Architectural strategies in the education of the sciences

Shanker Kumaracheliyan
1404969
Explanatory Document

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Principal Supervisor: Hugh Byrd
Associate Supervisor: Peter McPherson
Abstract

This research project is an investigation into how the architecture of educational facilities, primarily the science centre, can contribute towards enhancing the learning experience. It is a response to existing scientific educational facilities that lack the strength in generating the key components in education such as interaction and inquiry. It is specifically aimed at reinvigorating the science centre experience by showcasing scientific and technological advances in order to reintroduce the principals of STEM in a more exciting, eventful and explanatory way to all age groups.

Science is a complex subject that calls for various teaching methods, one of the most effective, as research shows is a hands-on, interactive and engaging approach. Vital to this concept are the out of school science learning environments that provide a captivating science experience such as museums and science centres.

The research project firstly reviews existing science museums globally and concludes that the external image of the building should convey a nature of its purpose rather than acting as a shed for its exhibits. Project aims include the incorporation and celebration of the sciences and technologies to inform and educate the community in a public educational and recreational facility.

A site was selected in Auckland’s city center that was strategically located linking the ‘University of Auckland’ and the ‘War Memorial Museum’. Through analysis of the site the project seeks to respond with a series of buildings interconnected with public routes that are accessible at all times. Each building will provide a unique experience related to its own scientific field. The buildings will address the key scientific fields of ecology, astronomy, natural history, marine science and geology using architecture. A key interest of my research includes how disruptive technologies may reduce resource consumption and improve quality of life for future urban societies. The project will seek to integrate these innovative technologies that are likely to be essential in the future.
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# Table Of Contents

1.0 Introduction ........................................... 05
   1.1 Project Background .................................. 06
   1.2 Definitions .......................................... 07
   1.3 Research Question .................................. 08
   1.4 Project Aims .......................................... 08
   1.5 Scope and Limitations ............................... 09
   1.6 Knowledge in the Field ............................. 09
   1.7 Methodology ......................................... 10

2.0 Transfer of Knowledge ................................. 13
   2.1 Literature Review ................................... 14
   2.2 Science Education ................................... 16
   2.3 Science Education in New Zealand ............... 17
   2.4 STEM/STEAM ......................................... 18
   2.5 Interactive Education ............................... 19
   2.6 Other Educational Models ........................... 20
   2.7 Education in Science Centres ..................... 21
   2.8 Summary ............................................. 23

3.0 Fields of Science ..................................... 25
   3.1 New Zealand’s Contribution to Science .......... 26
   3.2 Life Science ......................................... 27
   3.3 Earth Science ....................................... 28
   3.4 Astronomy ........................................... 29
   3.5 Natural History ..................................... 30
   3.6 Marine Science ..................................... 31
   3.7 Technology .......................................... 32
   3.8 Summary ............................................. 33

4.0 Precedent Studies .................................... 35
   4.1 Exploratorium ........................................ 36
   4.2 California Academy of Science ................... 40
   4.3 Ontario Science Centre ............................. 44
   4.4 Other Precedents .................................... 48

5.0 Design Elements ...................................... 53

6.0 Site Analysis ......................................... 61
   6.1 Site Selection ....................................... 62
   6.2 Site Overview ....................................... 63
   6.3 Auckland Central Context ......................... 64
   6.4 Site Context ......................................... 65
   6.5 Connection .......................................... 66
   6.6 Typography Study ................................... 67

7.0 Design Development ................................... 69
   7.1 Design Development ................................ 70
   7.2 Design Considerations .............................. 71
   7.3 Journey Map ......................................... 72

8.0 Design Process ...................................... 75
   8.1 Design Strategy ..................................... 76
   8.2 Urban Study ......................................... 77
   8.3 Zone Analysis ....................................... 78
   8.4 Journey .............................................. 79
   8.5 Masterplan Development ............................ 80
   8.6 Concept Development ................................ 82
   8.7 Design Strategies ................................... 90
   8.8 Concept Design Outcome ............................ 91

9.0 Conclusion ............................................ 93

10.0 References and Figures .............................. 97

11.0 Appendix ............................................ 107
1.0 Introduction
1.1 Project Background

Learning is the process of acquiring new skills, behaviours, values and knowledge. Human beings start learning before birth and continue to learn throughout their lifetime by interacting with people, the environment, educational resources and all things living, or dead. Learning can also occur in different states of awareness, consciously or unconsciously through the auditory, kinesthetic or visual transfer of knowledge. The first form of learning identified by many professionals in the field of education is through interactive play. From a young age, humans experiment, interact, and learn through play. It is a critical component of a child’s development and is also proven to be effective in adults learning generating one of the key ingredients for learning, inquiry.¹

Science is a key subject that relates to all aspects of the human and natural world. It is a core part of education at all levels from kindergarten to Doctoral degrees. The word Science has Latin origins, “Scientia” meaning knowledge. Science is an enterprise that systematically organizes and builds knowledge. It works in the form of tested predictions and explanations about the natural world works and how the world got to its current state.² Numerous studies suggest the subject of science is best learnt through the form of practical learning, also known as learning by doing or hands-on learning.³

Technology (science of craft), builds on the sciences with the aim to produce products or tools that solve problems and improve life. A simpler explanation would define technology as a practical application of science.⁴

Fig. 1.1: Interactive Education

To many the word science conjures images of large textbooks, lab coats, microscopes, diagrams and tables. These representations are most likely based off the school curriculum which introduces students to the basics of sciences. However, none of these easily imagined images provide a full representation of what science can be to its full extent.⁵

The majority of science centres, particularly those focused on school students have been focal points for interactive learning. They seek to inspire and educate on the connections sciences and technology make to everyday living. Science centres also provide the community with the resources, tools and programmes to support future aspirations, careers and educational successes of its members.

The most effective form of education by the science centre comes from its interactive focus on education. Interactive exhibits provide a more memorable learning experience making the transfer of knowledge more effective to visitors of all ages and backgrounds.⁶

This project’s architectural aims include designing a ‘Science Centre’ in Auckland that engages the learners and promotes the transfer of scientific knowledge with architecture. Currently, many Science centers outside of a few design features that capture the public typically have a repository response, also known as ‘Black box architecture’.⁷ Another term coined by Robert Venturi is the ‘Decorated shed’ defined as a conventional shelter that applies symbols to represent its purpose (Refer Fig. 1.2).

These terms refer to an architectural response that generally does not inform the visitor of the building’s purpose. It may require the visitor have prior knowledge

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or to enter the building to find out what it is about.\textsuperscript{8}

In contrast to the repository response are buildings that express themselves and inform the public of their function, for example ‘Ontario Science Centre’ in Canada. This is an example of a science centre that beings to inform the visitor of its purpose and identified by the architecture of centre. This type of architecture, through its design, clearly represent its function is known as ‘White box’ architecture.\textsuperscript{9} Robert Venturi coined a similar term, though more towards literal architecture as ‘The Duck’ referring to the structure, space and program being engulfed by a symbolic form.\textsuperscript{10}

The project proposed in this document includes project goals to design a facility which informs the visitor using architectural strategies and features that celebrates the sciences and technologies. It aims to incorporate the internal and external relationship to engage the visitor’s interest and generate one the most important thing in education, inquiry. This design strategy uses both the ‘Black box’ and ‘White box’ expression to create an ‘Interactive box’ architectural response.

1.2 Definitions

Below are a number of definitions of key terms used across this research project discussion.

**Interaction**: This project defines ‘interaction’ as communicating and reacting with the facility or its contents. It includes interaction on a large building scale, the small exhibition scale and the perceived interaction on a street scale. Sensory interaction is also crucial for this project as design incentives include meaningful visual, physical and auditory interactive stimuli in the design outcome.

**Interactive Architecture**: The art form of architecture with interacting features that encompasses engagement and responses that leads to creation of conversations with the public, within the architectural scale and the perceived street scale.

**Interactive Education**: focuses on but is not limited to education through interactive environments and exhibits at the hands-on level.

**STEM**: Science, Technology, Engineering and Mathematics

**STEAM**: STEM subjects with the addition of Arts

**White Box Architecture**: Defines that the architecture is the visual center piece. It is expressive and states itself a highlight of the visit informing visitors of the experience.

**Black Box Architecture**: In contrast to White box, it defines the exhibits as the highlight of the visit. The architecture is subdued and primarily is an enclosure for the exhibits.

**Interactive Box Architecture**: A term conceptualized by this project defining the highlights as the cohesion of the architecture and the exhibits at different scales of the facility.

1.3 Research Question

“How can architecture be designed to be more engaging in educating the fields of science and technology?

How can this be done through architecture expression avoiding a repository response?”

1.4 Aims & Objectives

The primary aim for this project will be to use existing principles used in science and technology centres, discovery centres and museums to develop an interactive model towards educating the fields of science and technology. This model will address existing issues that lack or fall short on making the science and technology centre an engaging and memorable educational experience.

The secondary aim is to design a modern educational/recreational facility that integrates, engages and celebrates itself architecturally as part of the exhibit to educate the different fields of science and technology.

The project attempts to achieve these aims by incorporating the fundamental elements of the sciences and technologies to engage visitors and generate an immersive transfer of knowledge. Interaction and practical learning is the proven method of a memorable educational experience by evoking emotions that engage the subject. An interactive learning environment shifts from ‘teaching’ to ‘learning’ increasing student responsibility for their own learning which makes the process more personal.12

Precedent research of existing facilities will bring attention to successful strategies, how they operate and the areas they lack in. Comprehensive research will be required on the visitor experience and how science centre designs may help achieve this successfully.

The science centre will also aim to incorporate the latest developments in science focusing on an interactive and immersive transfer of knowledge while technological developments will focus on how science has contributed to reducing resource consumption and to improve quality of life in future urban societies. Subsequent to my research the final design will attempt to integrate these sciences and technologies in a public educational/recreational facility that celebrates a low carbon future and exhibits innovative technologies that are likely to be a fundamental part of future urban societies.

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1.5 Scope & Limitations

The scope of this project is to investigate an architectural response for an educational facility (science centre) that reinvigorates and uplifts the public’s knowledge of the sciences through engagement and interaction. The focus will be to produce a design outcome that addresses the external image to convey the nature of the buildings purpose rather than acting as a repository.

Scientifically, the project can be extensive, this is mainly due to the nature of science as the brief for the project. A vast number of scientific topics can be covered, however the focus in the field of sciences will primarily address chosen sciences New Zealand excels at and the general sciences familiar to visitors through precedent analysis.

Internally, as science and technology is continually advancing, the project will approach the interior spaces that will allow for reasonable flexibility to adapt for future exhibits both static and interactive. The building envelope will express the internal exhibit, but the interior spaces will have the flexibility to adapt for future requirements.

The design will be used as a platform to introduce developments in science and technology and showcase its potential using architecture as a vessel for the sciences. It will seek incorporate everyday activity as part of the facility and revitalize the currently dormant area.

The scope will also tackle the project at an Urban planning level with incentives to promote pedestrian friendly areas around the science centre and connect the educational quarter of Auckland with the Auckland Domain and The War Memorial museum.

The scope will not include the intricate details of the buildings such as toilet locations, offices or even individual exhibitions, rather it will focus on the overall scheme of the buildings driven by the scientific field and how architectural expression of the buildings purpose can be achieved.

Limitations

This is a new concept in the field of museums and science centres, finding directly relatable precedents for an ‘interactive box’ may be challenging, however researching individual exhibitions and design features embedded in existing educational facilities an alternative approach.

