Compare data with predictions and develop explanations for results • Demonstrate an openness to new ideas and consideration of alternatives 	<p><i>Students are expected to know the following:</i></p> <ul style="list-style-type: none"> • the basic structures and functions of body systems: <ul style="list-style-type: none"> – excretory – reproductive – hormonal – nervous • heterogeneous mixtures • mixtures: <ul style="list-style-type: none"> – separated using a difference in component properties – local First Peoples knowledge of separation and extraction methods • Newton's three laws of motion • effects of balanced and unbalanced forces in daily physical activities • force of gravity • the overall scale, structure, and age of the universe • the position, motion, and components of our solar system in our galaxy



Learning Standards (continued)

Curricular Competencies	Content
<p>Evaluating</p> <ul style="list-style-type: none">• Evaluate whether their investigations were fair tests• Identify possible sources of error• Suggest improvements to their investigation methods• Identify some of the assumptions in secondary sources• Demonstrate an understanding and appreciation of evidence• Identify some of the social, ethical, and environmental implications of the findings from their own and others' investigations <p>Applying and innovating</p> <ul style="list-style-type: none">• Contribute to care for self, others, and community through personal or collaborative approaches• Co-operatively design projects• Transfer and apply learning to new situations• Generate and introduce new or refined ideas when problem solving <p>Communicating</p> <ul style="list-style-type: none">• Communicate ideas, explanations, and processes in a variety of ways• Express and reflect on personal, shared, or others' experiences of place	

Appendix C: Secondary Code Categories and Final Code Categories

fx Theme		A	B	C	D
1	Theme		Number of times indicated in diff. Qs(approx)		
2	Human Resources/staff/volunteers (23)		23		
3	Teachers (13)		13		PEOPLE
4	Funding/budget/Money (11)		11		INDEGENOUS ASPECTS
5	Program Design (11)		11		MONEY
6	Activities (10)		10		PROGRAMS
7	Public Programming (10)		10		LOGISTICS
8	Curriculum (10)		10		PHILOSOPHY
9	Grades (6)		6		
10	Indigenous aspects/awareness/pay/facilitators (6)		6		SINGLE THEME
11	Knowledge (5)		5		
12	Emotional Impact (5)		5		
13	Cross Content (5)		5		
14	Advertising (4)		4		
15	Capacity (not physical; staff) (4)		4		
16	Costs/fees for schools/Expensive (4)		4		
17	Busses/Bussing (4)		4		
18	Communications (4)		4		
19	Site features (4)		4		
20	Challenges (3)		3		
21	Relationships (3)		3		
22	Public knowledge/attention/awareness (3)		3		
23	Accessibility/Resource Access (3)		2		
24	Community (2)		2		
25	Collaboration (2)		2		
26	Staff/Volunteer training (2)		2		
27	Scientific instruments (2)		2		
28	Technology (2)		2		
29	Org vision (2)		2		
30	Free programs (2)		2		
31	Convince (2)		2		
32	Grade 4 curriculum (2)		2		
33	Grade 6 curriculum (2)		2		