The chosen site is hypothetical, there is no indication that this site has been considered for any future constructions. The is just the projects view that it is a natural location between academia and other sources of education and recreation.

1.6 Knowledge in the Field

The science centre, developed from traditional museums, primarily focus is on the interactive education of scientific subjects. The knowledge around this topic relating to this project’s goals splits into two key categories.

1. The transfer of knowledge
2. The science centre experience

The transfer of knowledge in science centres focuses on learning through interaction encouraging visitors to explore and experiment with the exhibits. Tim Caulton’s book introduces the principles of learning in science centres. He outlines the importance in allowing individuals to explore their interests and how the science centre is a rich source of information for visitors.

The school curriculum plays a viral role in the future of countries. Bruce Grimshaw addresses the STEM education model which is a cohesive approach to education. Many science centres are known to work with schools to support the curriculum and play a vital part in education as studied by John Falk.

For this project, the Exploratorium, California Academy of Sciences and Ontario Science Centre are key precedents as they each provide unique educational experience. Studying interaction at different scales including the street scale will help determine how architecture can play a vital role in engaging visitors in the education of the sciences.

The project will add to the field of knowledge by exploring a design outcome that seeks to convey the nature of the buildings purpose via the external architectural image over the more commonly found science centre repository design response.
1.7 Methodology

**Literature**
Research through literature will be the first step, understanding the fundamentals of science and technology, educational strategies and existing museum typologies will be essential.

**Educational Models**
Literature on education models used to teach will be important to understand as there can be pros and cons for each model. This is help understand how these models can contribute in an educational facility environment.

**Science and technology**
Understanding the fundamentals of each scientific field and technology will be crucial. Additional research will be required to understand the current and future advances in science and technology.

**Precedents**
A study of museums, science and technology centers and other educational facilities such as observatories through literature will help understand how each typology works in achieving their main goal of transferring knowledge to their visitors. There will be requirements for each field of science and technology, a study on how these can be achieved successfully will be required to achieve the projects aim.

**Experience**
It will be crucial to engage facilities that this project topic covers. Visiting national and international facilities such as museums, science and technology centers and other specialised scientific facilities such as observatories, and aquariums will be important as they have begun to explore and address issues that I am investigating.

**Engagement**
Visits will also aid in understanding the visitors journey and experience from beginning to end. Gathering information about the facility, experiencing it and following up with prepared post visit activities will help understand the designers and curators’ intentions for their intended visitor’s experience.

**Conversation**
If possible, attempts will be carried out to interview the designers, ground staff, curators and users of these facilities to investigate their designs successes, flaws and how it can be adapted to the New Zealand environment.
Design

Investigate

Literature and precedent studies will be used to drive the development of the design phase. Various investigations will be carried out to address each unique design requirement for each scientific and technological field. Each field’s requirement will be analysed in terms of their design successes and failures with relevance to research outcomes from the literature and precedent studies.

Context

The chosen site will be analysed to plan and determine contextual requirements for the design. Various factors such as current use and existing routes within the site will drive the design to incorporate and promote the use of the site.

Apply

Subsequently, findings will define the project and its parameters within its site context to help determine the requirements to successfully achieve the design goals. Design investigations will be conducted by means of diagrams, sketches, physical models and 3D modelling to achieve the projects goals implementing all the key findings.

Research Process
- Educational Strategies
- Science & Technology Fields
- Precedent Visits
- Urban Studies
- Site Analysis

Design Tools
- Diagrams
- Sketches
- Experimental Models

Design Process
- Investigation/Testing/Planning
- Collation of key ideas
- Determine Parameters
- Apply & Execute

Fig. 1.8: Process

Review

This research project reviews a wide range of literature including books, research texts, web pages and journal articles. They cover a range of topics from ‘formal educational methods’ to ‘how interactive design strategies can be used to inform’.

Research also includes the individual fields of science, their latest developments and how they can inform successful design strategies. Diagrams and images will be used to investigate and better understand concepts and ideas. Through research this project will be enlightened with successful transfer of knowledge, scientific advances and design strategies that are effective in education.

During the final stages of design stage it is important to review the initial processes of literature and experience to make minor adjustments in order to produce the desired outcome.
2.0 Transfer of Knowledge
2.1 Literature Review

Historically, museums have generally been used as storage centers for static displays which are usually skimmed over by visitors without any real engagement. When discussing interactive educational facilities, it is imperative to review Tim Caulton’s ‘Hands-on Exhibitions: Managing interactive museums and science centres’. In this book Caulton analyses the development of interactive museums and science centres and how they developed alongside their exhibitions within the context of parallel trends in the UK, Europe and USA.

Caulton introduces one of his key findings that the interactive movement consists of an immense array of attractions each with distinct objectives. Caulton also suggests classroom learning to be constricted by the curriculum prevent students from entirely explore their environment. Interactive museums however are rich in knowledge allowing the visitor to explore their own interests unrestricted by the bell as long as their attention is retained.

Crucial to this project is Caulton’s notion that there is no one ‘right’ way to develop an interactive museum. Precedents will include an early built science centre as well as a contemporary science centre to investigate how Caulton’s findings have been applied into design over time.

Bruce Granshaw in ‘STEM education for the twenty-first century: A New Zealand perspective’ clarifies the concept of STEM education in the New Zealand context applying it to the existing NCEA education programme. STEM refers to science, technology, engineering and mathematics.

Granshaw also addresses STEAM which includes the arts as a subject. Granshaw suggests this interdisciplinary educational strategy which is focused on integrating the knowledge and modes of thinking attained from each subject is the future of educational success. The intention is to echo real life skill requirements such as problem solving, creativity, teamwork, lateral thinking, resilience and critical thinking through quality STEAM education.

The New Zealand curriculum encourages the STEAM approach supporting the development of programmes that includes integration and interaction of learning. NCEA however is yet to fully encompass the strategy primarily in the aspects of student assessments.

In ‘Science Centers Inspire Lifelong Interest in Science’ a study carried out by John Falk and his co-authors addresses the importance of science and technology centers in creating a STEAM literate society. A key finding from the study revealed of the five types of experiences learning science, a science centre visit was the only consistent impact, present and past on both youth and adult's science interest. The types of science learning experiences included using the internet, attending science classes, watching science television, reading scientific books and visiting a science centre.

Falk and his teams study revealed that free-choice learning experiences outside school in all ages played pivotal goals in sustained scientific interest. Science centres are also perceived as a premier science resource for low-income visitors for quality science education constituting between 55% to 72% according to this study.

Fig. 2.1: Proposed Sydney Science Centre (Internal Black box)
When discussing experiential education or progressive education, also known as hands-on learning, John Dewey is considered to be the philosophical father. In his book “Experience and Education” Dewey claims that a division exists between traditional and progressive education. Traditional learning being the passive teaching method and progressive education, through interaction and experience. Dewey believes that there is not enough experiential learning incorporated in teaching methods.  

Dewey viewed freedom in education to be essential in progressive education as it gave students a chance to learn through experience of their own interests. Experiential learning relies on obtaining skills which are crucial for students as it offers individual development. However, Dewey highlights that educators should provide freedom in the form of guidance in a disciplined democratic way without hindering their future learning. Dewey argues that hands on learning provides an enjoyable learning experiences which is a key influence in motivating students to continue learning.

These findings highlight the importance of science centers and how they can impact the growth of a mind, community and in a larger context, the economy. Dewey highlights the importance of interactive learning and its benefits on individual development. Granshaw brings to light the importance of a new educational model that falls in line with the research carried out by Falk and his team. Both literatures support Caulton’s findings about facilities developing alongside exhibitions as this project is to embrace the foundation of each science and new technologies in the design outcome. Understanding the existing field of knowledge on this topic helps generate an informed design outcome that is imperative towards scientific education. The final design outcome will aim to evoke inquiry which is naturally generated through good design that has a purpose more than a repository for the science and technology installations.

17. John Dewey, Experience & Education (New York: Collier, 1963), 17
18. Ibid, 27
2.2 Science Education

Science is learnt through multiple sources, this includes schools, the internet, science facilities, print media, broadcast media, and science events.

Schools introduce the sciences through the natural science subjects and programmes they offer. Universities offer more specialised science subjects.

The internet is a very rich source of science and is easily available for anyone with an internet accessible device such as a computer or phone.

Public science facilities fall under the category of informal science education, they are a valuable source that encourage visitors by guiding individual thought, sparking discussions and encourage interactive learning. The most common science facilities found in most cities are observatories, aquariums, zoos, museums and science centres.

Print and broadcast media are also easily accessible, print generally includes the magazines, books and newspapers found in universities, bookshops and libraries and broadcast media include documentaries, television shows, pod casts and radio.

Science events are occasional sources of science education, these include events like science festivals, technology expos and special events hosted by science facilities.19

Overall, scientific knowledge is not gained from a singular source, the different sources work cohesively generally supporting each other in areas where they lack strength.

As this project is based on education and uplifting the publics knowledge on science, researching the sources of scientific education, teaching and learning concepts past, existing and proposed is critical.

Understanding these concepts will inform the projects design on suitable effective techniques in the transfer of knowledge, skills and behaviors in the field of science. The research focuses on how the sciences are being taught, the educational models used to investigate how effective transfer of knowledge is achieved and how this can be applied to the design outcome.

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2.3 Science Education in New Zealand

Science and Technology Education in New Zealand Schools

Education of science and technology in New Zealand schools currently is primarily classroom based and follows the traditional approach of teaching that focuses on an intra-disciplinary transfer of knowledge. Years 1 to 10 (primary to junior secondary school) follow a standard set by the Ministry of Education that allows schools and teachers flexibility in implementing the science curriculum. The curriculum provides a framework that the school can develop to their preference and set specific learning outcomes. Achievement objectives can be broad and learning outcomes can depend on the individual school's science scheme, however schools are expected to integrate the strands addressed in the framework set by the Ministry of Education.\(^{20}\)

NCEA

At the high school level years 11 to 13, the current system is the National Certificate of Educational Achievement system also known as NCEA. Teaching happens primarily through vocal transmission with a low rate of practical scientific activity in class. Internal practical tasks exist but are generally focused on instructional assessment rather than creative inquiry. The forms of assessment include in-class written internal and external examinations where students regurgitate memorized information rather than exploration through experiments to be graded.\(^{21}\)

NCEA has Science divided into four standard contextual strands which are biology, physics, biology and earth/space science.\(^{22}\)

Technology is divided into three strands of technological practice, technological knowledge and nature of technology. Technology is taught in a similar concept to science in a teacher-centered approach based on five technological areas.\(^{23}\)

State of NCEA

At the secondary school level, the current National Certificate of Educational Achievement system has been receiving mixed reviews from students and teachers alike. While NCEA has proven to be a vast improvement by exposing students to a wider range of learning over the previously exam-based system which was dominated by university entry requirements there are still some shortcomings. Two of the most important issues include the over assessment of students and high workload of teachers.

The current NCEA structure also has many students opting for easier courses avoiding the more difficult courses that provide a higher quality learning outcome of a subject. Students focus the easiest path of accumulating credits over depth or quality of learning. There have been good indicators of overall improvement however among school leavers literacy rates remain low and youth unemployment remains high.\(^{24}\)

A recent study has revealed New Zealand high school students to have the highest anxiety rates around exams of any OECD country due to NCEA. These findings have produced proposals by the secondary school union to completely overhaul the NCEA system.\(^{25}\)


2.4 STEM & STEAM Education

STEM

STEM is an interdisciplinary curriculum approach based on education in four specific disciplines, science, technology, engineering and mathematics. STEM is based on the real-world application integrating the disciplines into a cohesive learning paradigm. STEM lessons are focused on real-world problems where students address real economic, social and environmental problems using collaborative and creative thinking.26

STEAM

STEAM is the same curriculum as STEM with the addition of arts as a discipline. The arts include disciplines such as design, humanities, visual arts and new media. Including the arts also provides opportunities for students to learn creatively using skills such as creative planning, problem solving, teamwork and lateral thinking.

An example of the practical application of STEAM can be a nanotechnologist who designs and develops jewellery to administer insulin to diabetics.27

However, there are ongoing debates on including the arts as its own subject with STEM, primarily as STEM subjects naturally involve arts and specifying art as its own subject can reduce focus on STEM subjects primary purpose. This is prominent in organizations such as NASA for example, who only promote STEM programs for educators and students.28

2.5 Interactive Education

Interactive education is a hands-on and participatory approach to effective learning in classrooms as opposed to the more popular passive learning model that relies on the vocal transfer of knowledge from a teach or a routine of memorization of information and figures.

Interactive learning, also known as experiential learning or simply hands-on learning falls in line with experiential learning. It is a multi-sensory approach in education engaging students physically, mentally and emotionally. This approach gives the student a chance to participate in the teaching process through technology, role-playing group exercises with classmates or self-guided experimentation of subjects in their field of interest. It also helps engage students in a hyper-stimulated environment and sharpens their critical thinking skills which are fundamental in developing analytic reasoning.

Through interactive learning there are opportunities presented to the student to explore open-ended questions with logic and creativity learning to make decisions instead of just repeating memorized information. As workplaces become structurally more team based it is important to teach students how to work in groups and collaborate successfully.

A significant figure for education was John Dewey, he was referred to by some as the father of American education.

He changed the fundamental approaches to learning and teaching by establishing theories on pragmatism. He believed in a child centered approach that allows for hands-on interaction with their environment to adapt and learn. John Dewey’s role in progressive education put an emphasis on an interdisciplinary curriculum guiding students to follow their interests. The teacher’s role was to facilitator and develop the student’s skills.

Many of the interactive teaching models used today are based off Kolb’s experiential learning theory published in 1984. Kolb states that his approaches are heavily influenced by John Dewey theories.

Multiple innovative educational styles were researched in order to discover all aspects of education. Researched models include Project based, Inquiry, Interdisciplinary, Neuroscience, Place, and Multiage. All the educational models stem from a general philosophy of knowledge, life, truth, and ethics.  

Research has shown the effectiveness of hands-on activities in learning science. It has had very positive reviews and is the preferred method by students according to the 2014 study by Dhanapal and Wan Zi Shan. Hands-on activity builds on the student’s intrinsic motivation and promotes students' self-learning. Teachers who conduct hands-on interactive activities have been graded over their peers by more than 40% in science subjects.

Results have been so positive that in 2009 the US President Barack Obama declared a day as “National Summer Learning Day” to “provide students with hours of focused time for hands-on learning and creative projects.”

Multiple innovative educational styles were researched in order to discover all aspects of education. Researched models include Project based, Inquiry, Interdisciplinary, Neuroscience, Place, and Multiage. All the educational models stem from a general philosophy of knowledge, life, truth, and ethics.

**Concrete Experience**
(does having an experience)

**Active Experimentation**
(planning / trying out what you have learned)

**Reflective Observation**
(reviewing / reflecting on the experience)

**Abstract Conceptualisation**
(concluding / learning from the experience)

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References:


2.7 Education in Science Centres

Education in science centers

A science centre or museum is public educational facility primarily devoted to teaching science. Its primary aim is to enrich the learning experience using effective methods to teach the fields on science and technology. Historically, the key teaching methods depend on events, activities and interactive displays, however over the years new technologies such as web-based education programs, remote learning techniques and social media have been implemented to prepare and inform visitors.\(^{36}\)

World class interactive exhibits are the core of the facility, these exhibits are designed to increase the visitor's skill and understanding of technology and science helping reduce the mystery of these fields.

Science centres develop inquiring minds by stimulating curiosity and exposing children and adults to unique learning experiences based on engagement and entertainment. It helps inspire individual self-guided learning but is also school and family friendly for collaborative activities.

Personal interest is crucial in science centres, visitors have a vast array of topics to interact with experimenting and answering their own curiosities. They inform and engage visitors with the rapidly changing technological and scientific environment empowering them with real life skills.

Science centres are usually the host facilities for showcasing the latest technological advances and scientific discoveries enabling an environment for dynamic experience sharing. Science centres also contribute to the school curriculum and coach multipliers of science such as teachers and parents. Teachers are recommended to prepare students on basic principles prior school trips to museums to allow for efficient use of time on the student's individual interests.\(^{37}\)

The key difference between traditional museums and interactive science centres is the flow of information between the user and institutions. Traditional museums provide one-way content to absorb, designs are focused exhibition quality and consistency, so every visitor gets a reliably good experience regardless of background or interests.\(^{38}\)

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In New Zealand, currently there are only two dedicated interactive science centres. Science Alive and the International Antarctic Centre, both located in Christchurch are facilities that educate through interactive exhibits covering a range of topics in science and technology.

The International Antarctic Centre focuses on the different sciences of the Antarctic region and ‘Science Alive’ covers a range such as engineering, technology, physics and including art activities. Science Alive, due to its range would be considered as the more traditional science center. The centre has been relocated to the heart of the city due to the 2011 earthquake.

Other facilities such as the MOTAT, Te Papa Tongarewa and the Auckland War Memorial museum do exist as sources of science education but are limited in hands-on learning and are primarily focused on archives and static collections to educate visitors.

2.8 Conclusion

Summary

Near the end of the 20th century, education began to shift to a new paradigm internationally. The shift in education was guided by an awareness of the extensive and ongoing changes in society, technology, and economy. These changes generated a vast increase of new human knowledge. Many serious new challenges were spanning multiple domains recognizing the much-needed support in education to engage the 21st century problems.

Two important concepts where change needs to be addressed includes the meaning of knowledge and new understandings about learning. Knowledge refers to the move away from the industrial age where primary production and exploitation of natural resources was the standard model for economic development. A refocus on knowledge addressing the ability to innovate and the development of learners’ competency and capacities to deal with new challenges and environments.

Research has redefined learning, it reveals that as ‘spectators’ humans do not learn well. Positive learning experiences require active engagement through interdisciplinary approaches. These principles are understood by many educators however, existing education systems do not support these principles to actively practice them. Education systems need to be reconfigured to support initiatives such as STEM with supporting in-school and out of school structures to prepare ‘knowledgeable societies’ of the future. 41

Conclusion

Based on the research material on education, it reveals that education may require a shift towards preparing students for future challenges. A refocus from production and the exploit of natural resources to reducing resource consumption and innovating new methods of sustainable production is essential.

Researching the different learning styles for this project was also important to inform an effective design strategy. Learning has been redefined to become more personalizing with active education systems addressing the importance hands-on learning where creative thinking has a common place. Teachers’ contribution includes working together to guide and mentor students through theory and practical formats.

Interactive education informs the design by generating ideas to create an engaging environment that has visual, auditory and participatory strategies implemented in the final design outcome.

3.0 Fields of Science
3.0  The World of Science

3.1  New Zealand’s Contribution to Science

“The intellectual and practical activity encompassing the systematic study of the structure and behavior of the physical and natural world through observation and experiment.” 42

Ernest Rutherford
Discovered Nuclear model of atom

Maurice Wilkins
Discovered DNA Structure with Rosalind Franklin

William Pickering
Directed engineering of Explorer 1 (First U.S.A Satellite) 43

42. P. M. B Walker, Chambers Dictionary of Science and Technology (New Delhi: Allied Chambers, 2004), 1021.
3.2 Life Science

Life Sciences involves the study of organisms and life. This includes plants, animals, microorganisms and their interaction with their environment. The study of life sciences varies from being very specific to a type of life such as botany to a common life form aspect such as genetics. However, certain topics of study in the life sciences may have considerable overlaps between them.

The study of the life sciences contributes by clarifying and improving the standard and quality of life. The agricultural, health, medicinal, food and pharmaceutical science industries all have applications in the study of life sciences.44

3.3 Earth Science

Earth science is the scientific branch that studies the physical structure and the atmosphere of earth. This includes our planet’s physical characteristics from fossils, floods and earthquakes. The includes approaches to earth science can be both holistic and reductionistic. The study of earth science is used in various ways to help life on earth. It is used to:

- locate and develop mineral and energy resources
- Study the impact of human activity on the environment of earth
- Design methods to protect the planet
- Study earth processes to plan communities for dangerous events such as earthquakes, volcanoes and hurricanes.  

3.4 Astronomy

Astronomy is one of the oldest natural sciences that studies celestial objects and phenomena. The study of astronomy incorporates other sciences such as physics, chemistry and mathematics to analyze and explain the origins of astronomical objects, phenomena and their evolution.

Generally, the scope of astronomy includes all phenomena with origins outside of the earth’s atmosphere. Historically, astronomy was used in the making of calendars, celestial navigation and observational astronomy. However, in the modern day, astrophysics is considered as the fundamental of professional astronomy.

Amateurs Astronomers play an effective role in astronomy, it is one of the few sciences that have had significant contributions to astronomical discoveries from amateurs, particularly in the observation and detection of momentary phenomena such as finding new comets. 46

3.5 Natural History

Natural history is an observational method of study that involves a span of scientific disciplines. It includes the sciences such as botany, zoology and mineralogy dealing with the examination of all phenomena in nature. Natural history specifically represents an exploration towards the origins of these sciences over history. While it includes scientific research, it is not limited to it as naturalists use a systematic approach to identify patterns in organisms and nature.  

3.6 Marine Sciences

Marine Biology is the study of living organisms in the ocean. The scientific study of marine life classifies species based on the environment as biology covers the scope of families and genera of which some live on land and some in the sea.

The ocean is the source for a large proportion of all life on Earth, many of which are still to be discovered. Covering over 70% of the earth surface, the oceans habitat studied in marine biology has the scope from the depths of the oceanic trenches thousands of meters below the ocean’s surface to the organisms trapped in the surface tensions of the tiny layers of surface water.

Marine life is an immense resource for raw materials, food and medicine additionally helping support tourism and recreational activities around the world. Fundamentally, marine life determines the essence of Earth by contributing to the oxygen cycle and balancing earth's climate. Humans also depend on many of the oceans species as a food, mineral and biomedical resources.  

48

Fig. 3.19: Branches of Marine Sciences

Fig. 3.20: Marine Sciences

Fig. 3.21 a,b,c: Marine Science Architecture

Technology is the body of knowledge both scientific and theoretical dealing with the creation and application for technical means interrelating with the environment, society and daily life. It draws on subjects such as the mathematics, industrial arts, engineering, natural science, applied science and pure science to improve and accomplish various life tasks. Simply defined technology is the practical application of science.\(^{49}\)

The term ‘Technology’ however is wide and may have a different understanding for different disciplines.

3.8 Summary

Researching the fields of science is crucial to produce a brief for the project. Understanding the scientific fields will help inform the project of possible design strategies. Each field of science has unique contributions to design and application into design will require careful consideration to be successful. By understanding educational techniques highlighted in the previous chapter, an incentive to provide an educational journey was developed, therefore using the characteristics of the scientific fields strategically will be vital.
4.0 Precedent Studies
4.1 Exploratorium

**What**
Science museum – Exploration into the world of science, art and human perception.

**Visitors**
Primary, middle school students, Teachers, families, local community, Adults

**Where**
Pier 15 & 17, San Francisco, USA

**Architects**
EHDD 2013 Relocation

**When**

**Visited**
May 2018

**Highlights**
- One of the first and most recognized and influential science centres in the world.
- Hosts events for all ages and specific age groups
- Visible setting from ferries, bridge and street
- Wide range of exhibits including very detail section on social sciences
- Use of sea water for exhibition (mist machine)

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EXPLORATORIUM

- **Human Phenomena**
  - Feelings, Social Behaviour

- **Tinkering**
  - Practical Creativity

- **Observing Landscapes**
  - Geography, Ecology, History

- **Outdoor Exhibits**
  - Winds, Tides, Natural Phenomena

- **Seeing & Listening**
  - Light, Vision, Sound, Hearing

- **Living Systems**
  - Organisms & Ecosystems

- **Outdoor Exhibits**
  - Winds, Tides, Natural Phenomena

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EXPLORATORIUM

- Solar Panels
- High Performance Glass
- Natural HVAC Pier Water Circulation
- 16% Roof area Rainwater Capture – Toilets
- 100% Outdoor Air Ventilation
- Recycled Structural Material
- Use of existing structure

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EXPLORATORIUM

- Precedent Studies
Circulation:
- Public circulation is generally based around the ground level, the only areas for public unsupervised access is on the ‘Observing landscapes’ exhibition areas.
- Most of the L1 floors are for staff except the workshop area on the ground level.
- Additional circulation is opened up during functions allowing access into the neighboring shed.
- The Café and store is located by the entrance and a sea view restaurant at the end of the building.

The Exploratorium has a linear circulation scheme with the entrance into the exhibition areas a quarter of the way into the building past the ticketing area. Upon initial entry into the exhibition area there is a choice between the ‘Tinkering area’ and ‘Human phenomena’, this according to staff upon interviews creates confusion between many visitors. A preferred layout would include visitors entering at the front of the building though the classical façade for a complete linear circulation. Currently the façade acts as an architectural feature only.

Exhibitions:
A flow is present between galleries. Each exhibition gallery is positioned next to a related neighboring exhibition gallery that allows the visitor to gradually learn with a flow of topic. Generally starting with the ‘Human phenomena’ which explores social behavior, thoughts and feelings the visitors are led onto the ‘Tinkering’ gallery which explores thinking with your hands and creativity. Followed by Seeing and listening’, ‘Living systems’, ‘Outdoor exhibits’ and ‘Observing landscapes’ consecutively.

Entry Points
The main entry for visitors is to the left of the main facade. Schools groups however, due to high numbers have separate entrances past the main entrance through larger doors on the same side. During functions/events multiple entrances are opened, however controlled with gates.
4.1 Exploratorium

Natural Light
The Exploratorium is naturally well lit, high windows and skylights along the full length of the building allow a lot of natural light into the building. At ground level large sectional curtain walls and doors provides additional natural light sources. Exhibition galleries were designed and positioned to maximize views and take advantage of the natural sunlight.

Expressive Components
The Exploratorium, architectural is limited in expressing its internal contents. The large classical facade on the front of the shed follows the traditional Greek museum entrance that generally signifies the contents as historical artifacts. The Exploratorium however is more about learning through interaction with unique installations and this is not expressed architecturally. Any information on the contents is generally gathered through personal inquiry or internet research. The roof exhibits technological advances with solar panels but this is not visible at normal eye levels. An outdoor sculpture and the visible outdoor exhibit area helps inform the public on the Exploratorium’s function.

Interaction
Front Facade: A classical Greek façade frames the building which allows visual interaction with the store, however the windows viewing into the exhibition galleries are blocked with curtains.
Side Entrance: Public access from the west side shows activity into the ticketing areas and the outdoor exhibition areas. The outdoor exhibition area however is limited to ticketed visitor access only.
North and East: Only visual interaction is available, however limited public access to these areas.
Building Features

Supported by the Exploratorium building features it is the largest net-zero energy museum in the U.S with annual savings of approximately $160,000 without accounting for the solar panel savings. However many of these building features are hidden or is not highlighted as a feature as an educational tool.

Solar panels: High efficiency PV modules covers majority of the roofs surface providing 100% of the Exploratorium’s energy needs.

Outdoor air ventilation: 100% of the outdoor air is used without recirculation to achieve higher air indoor quality

Rainwater capture: 16% of the roof area is used to capture and store rainwater for toilets and drain trap primers. Unused water is filtered before returning to the bay.

High performance glass: Fitted glass fitted around the building limits heat gain and provides a bird friendly façade.

Recycled structural material: The structure is built with low-emitting materials and recycled materials

Natural HVAC water circulation: The pier location by the San Francisco bay is used to take advantage by the HVAC system by circulating bay water through the heat exchangers. Seasonally the fluctuating bay waters temperature is used to heat and cool the building’s radiant slab eliminating the need for cooling towers.

The Exploratorium’s sustainable and environmentally conscious approach has achieved a gold LEED green building certification by the U.S Green building council.

Important outtakes from this building?

Simple linear circulation routes proved easy to navigate
Even a simple shed found useful ways to sustainable strategies
Net-0 energy production
Simple linear form opened up a lot of options for managing circulation
Even though building was a shed, it has been very popular and an influential precedent for science centres around the world.

Key Points

Pros
- Reusing components of existing structure
- Exterior play areas
- Multipurpose areas for events/functions
- Weekly adults only times
- Light use of water to create environment (mist)
- Central location generating interest
- LEED Certified
- Country’s largest net zero energy museum

Cons
- Exterior play areas closed off outside opening hours
- Based on the warehouse model
- Interior activity closed off from outside, no view points for general foot traffic
- No natural elements involved with structure
- Minimal interaction with surrounding

Conclusion

- This is a very good example of a repository response for an interactive science museum.
- Originally opened in 1969 it was later relocated to piers 15 and 17 in 2005.
- In 2007 the Exploratorium was voted as one of 12 most effective non-profits in the USA.
- Inspired science museums worldwide following this example.
- 2008 Visitor ratio – 55% adults, 45% children
4.2 California Academy of Sciences

What – Research Institute, Science and Natural history museum

Visitors – Primary, Middle & High school students, Teachers, Families, Local community, Adults

Where – Golden Gate Park, San Francisco, USA

Architects – Renzo Piano

When – Established in 1853, Reopened after earthquake damage in 2008

Components – 14 unique spaces available for private events

Visited – May 2018

Highlights
- World’s only aquarium, planetarium, rainforest and natural history museum.
- Rainforest in 90ft glass dome
- Steinhart Aquarium – one of most biologically diverse and interactive aquariums in the world
- Morrison Planetarium – 75ft Digital dome accurate display

Components –
- Solar Panels
- Courtyard
- Natural Ventilation
- Spider Web Structure
- 100% Recycled Steel
- LEED Platinum Certified
- Sustainable Insulation
- Native Green Roof
- Low Iron Glass
- Cutting Ground Plane
Circulation:
- Ground floor generally has an open plan setting.
- Visitor has the option to choose their path and choice of exhibit they wish to experience first.

Public Circulation: Upon entry past the ticketing area, a large piazza is visible centered in front of the first display, a complete dinosaur skeleton reconstruction. The visitor is given options to openly choose their starting point, either to their right towards the Rainforest ecosystem, earthquake simulator and giant creature exhibits or to their left where the planetarium, color of life and African hall exhibits are displayed. The open plan allows the user to choose their path, they also have the option to use the elevator straight to the green roof level and then work their way down to the lower level where the aquarium is located. The only controlled circulation is the entry/exit zones for the Planetarium and the Amazon rain forest exhibits.

Exhibitions:
Exhibitions are clustered into different groups, segments and science specific areas. Some are visible over multiple levels due to floor to roof open areas, other exhibits are visible at a single level only. The feature exhibits that are displayed architecturally include the Planetarium, Amazon flooded rain forest, Aquarium and the Green roof. Excluding the Rain forest and Aquarium exhibits, there is no intentional flow observed between exhibition areas. An example is the Naturalist center isolated on level 3 with the gems and minerals section which is a private pre-booked exhibit.

The exhibits are generally not visible from un-ticketed exterior public areas apart from the green roof which can be seen from parts of Golden Gate Park.

Entry Points
The main entrance for visitors is centrally located and highlighted architecturally by two structural masses. Floor to roof curtain walls make it clear and are guided by large spanning stairs funneling visitors towards the ticketing area. A secondary entrance is available at the opposite end however this entrance is generally used by business clients, staff and functions. Additionally, private staff and service specific entrances are available at east and west sides of the building.
4.2 California Academy of Sciences

**Natural Light:**

The California Academy of Science is naturally well lit, large floor to roof low iron content glass curtain walls is extensively used throughout the building. The high-performance glass also minimizes energy used for cooling and reduces levels of heat absorption. The rear southern section of the building where offices are located also gain a lot of natural light. Centrally above the spheres are more circular skylights that are operable to allow light and air into the building. Overall 90% of regularly occupied spaces have access to daylight and exterior views.

**Expressive Components:**

The Academy has a some architecturally expressive components such as the uniquely shaped green roof, solar panel canopy, classical façade, and large glass panes. These components work well enough to inform the public of what the academy could be. The floor to roof curtain walls shows some internal activity through the Piazza while the green roof and solar panel canopy educate the public of the buildings eco-friendly design features.

**Interaction**

- **Front Facade:** The front façade has the most active interaction with the exterior public areas, large panes of glass allow for internal activity to be seen from golden gate garden areas and vice versa.
- **North and East Facades:** Full glass plane revealing private garden and outdoor activity area. Only level one is clear glass.
- **Rear Entrance:** The most restricted interaction is on the southern end both visually and physically. This could be intentional to inform and avoid confusion for the general public visitors indicating the correct entrance. Large Trees used for a forest backdrop.
Building Features
The Academy's ecofriendly and sustainable approach, from the larger features such as the green roof to the several smaller energy harnessing methods such as sensor bathroom faucets has contributed towards obtaining a double platinum LEED certification from the U.S Green building council and as the world’s greenest building.

Solar Canopy: The roof perimeter includes a solar photovoltaic canopy supplying the academy and prevent the release of a large amount of greenhouse gas emissions.

Green Roof: Native plants inhibit the green roof providing towards the much-needed habitat and food for birds, butterflies and other beneficial animals. The heat island effect is minimized as 87% of the total roof area is planted. The roof is used as an outdoor classroom offering a range of programs and learning opportunities. It is also maintained by many volunteers from the areas.

100% Recycled Steel: Used where possible including the planetarium dome.

Low Iron Glass: Full glass panes, maximizing light and high performance low iron glass to minimize energy use

Heating and Cooling: Parks natural air currents used to ventilate building through piazza and auto ventilation systems.

Water Conservation: 5.6km Underground pipe to draw sea water. Salt regulated and treated to suit aquarium. Storm water also captured, stored and used to prevent excess water run off into city storm network.

The Academy's ecofriendly and sustainable approach, from the larger features such as the green roof to the several smaller energy harnessing methods such as sensor bathroom faucets has contributed towards obtaining a double platinum LEED certification from the U.S Green building council and as the world’s greenest building.

Important outtakes from this building?
Sustainable techniques used in this building to obtain its platinum LEED certification
Use of sea water even being located far inland.
Techniques to draw people in using the green roof and large staircase entrance.
Simple masses used to create a good balanced interior space, also was able to capture a lot of natural light with simple techniques, framing views and creating a wow factor upon entry.

Key Points
Pros
- Park allows natural wildlife interaction with green roof
- Wide range of sciences covered with original elements used with architecture for education and research.
- Designed for all ages
- Architectural techniques used to highlight each science, rainforest dome, planetarium, Living roof, Reef tanks
- Energy: Solar, green roof, Bio & Mech heat capture, natural ventilation, lighting, storm water, food production

Cons
- No exterior interaction, all activity inside the building facility, no free activities
- Closed off from public outside opening hours
- No architectural guidance, pro/con for self-discovery.
- Mostly Visual learning rather than interactive experiments
- Has the classical facade, green roof and visible solar panels that express architecturally, however the building is essentially a modern warehouse
- Park setting means its hidden to daily city life interaction

Conclusion
- The California Academy of Sciences is a good example that is a step up from the Exploratorium as it shows signs of expression of its internal contents.
- The large glass planes allowing some views inside, the living roof, and domes amongst other features starts to excite and generate inquiry, the need to know of the building's interior contents.
- The building has a formal exterior, a large green roof and visible solar panel installations. While there are interesting features the building fails to interactively engage people with its interior contents essentially making this a beautiful warehouse. (Pretty black box)
4.3 Ontario Science Centre

What – Science museum – Exploration into the world of science, art and human perception.

Visitors – Primary, middle school students, Teachers, Families, local community, Adults, Expo event guests, Researchers, Toronto, Ontario, Canada

Architects – Raymond Moriyama

When – 1969, Renovated 2007

Visited – May, 2018

Highlights
- Exhibits catered for children and adults
- Exterior play and experiment areas outside staffed hours
- Embedded into a natural setting and incorporates external elements with center to learn from.

Fig. 4.21: Ontario Science Centre

Fig. 4.22: Ontario Science Centre Zones

Fig. 4.23: Ontario Science Centre Features

Fig. 4.24: Ontario Science Centre Views
Exhibitions

Upon arrival even before entering the building there is an exterior plaza provided for interactive exhibits. This space invites visitors with experimental opportunities to play, investigate and interact with their environment through playful experimentation. These exhibits are also responsive to the natural environmental conditions such as wind, time of day and climate constantly showing kinetic movement. The theme behind this outdoor plaza is to make visitors question the landscape through transitions and experiences between the natural and urban elements.

A: Internally building A is primarily used for ticketing and visual shows. This includes the Omnimax theatre and conference rooms. A discovery zone separates building A and B informing visitors of Canada’s major contributions to science.

B: Building B has the auditorium for interactive shows, the planetarium and interactive kids zones. Building C is accessible by a long escalator as it is located further down the valley.

C: Building C is the most informative and interactive of the science center and can be viewed as the core of the visit. This building covers most of the feature exhibits, has a unique ecosystem greenhouse and a large restaurant.

All 3 buildings have an outdoor area where visitors can interact with the natural surroundings of Flemingdon Park strategically used to educate and inform visitors of the park’s ecology. Over all between all 3 buildings there is a flow between each exhibition area where repeating an exhibition or walking past the same exhibition again is not necessarily required. Only the Omnimax Theatre has a one-way circulation scheme.
4.3 Ontario Science Centre

Entry Points
The main entrance is located next to the Omnimax Theatre dome past the interactive plaza. Floor to ceiling curtain walls working with the landscape make it clear where the primary entrance is. A secondary entrance is available for groups and functions, this is indicated architecturally with a smaller façade and guided pathway. In building C, as this is a multi-use facility primarily for private research spaces the only entry points are for staff and services.

Natural Light
Building A is naturally well lit with large floor to ceiling curtain walls along the linear face of the front façade and sky lights. Building B uses sky lights along the perimeter of its core structure however its vertical planes have limited glass surfaces. Building C was the most limited, this is due to part of its structure being built under the ground level into the valleys face.

Generally, all 3 structures due to being built on the valley of Flemingdon Park have forest like surroundings which in some areas can limit light on the vertical planes, this is very noticeable in building C as natural light was very limited.

Expressive Components
The most expressive components is on the building A, particularly on the entrance areas. This is the most visible part of the building by the public vehicle or foot traffic. The large Omnimax dome works well with the plaza exhibits at gaining attention as it's the only unique building around the area. The surrounding areas include two large carparks, large block apartments and office buildings as neighboring structures helping the science center standout. The free exterior interactive plaza is also very effective for the science center as it is easily viewable and accessible anytime of the day generating inquiry and activity.

Understandably due to the limited public routes and activity on Flemingdon park there has been less focus on expressive features for building B and C which is further down the valley.
**Precedent Studies**

**Important outtakes from this building?**

It was a multi-structured building however was still connected as one unit and often experienced as one unit. The separations were not unique or noticeable as the flow generally throughout the whole building consisted of similar materials and environment internally and externally.

The entrance plaza stood out showing techniques for interaction during and after staffed hours. Simple but very informative exhibits helped draw crowds and activity to the science centre.

There were also instances reminding of your surroundings between buildings of Flemingdon Park. This was a nice reminder as access points were present to experience the park and took you on a journey down the valley.

This precedent was architecturally expressive especially in the entrance areas and reflects the nature of its purpose. The Ontario Science Center, primarily the entrance falls in-line with the 'White box architecture' analogy.

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**Key Points**

**Pros**
- Entrance in commercial setting but journey into the centre is through a park behind the entrance (introduced into a new setting)
- Exterior play areas and experiments to learn from (free) accessible outside open hours
- Nature escape park/ greenhouse for rainforest
- Building embedded into landscape form (wood ravine), respects existing trees, valley and land configuration (sloping down with hill)

**Cons**
- Activities designed mainly for kids.
- Active areas hidden to public, no visual interaction with public life.
- A lot of inactive/empty areas

**Interaction:**

The Teluscape Discover plaza and the entrance has the most architectural interaction. The interactive plaza activates the area generating interest and activity, being free also contributes to capturing an audience and gives a sample of the science center’s experience.

Building A works together with the plaza and Flemingdon park generating internal/external interaction with the public. Full sized floor to ceiling curtain walls reveals the internal activity and the plazas activity.

**Building Features:**

From the initial planning stages in 1969 the design focuses on smart design rather than adding green features such as green roofs. The design focuses on respecting the existing trees and typography by designing with the landscape reducing demand on heavy machinery resources during the construction phase. Where possible, curtain walls are used for natural light and heat gain from these large walls are countered with large open exhibition spaces reducing the demand on electricity. Additional to its unique typography Flemingdon Park also provides shading for the science center further reducing energy consumption and provides water from the river as a natural resource to the centers required areas.

**Interaction:**

The Teluscape Discover plaza and the entrance has the most architectural interaction. The interactive plaza activates the area generating interest and activity, being free also contributes to capturing an audience and gives a sample of the science center’s experience.

Building A works together with the plaza and Flemingdon park generating internal/external interaction with the public. Full sized floor to ceiling curtain walls reveals the internal activity and the plazas activity.

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**Fig. 4.29: Ontario Science Centre Interaction**

**Fig. 4.30: Ontario Science Centre Section**
4.4 Other Unvisited Precedents

The Exploratorium, California Academy of Sciences and Ontario Science Centre were three of many precedents visited and experienced for a thorough analysis. However, it was also important to analyze other unvisited precedents to review the different approaches taken in different contexts towards the education of sciences.

4.4.1 The City of Arts and Sciences

The City of Arts and Sciences is an unvisited precedent. It was included as a precedent for this research project as it covers different disciplines outside of science and is a multi-structural complex. It includes sports, arts, performances and other events in the programme.

What – Entertainment based scientific and cultural complex
Visitors – Primary, middle school students, Teachers, families, local community, Adults, Artists, Researchers, Athletes, Tourists
Where – Valencia, Spain
Architects – Santiago Calatrava and Felix Candela
When – Started 1998
**Pros**

- Accessible by multiple modes, foot, bikes, bus, metro, boat, train, plane (airport closeby)
- Use of natural resources, and sustainable strategies
- Canal used for supply in aquarium and surrounding pools
- Cool Ocean water used for required refrigeration
- Cogeneration plant used with natural gas motors for energy (sustainable)
- Sustainable filtration systems
- Use of aquarium tides for tidal energy generation
- Some facilities are multifunctional for sports, arts and education
- Includes exhibits with tropical and subtropical environments of mangrove swamps
- Stands out, has a wow factor

**Cons**

- Designed to generate international buzz to host events over local needs and requirements.
- No connection to city at all, a lot of poor areas close by to this very grand complex.
- Designed more for entertainment value than science education. El Museu: Majority of the ground floor is taken up by a basketball court used by the local team and various companies.
- Unoccupied spaces available with low use
- Buildings very separated, connected by bodies of water.
- Sustainable strategies are not highlighted in the complex or even mentioned to educate.
- Structures were generally design driven by entertainment over function

**Facilities**

- Complexes cover a wide range of sciences and arts
- L’Hemisfèric – 1998 - Planetarium, Souvenir Shop
- El Museu de les Ciències Príncep Felipe - 2000 - Interactive Science, Basketball court, Marvel superhero art gallery, Restaurant
- L’Umbracle – 2001 - Landscaped indigenous ecology walk, Parking
- L’Oceanogràfic – 2003 - Open air oceanographic park, under water restaurant, Marine research
- El Palau de les Arts Reina Sofia - 2005 – Opera house and performance arts center, Cinema, Conferences
- El Pont de l’Assut de l’Or – 2008 – Cable stayed bridge next to L’Agora
- L’Àgora – 2009 – Covered plaza for sports, conferences and concerts

**Conclusion**

This precedent revealed that in the grand scale of things, even though it had very attractive features and was an architectural marvel internationally it still didn’t draw people in as expected.

The project overall evokes that it was done mainly for display with many exaggerated elements. Architecturally some buildings are designed to reveal activity of interior common areas.

The most successful complex of the many would be the oceanographic park given its purpose to educate drawing in a lot more interest than other facilities around. Activity is not constant as certain buildings are only active during events.
**4.4.2 Eden Project**

*Fig. 4.36: Eden Project: Interior/Exterior*

**What** – Multiple Greenhouse Complex

**Visitors** – School students, Teachers, Families, Local community, Adults, Artists, Researchers, Entertainers(concerts), Tourists

**Where** – Cornwall, UK

**Architects** – Nicholas Grimshaw

**When** – 2001

**Highlights** – Embedding to land form. Nocturnal exhibitions. Hosts events/concerts

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**4.4.3 Cité des Sciences et de l’Industrie**

*Fig. 4.37: Cité des Sciences et de l’Industrie: Interior/Exterior*

**What** – Science Museum

**Visitors** – School students, Teachers, Families, Local community, Adults, Researchers, Speakers(Conferences), Tourists

**Where** – Paris, France

**Architects** – Adrien Fainsilber

**When** – 1986


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**4.4.4 Abu Dhabi Central Market**

*Fig. 4.38: Abu Dhabi Central Market: Interior/Exterior*

**What** – Shopping Complex

**Visitors** – Families, Local community, Tourists

**Where** – Abu Dhabi, UAE

**Architects** – Foster + Partners

**When** – 2014

**Highlights** – Kinetic Roof controlling sun levels. Designed after traditional Islamic roof.
4.4.5 The Blur Building

4.4.6 Other Visited Precedents

Fig. 4.39: The Blur Building: Interior/Exterior

Fig. 4.40: California Sciencenter

Fig. 4.41: Melbourne Museum

Fig. 4.42: Griffith Observatory

Fig. 4.43: Spyscape

Fig. 4.44: 911 Memorial Museum

Fig. 4.45: Guggenheim Museum

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What – Media Pavillion (Swiss Expo)
Visitors – Exhibition visitors, Families, Local community, Adults, Tourists
Where – Yverdon-Les-Bains, Switzerland
Architects – Elizabeth Diller & Ricardo Scofidо
When – 2002
Highlights – Man-made cloud using fog nozzles (lake water), Brain coats worn: changes color reacting to personality of visitors close-by.
5.0 Design Elements
A collection of design elements that can be considered for the project design as architectural components or strategies influenced by the fields of science and researched precedents.
Fig. 5.3
Facades

- Glass Facade
- Solar Systems
- LED
- Bio-reactor
- Bio-Metal
- Kinetic
- Wind Veil
- Extrusions
- Artistic
- Perforated

Fig. 5.4
Astronomy

- Views
  - 1. Representation
  - 2. Space Technology
- 1. Vastness
  - 2. Journey
- 1. Orbit
  - 2. Space Travel
- 1. Planetarium
  - 2. Solar System
- Virtual Reality

Life Science

- 1. Journey
  - 2. Ecology Layers
- 1. Underwater Access
  - 2. Foreign Ecosystem
- Nocturnal Experience
- Wildlife
- Recreational Areas

Fig. 5.7

Fig. 5.8
6.0 Site Analysis
6.1 Site Selection

Grafton Road, Auckland, New Zealand

This research project’s primary aim is to enhance the scientific learning experience by architecturally generating a key component in education, inquiry. The chosen site therefore needs to be well exposed and at a close proximity to educational and recreational areas in order to be distinct and accessible to all. As this building also seeks to showcase the sciences and technologies, other considerations such as exposure to the natural elements may be required.

The chosen site is in the proximity of the Grafton Road and Stanley Street intersection in Auckland. It is strategically located linking the ‘University of Auckland’s three campuses and the ‘War Memorial Museum’. The site also allows for interaction with the surround landscape, the natural elements and the existing activity as considerations amongst others for the design.

Following an investigation, suitable design areas were established as highlighted on figure 5.4.
6.2 Site Overview

Fig. 6.6

Fig. 6.7

Fig. 6.8

Fig. 6.9

Fig. 6.6 - 6.9: Site Views
6.3 Auckland Context

Fig. 6.10: Auckland Context
6.4 Site Context

Fig. 6.11: Site Context
6.5 Connection

Through the design, the project aims to promote an alternative path from the current commonly used path. Primarily focused on students traveling between campuses however considering the public also.

Alternative Path Benefits
- Faster (by 5 mins walking to Grafton Campus)
- Safer (No Traffic)
- Less Stops (Crossing)
- Tranquil (Noise)
- Scenic
- Dedicated Path
- Lower Gradient
6.6  Topography Study

The chosen site area consists of multiple level changes. Contributing, is a valley where the motorway intersection is currently sits on. The valley is in between two historic Auckland Volcanic cones, the Auckland Domain and the Albert Park ridge. Site A has a steep cliff face to its North West, part of site B has an existing carpark which is paved flat, C follow the natural contours of Auckland Domain and site D is fairly flat possibly due to the highway.

Site Zones

The site area is divided into four zones. A, B and D are currently connected over State highway 16 by a bridge on Grafton road, and C is part of the Auckland Domain separated by Stanley Street. These zones are established as possible design areas for the final design outcome while respecting the existing facilities such as the ‘Auckland Lawn bowls club’ which has historic significance.
7.0 Design Development
7.1 Design Development

Following the literature reviews, precedent studies and site analysis, design strategies were developed to tackle the project. Prior to any sketches or concept designs it was important to understand all the components required to the design and how a educational facility would be experienced by a visitor. Answering key questions of the intended experience, generating a vision for the project and producing a journey map is crucial before any significant design commences.

**Theme:** Science & Technology

**What is it?**
- A place to discover/learn/explore/research and experiment the fields of science and technology
- A facility that is accessible and celebrates discovery at all times
- A venue to showcase and discuss science and technology by and for professionals and its visitors

**What is it about?**
- Providing a form of “uplift” in the general public in the understanding and familiarity of the science, scientific methodology and technology.
- Visual, tactile engagement with the architecture introducing the most important thing in education, inquiry.

**What is the experience?**
- An interactive and practical experience of learning
- Interdisciplinary learning
- Meaningful and exciting visitor contribution to the institution
- Growth in ______ through the senses
  - Confidence
  - Knowledge
  - Familiarity
  - Awareness
  - Participation

**Achieving the experience**
- Hands on learning and visitor contribution to scientific/tech experiments/projects through participation.
- Allow for activity inside/outside and around the building.
- Activity unrestricted by operating hours.
- Dynamic structures for rotation of exhibits, experiments and façades informing activity in and around the building.
- Visually revealing scientific and technological mechanical systems operating processes for observation and investigation eg: energy turbines, green roof systems, living bridges, Aquarium systems

**Who is it for?**
- **Informal Audience**
  - Tourists
  - Families
  - General Public

- **Formal Audience**
  - Students/Teachers
  - Researchers
  - Conferences/Keynote Presenters

**Vision**

Design that
- Educates, engages and uplifts the general public in the understanding and familiarity of science and technology.
- Addresses environmental issues that relate to protecting the natural world while reflecting the beauty of the natural world.
- Enforces and announces the function of educating, engaging, displaying and researching.
- Allows for activity inside and outside the structure, during and after staffed hours for the community.
7.2 Design Considerations

Once the site is analyzed and possible building zones are established, the project seeks a response with a series of buildings to suit each zone interconnecting existing public walking and cycle routes.

An outline of architectural queries to consider for each space/science is listed. Key behind every space includes interaction and visual connection at different scales including the perceived street scale.

**Transition Spaces**
- Educational/Interactive
- Acknowledge natural and existing Elements
- Visual and social connection
- Spacious, seating spaces
- Safe walking and cycling areas
- Well-lit social areas day and night
- Walkways and scenic viewpoints
- Accessible for all ages and cultures
- Active Play Areas
- Convertible event spaces (farmers markets etc)

**Architecture**
- Flexible spaces for circulation of new exhibits in certain buildings
- Entrances/Ticketing areas
- Connection (Bonds) between buildings
- Ticketing reactive with architecture
- Active surfaces (Eg: rock climbing walls)
- Sustainable, Passive Systems, materials etc
- Special exhibition spaces
- Conferences/Lectures
- Research Facilities
- Resting areas

**Ecology**
- Natural elements and landscape
- Foreign ecosystem supporting wildlife/plants
- Multiple learning experiences within ecology
- Introduction of the aquifer as source of water
- Incorporating other sciences into ecology (Technology, history etc)
- Comfortable relaxing spaces
- Event space
- Water bodies

**Geology**
- Embed existing elements and rock faces
- Visual connection and interaction
- Underwater geology
- Rock formations

**Astronomy**
- Vast
- Connection to outside/sky
- Dark areas for observatory (Domain)
- Event spaces

**Natural History**
- Educational, mix of static and interactive elements
- Cohesion of other sciences
- Main building addressing beginnings of science

**Technology**
- Showcasing modern technologies
- Disruptive technologies addressing sustainability

**Marine Science**
- Water supply from ocean
- Multiple levels of life in ocean
- Geological Cohesion

**Connection**
- Public Paths, Cycle/Walking
- Street connection
- Visual street scape interaction
- Multi directional experiences In/out/up/down

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Fig. 7.1: Science Centre
7.3 Journey Map

Based on the successful precedents visited and investigated, a journey map was produced which effectively becomes an important part of the project brief. It is a key turning point for this project as it translates all the researched material into a diagram guiding the starting point for design.

It is a result of extracting key information from the literature, experiential and design research carried out and presented in a diagram format which essentially becomes a blueprint for the design outcome.

The journey map shows an outline of key questions, opportunities and experiences a visitor may encounter at each stage of their visit to the science centre. Mapping the visitors experience gives a thorough understanding of what is required during their journey. Using the journey map to analyze, architectural strategies can be developed to respond to key questions and opportunities the at each stage.

Multi-Building Educational Facility

Following the site analysis and established brief, the design seeks to respond with a series of buildings. The design outcome seeks to interconnect the buildings with public routes to promote a free-willed educational experience strategically positioned in the learning quarter of Auckland.

Benefits of independent buildings include

- Integrate buildings into existing routes so they become part of peoples everyday life and not just a destination.
- This strategy brings science into everybody’s life rather than them having to go find it.
- Site positioned in the learning quarter of Auckland connecting other educational nodes.
- Multi-day passes can allow visitors to have a complete experience of a single building per day without rushing.
- Each building highlighting a small group or a singular field of science allows visitors the flexibility to come-back another time to have a completely unique experience in a different building.
- Each zone with different site conditions allows for unique design responses.
- Buildings are physically separated but links between buildings pull them together and act as a bond becoming a learning process in their own right.

Fig. 7.2: Visitor Experience Stages
8.0 Design Process
8.1 Design Strategy

The project programme seeks to educate the key sciences outlined above. However, there will be emphasis on the fields of geology, marine sciences, ecology, astronomy and technology following New Zealand’s achievements in these scientific fields. Incorporated with these emphasized fields the project will also seek to highlight other sciences that are taught in the New Zealand school curriculum.

Embedded into the programme are strategies and incentives the project seeks to integrate into the final design. As the design response involves a series of buildings following the site analysis, connections between them crucial using existing bridges and proposing new connections to create an educational journey for the visitor.

Design areas were established following a site analysis. Established zones are open spaces currently available without having to make many drastic changes to the site giving the design a character of adapting to the site and extending the educational.

3D masses were generated to grasp a scope of the design. The programme superimposed over the site to explore the conditions of the sites design extents.
8.2 Urban Study

An analysis was carried out on existing motor vehicle routes through the site. This was an investigation into promoting a safer environment around the science centre.

As the brief seeks to promote a safer pedestrian and cyclist environment around the chosen site, a new route was proposed for vehicles. A new roundabout and road connection was included through underutilised existing routes.

The new route allows closure of roads with limited vehicular access for emergency or service vehicles. This allows for safer and more flexible transition areas around the facility.
8.3 Zone Analysis

A : Closed steep area including a rock wall face, connections via bike path under highway and walkway next to UoA Architecture building from Shortland street.

B : Open area including a carpark and grassy area. Has open connections with Grafton road intersecting the zone.

C & C.1: Part of Domain, low gradual gradient, high vegetation area including car park. Connection via public walkway.

D : Closed area enclosed by car park lot, UoA Sir Owen G Glen building and motorway. Only connection via bike path.
Zone Allocation

Following zone investigations the programme was allocated

A: Geology/Marine - Steep zone with existing geological elements. A strategy to include the marine environment with geology was developed to show different section levels of both fields.

B: Main technology and natural history/science hub - highly exposed area with multiple existing connection possibilities. Nucleus of the Science Centre.

C: Ecology - taking advantage of the existing ecology of the domain and landscape to embed other elements of nature with the facility. Access to aquifer and existing waterway.

C.1: Astronomy - Highly exposed area including multiple view points, also potential for dark areas further towards the domain for observatory design strategies.

D: Mainly utilised as a connection zone to the facility. Seeks to benefit from UoA Sir Owen G Glenn building and car park to provide a direct connection with the students and visitors to the science centre.

Bridges: Established as the bonds between each science centre node. Bridge designs will consider existing elements such as protection from the motorway.

Zone Connections

The journey was developed to include the science centre as part everyday life and not just a destination. This strategy seeks to bring science into the publics life rather than having to go find it.

The journey aims to include connections that go over structures, underground, in and out of buildings at multiple levels. Interconnecting with the University also allows a natural flow of visitors to use the science centre as a informative or tranquil space for study or recreation.

8.4 Journey
### 8.5 Masterplan Development

The master plan was first developed using plan mapping. The zone map was superimposed over the site to correspond and establish the overall organization of the site. Multiple sketches were studied in order to establish their relationship with existing routes gradually refining to a master plan that correlated to the brief.

A key strategy in the design included closing off roads to vehicles. The north and south entrance (Grafton Road) in the main hub is a vital transition zone to introduce the science centre to visitors. The redesigned Grafton bridge plays an important function in introducing visitors to the science centre experience by removing them from their daily surroundings into a new environment.
Masterplan - Concept

A key focus of the project was to develop a refined master plan that communicates the science centre's purpose with the site. Learning from various literature and precedent analysis it was discovered that the visitors experience is crucial to the project outcome. The experience is outlined as a journey in this project with the buildings physically separated, however the links between the buildings pull them together and act as a bond becoming a learning experience themselves.

The project seeks to minimize any visitor confusion by avoid elements that relate to a maze or dead end routes. It also seeks to avoid any “black box architecture” surprises, rather looks for cohesion between the buildings and the exhibits.

North & South Entrance: Recreation Areas for visitor.
Meeting areas, discovery park
Pedestrian/Bicycle only area

Marine Science & Geology Zone (A):
Entrances via bridges integrated with existing public routes
Connections: Strategy to create a visitor journey experience
Astronomy (C.1): Entrance via ground and underground path.

Existing Car park
UoA Connection (D): Use of Sir Owen G Glenn building to establish student connection to centre
Central Hub (B): Main science centre building. Key building for arrival sequence welcoming visitors. Technology and Natural science node.
Ecology (C): Entrance via overpass and underground Path
Underground Access point

Fig. 8.21: Refined Masterplan (Work In Progress)
8.6 Concept Development: Zone A - Marine Science / Geology

The Marine and Geology centre is designed cohesively. This design seeks to educate visitors of the different layers (depth) of the geological and oceanic zones. Through the different levels, visitors are educated of the marine species, geological layers including volcanology as they descend down the facility.

- **Entry points/Circulation**
  
The primary entrance to the facility is through the roof area. The roof area is designed as a high altitude geological area (Ref fig. 8.23) where visitors are then descended through the central marine tank either walking or using the elevator progressively providing a journey through the geological and oceanic levels. On both sides of the central tank are areas for other geological and marine exhibitions. Further below ground level are flexible areas designated for special exhibitions, functions, conferences and lectures.

- **Features**
  
  A key feature for this building, due to the high volume of salt water required includes an underground water pipe to the ocean (Approx. 1.3km). This strategy was influenced by the California Academy of Sciences Precedent. Water is also provided and circulated into Zone D.

  The Geo-roof is more than an architectural feature, it helps with the buildings cooling and heating efficiency. The substrate acts as a natural insulation and prevents rainwater runoff which can be captured, reused and supplied to other science centre buildings.

  Centrally, the glass sphere allows for natural light to be provided into the building.
• **Interaction**

Visually, the marine and geology centre is less exposed in comparison to the other science centre buildings due to its location. However, visual connections include the glass fractures embedded in the building’s façade where internal visitor activity can be seen, the rooftop recreational activity and the public routes interacting with the building.

Physically the building interacts with the public bicycle and walkways on both the ground level and the roof level via Symonds Street. These routes show glimpses of the exhibits inside informing the public of exhibitions inside.

A rock climbing wall is designed on certain faces of the building harmoniously engaging with the subject of geology.

The Marine and Geology centre is designed cohesively. This design seeks to educate visitors of the different layers (depth) of the geological and oceanic zones. Through the different levels, visitors are educated of the marine species, geological layers including volcanology as they descent down the facility.
The Central hub is the core of the science centre. Though other buildings support introducing visitors to the science centre, the main arrival area is highlighted in the central hub. The arrival sequence in the central hub includes welcoming, ticketing and guiding visitors into the exhibition areas.

Technology and natural history are key subject areas in the main hub exhibiting modern advances in technology, sciences and the natural evolution of life and the planet. The hub introduces visitors to the sciences which are then further specialised in the other specified (ecology, astronomy, marine, geology) science centre buildings.

The hub programme includes educational spaces, research hubs and flexible spaces for special exhibitions, conferences, lectures and functions such as award ceremonies. Additionally, spaces in and around the hub such as the discovery park can be used recreational and leisure activities.

The hub also invites professionals and students from universities to showcase their projects in the science centre initiating discussions on new advances and discoveries.

**Entry points/Circulation**

There are multiple circulation points connecting to the main hub, and this includes public routes integrated into the building making this the most active building of the science centre. Free exhibition areas are available along public routes in the central hub promoting interaction with the public.

Zone D is a transitional space that connects the University of Auckland directly with the science centre inviting students and teachers into the science centre as an educational space or a transition zone to the Auckland War Memorial Museum or other university campuses.

**Features**

The central hub is designed to include technologies that highlight sustainable approaches. Facades, green roofs, atrium spaces, renewable energy strategies, water capture, choice of materials, automated systems and other disruptive technologies are integrated into the hub. The hub is a focal point of the science centre working with other science centre buildings to showcase how disruptive technologies can reduce resource consumption and improve quality of life for future urban societies.

**Interaction**

The hub is the nucleus of the science centre, it is located centrally on the site and has the most visual and physical interaction of all the science centre buildings. Visually, areas are designed to be active in and around the building. The public routes integrated with the hub translates as an everyday use facility bringing the sciences to the public without requiring people to go find it. Transition areas around the building are designed to provide recreational and leisure spaces generating inquiry and enabling interaction and various scales from the perceived street scale to the intimate hands on scale.
Fig. 8.29: Central Hub Features (Work In Progress)
Concept Development: Zone C - Ecology

The ecology centre is an exhibition of the world’s most bio-diverse rain forests. Inside the domes, the rain forest includes a rich bio-diverse range of plants, animals and insects. The exhibition takes the visitor at multiple levels from the high tree line canopy to the underwater freshwater network. The location takes advantage of the Auckland Domain’s natural green surrounding and the waterways to exhibit New Zealand’s biodiversity as well as environments overseas.

**Entry points/Circulation**

Entrance to this facility is primarily an underground approach. The incentive is to remove the visitor from the surrounding city environment and transport them instantly into one of the world’s most bio-diverse environments on earth. Once entered the visitor is taken on a journey via a boardwalk that radially circulates at multiple levels of the rain forest canopy down to the forest river.

- **Features**

  The location takes advantage of the Auckland Domain’s natural green surrounding and the waterways to utilise a sustainable approach. Another natural source of water is through aquifers in the domain, which can be pumped when required. The design controls the micro-climate by combining material of the dome’s panels with ETFE and glass to control light, temperature and humidity. The panels are also operable to open and close giving further control.

  Additionally, bio-reactor algae panels are used in high exposure zones to provide green energy to the facilities power network.

**Interaction**

Visually, the ecology centre stands out from the Auckland Domain surroundings in scale and can be seen from multiple viewpoints such as the UoA Owen G Glenn Building, the School of Architecture and the motorway. Internal activity is expressed through the strategically chosen glass panels that show the walkway where visitors pass by during their experience.
Concept Development: Zone C.1 - Astronomy

Entry/ Circulation
Entrance into the Astronomy Centre is similarly based on the ecology experience. The underground tunnel guides visitors by removing them from the city surroundings and acts as a buffer zone to transition them into a new environment.

Features
Floor to ceiling panes of glass curtain walls is extensively used around the main astronomy hall. High performance, low carbon glass minimises the energy required for cooling and reduces heat absorption levels. Seasonally, hot air is collected and used to circulate around the building. An operable roof structure allows for interior conditions to be controlled taking advantage of the natural air currents of the valley and the Auckland Domain to ventilate the building.

Switchable glass allows the building face to become a projected screen surface. Special projection exhibitions, announcements, promotional banners or public screenings are options for this surface.

Interaction
Visually the astronomy centre is very visibly located at a high point of the site. The elevated zone allows the building to be seen from various angles and large panes of floor to ceiling glass with a lightweight roof communicates the vastness of the solar system. The observatory is designed to be more of an intimate experience in contrast to the open setting of the main astronomy hall.

The Astronomy centre experience is based on the solar system. Components of the exhibitions revolve around the planetary experience. Each sphere provides a unique experience either it is a planetarium, a planet landscape or space travel. The spheres are designed with flexibility in mind allowing for future changes. The ground level is a flexible space to host special exhibitions, functions and conferences when required. Additionally, an observatory is designed further into Auckland Domain where its darker and ideal for observing celestial and terrestrial events.
Concept Development: Academic Gateway

Zone D is a academic gateway transition zone that utilises the existing carpark as drop off zones for both small and large groups. Visitors are directed through this zone passing free exhibitions of various sciences that react to natural environmental conditions.

- **Entry/Circulation**
  Additional to incorporating the existing public routes with the facility, the design strategy includes connecting the University of Auckland Sir Owen G Glenn building’s main staircase with Zone D. This redesign directly invites students to the science centre.

- **Features**
  Exhibitions that include water circulation in Zone D is provided by the marine and geology centre which includes a supply of ocean water. The open area in Zone D also allows for additional future developments to the science centre if required. This may include a University quarter.

Fig. 8.38: Academic Gateway (Work In Progress)

Fig. 8.39: Academic Gateway (Work In Progress)
Concept Development: Science Centre Connection (Bonds) Concepts

Circulation between buildings consists primarily via bridges. These bridges integrated with public pathways represent the bond between buildings. These are a collection of lightweight bridge structures influenced by the fields of science. Services are hidden below but also exposed in certain bridges to use as an educational tool to show the network of the facility.

Fig. 8.40: Concept Lightweight Bridge Structures

Fig. 8.41: 3D Concept Bridge Perspective (Work In Progress)
8.7 Design Strategies

Sustainable Strategies

The Science centre, though designed as multiple buildings work as a single entity. They provide each other with energy and services when required. There are many design features highlighted (Ref fig 8.25) such as wind trees and photovoltaics. Any excess energy generated can be stored and provided back to the local power grid when necessary. The same strategy can be used with storm water which can be collected and stored in tanks for use when required.

As this is an educational facility there is an emphasis on exhibiting these technologies as an educational tool to inform visitors.

Sustainable Strategies include:
Photovoltaics
Wind generation
Bio-reactor panels (Algae facades)
Bio metals (Facade)
Recycled Material
Green Roof
Hydro-power
Playground kinetic and Walking tile energy
Water capture/recycling systems
Natural Ventilation Design
Heat capture and distribution systems

Underground Passage

The Science centre includes an underground passage to exhibit technologies that have been designed to sustain life underground. The Lowline is an example of a project that utilised technology to capture sunlight and redirect it underground.

It is also used as a buffer zone to remove visitors from their city scape surrounding and reintroduce them into the facility. The ecology and astronomy centres make use of the underground passage as an entry points.

Additionally, the science centre can use the underground passage to initiate the refurbishment and reopening of the existing Albert Park tunnels.
8.8 Concept Design Outcome

Fig. 8.45: Masterplan (Work In Progress)

Fig. 8.46: Masterplan Perspective (Work In Progress)

Fig. 8.47: Masterplan Section (Work In Progress)
9.0 Conclusion
Conclusion

This research project used a number of methodologies including precedent studies, literature studies and site study. These methods informed the design process by providing solutions unique to each scientific field. Other elements such as connections between buildings were also informed through the research process.

The project outcome was unique as a result of the chosen site. The site drove the design outcome to respond with multiple buildings connected by bridges and public pathways. The integration of the public routes with the building was a successful strategy to promote daily public interaction with the science centre.

An unexpected part of the project was the visitor journey. Research and relevant precedents help establish a connection with the visitors by providing a unique journey through multiple access points to the building at different levels to generate a unique experience in each science centre building.

As an educational facility the location of the science centre also played an important part by designing a connection with University of Auckland’s students. Strategically located in the educational quarter of Auckland the science centre becomes a destination for students or a thoroughfare connecting the Auckland War Memorial Museum and other University campuses.

The Design outcome also supports future developments by allowing the design to adapt and be flexible for special exhibitions or functions.

Importantly the projects aims included engaging visitors in the education of sciences by designing an outcome that conveys a nature of the buildings purpose rather than a repository response. Incorporating and celebrating the sciences with architecture was addressed in the design outcome.

The science centre plays an important role in the education of the sciences. With more emphasis on hands on and vocational education, support structures such as the science centre become a crucial part of education and is likely to become a core part of education.
10.0 References
References


List of Figures

All Figures by author unless stated otherwise.

Chapter 1
Fig. 1.1: Interactive Education
Fig. 1.2: MOTAT, Auckland - ‘Black box’ Architecture
Fig. 1.3: Ontario Science Centre, Canada- ‘White box’
Fig. 1.4: Black/White Box Architecture
Fig. 1.5: Science Centre Diagram
Fig. 1.6: Key Scientific Fields
Fig. 1.7: Methodology
Fig. 1.8: Process

Chapter 2
Fig. 2.1: Proposed Sydney Science Centre (Internal Black box)
Fig 2.2: Experiential Learning
   Outdoor Education Center. 2013.
Fig. 2.3: Musée Du Louvre (White box Interior)
Fig. 2.4: Sources of Science Education
Fig. 2.5: Contextual Model of Learning
Fig. 2.6: Ministry of Education, Science Framework
Fig. 2.7: STEM Subject Diagram
Fig. 2.8: STEM Educational Framework
Fig. 2.9: STEM Education Focus
Fig. 2.10: Hands-on Learning
   NSPE--NJ. 2016.
Fig. 2.11: Kolb’s Experiential Learning Cycle
   2011.
Fig. 2.12: Innovative Education Models
Fig. 2.13: Hands-on Education
Fig. 2.14: Science Centre Education Model
Fig. 2.15: Institute/Visitor Relationship
   Atkins, Jennifer R. 2015.
   http://www.participatorymuseum.org/chapter1/.
Fig. 2.16: Science Alive (Christchurch)
   http://www.sciencealive.co.nz/about.html.
Fig. 2.17: International Antarctic Centre (Christchurch)
   https://www.iceberg.co.nz/.
Fig. 2.18: Te Papa Tongarewa (Wellington)
   https://www.tepapa.govt.nz/.
Fig. 2.19: The Pedagogy Triangle
   2011.
Fig. 2.20: Synthesized Conceptual Framework
   2011.

Chapter 3
Fig. 3.1 - 3.6: New Zealand Scientists Global Contribution
   NZ Edge. 2018.
Fig. 3.7: Branches of Life Science
Fig. 3.8: Life Sciences
   https://www.pinterest.nz/search/life%science
Fig. 3.9a: Life Science Architecture

Fig. 3.9b: Life Science Architecture

Fig. 3.9c: Life Science Architecture

Fig. 3.10: Branches of Earth Science

Fig. 3.11: Earth Sciences
https://www.pinterest.nz/search/earth%science

Fig. 3.12a: Earth Science Architecture

Fig. 3.12b: Earth Science Architecture

Fig. 3.12c: Earth Science Architecture

Fig. 3.13: Branches of Astronomy

Fig. 3.14: Astronomy
https://www.pinterest.nz/search/astronomy

Fig. 3.15a: Astronomy Architecture
Thirty Meter Telescope. https://www.tmt.org/

Fig. 3.15b: Astronomy Architecture
Infoversum. https://www.archdaily.com/528037/infoversum-archiview

Fig. 3.15c: Astronomy Architecture
Two Moon/Moon Hoon. https://www.archdaily.com/645642/two-moon-moon-hoon

Fig. 3.16: Branches of Natural History

Fig. 3.17: Natural History
https://www.pinterest.nz/search/natural%history

Fig. 3.18a: Natural History Architecture
American Museum of Natural History. https://www.amnh.org/about-the-museum

Fig. 3.18b: Natural History Architecture
Natural History Museum of Denmark. https://snm.ku.dk/english/

Fig. 3.18c: Natural History Architecture

Fig. 3.19: Branches of Marine Sciences

Fig. 3.20: Marine Sciences
https://www.pinterest.nz/search/marine%science

Fig. 3.21a: Marine Science Architecture

Fig. 3.21b: Marine Science Architecture

Fig. 3.21c: Marine Science Architecture

Fig. 3.22: Branches of Technology

Fig. 3.23: Technology

Fig. 3.24a: Technological Architecture
Milwaukee Art Museum . https://mam.org/

Fig. 3.24b: Technological Architecture
Bahrain World Trade Center. https://www.bahrainwtc.com/content/about-bahrain-world-trade-center

Fig. 3.24c: Technological Architecture
List of Figures

Chapter 4
Fig. 4.1: Exploratorium
Fig. 4.2: Exploratorium Zones
Fig. 4.3: Exploratorium Features
Fig. 4.4: Exploratorium Views
Fig. 4.5: Exploratorium Circulation
Fig. 4.6: Exploratorium Entry Points
Fig. 4.7: Exploratorium Natural Light
Fig. 4.8: Exploratorium Expression
Fig. 4.9: Exploratorium Interaction
Fig. 4.10: Exploratorium Section
Fig. 4.11: California Academy of Sciences
Fig. 4.12: Cali. Academy Zones
Fig. 4.13: Cali. Academy Features
Fig. 4.14: Cali. Academy Views
Fig. 4.15: Cali. Academy Circulation
Fig. 4.16: Cali. Academy Entry Points
Fig. 4.17: Cali. Academy Natural Light
Fig. 4.18: Cali. Academy Expression
Fig. 4.19: Cali. Academy Interaction
Fig. 4.20: Cali. Academy Section
Fig. 4.21: Ontario Science Centre
Fig. 4.22: Ontario Science Centre Zones
Fig. 4.23: Ontario Science Centre Features
Fig. 4.24: Ontario Science Centre Views
Fig. 4.25: Ontario Science Centre Circulation
Fig. 4.26: Ontario Science Centre Entry Points
Fig. 4.27: Ontario Science Centre Natural Light
Fig. 4.28: Ontario Science Centre Expression
Fig. 4.29: Ontario Science Centre Interaction
Fig. 4.30: Ontario Science Centre Section
Fig. 4.31: The City of Arts and Sciences
Fig. 4.32: C.A.S Buildings
Fig. 4.33: C.A.S Buildings
Fig. 4.34: C.A.S Site Map
Fig. 4.35: C.A.S 3D Map
   https://www.pinterest.nz/search/City%of%arts
Fig. 4.36: Eden Project: Interior/Exterior
Fig. 4.37: Cité des Sciences et de l’Industrie: Interior/Exterior
Fig. 4.38: Abu Dhabi Central Market: Interior/Exterior
Fig. 4.39: The Blur Building: Interior/Exterior
Fig. 4.40: California Sciencenter
Fig. 4.41: Melbourne Museum
Fig. 4.42: Griffith Observatory

Fig. 4.43: Spyscape

Fig. 4.44: 911 Memorial Museum

Fig. 4.45: Guggenheim Museum

Chapter 5

Fig. 5.1: Circulation

Fig. 5.2: Transition Zones


Fig. 5.3: Technology

Fig. 5.4: Facades
List of Figures


Fig. 5.5: Earth Science

Fig. 5.6: Marine Science
Unique Angles. 2018. matadornetwork.com/trips/worlds-aquariums/

Fig. 5.7: Astronomy

Planetarium. 2017. https://supernova.eso.org/about/planetarium/

Fig. 5.8: Life Science

Chapter 6

Fig. 6.1: Site Considerations
Fig. 6.2 - 6.4: Site Boundaries
Google Earth Imagery, Auckland CBD,

Fig. 6.5: Key Locations
Fig. 6.6 - 6.9: Site Views
Fig. 6.10: Auckland Context
Google Earth Imagery, Auckland CBD,
Fig. 6.11: Site Context
Fig. 6.12: Public Routes
Fig. 6.13: Student Walking/Cycling Routes
Fig. 6.14: 3D Site Plan
Fig. 6.15: 3D SECTION A-A
Fig. 6.16: 3D SECTION B-B
Fig 6.17: Potential Design Areas
Fig. 6.18: SECTION C-C

Chapter 7
Fig. 7.1: Science Centre
Fig. 7.2: Visitor Journey Stages
Fig. 7.1: Project Journey Map

Chapter 8
Fig. 8.1: Establishing Sciences Fig.
Fig. 8.2: Programme and Strategies
Fig. 8.3: Site Boundaries
Fig. 8.4: 3D Site Boundaries
Fig. 8.6: Existing Routes
Fig. 8.7: Proposed Routes
Fig. 8.8: Proposed Routes & Zones
Fig. 8.9: Site Zones
Fig. 8.10: 3D Zone Map
Fig. 8.11 – 14 : Site Views
Fig. 8.15: Zone Connection Map
Fig. 8.15: 3D Multi-Level Zone Connection
Fig. 8.16-19: Masterplan Sketches
Fig. 8.20: Refined Design (Work In Progress)
Fig. 8.21: Refined Masterplan (Work In Progress)
Fig. 8.22: Spatial Diagrams
Fig. 8.23: Sketch (Work In Progress)
Fig. 8.24: Perspective (Work In Progress)
Fig. 8.25: Marine/Geology Centre Features (Work In Progress)
Fig. 8.26: Section (Work In Progress)
Fig. 8.27: Sketch (Work In Progress)
Fig. 8.28: Perspective (Work In Progress)
Fig. 8.29: Central Hub Features (Work In Progress)
Fig. 8.30: Ecology 3D Concept (Work In Progress)
Fig. 8.31: Perspective (Work In Progress)
Fig. 8.32: Ecology Spatial Diagram (Work In Progress)
Fig. 8.33: Sketch (Work In Progress)
Fig. 8.34: Astronomy 3D Concept (Work In Progress)
Fig. 8.35: Sketch (Work In Progress)
Fig. 8.36: Astronomy Spatial Diagram (Work In Progress)
Fig. 8.37: Perspective (Work In Progress)
Fig. 8.38: Academic Gateway (Work In Progress)
Fig. 8.39: Academic Gateway (Work In Progress)
Fig. 8.40: Concept Lightweight Bridge Structures
Fig. 8.41: 3D Concept Bridge Perspective (Work In Progress)
Fig. 8.42: Albert Park Tunnel Section
Fig. 8.43: Underground Access Concept
Fig. 8.44: Lowline
Fig. 8.45: Masterplan (Work In Progress)
Fig. 8.46: Masterplan Perspective (Work In Progress)
Fig. 8.47: Masterplan Section (Work In Progress)
Visited Precedents

- Auckland (NZ)
  - Auckland War Memorial Museum
  - Auckland Zoo
  - Auckland Art Gallery
- Wakana (NZ)
  - Puzzle World
- Melbourne (AUS)
  - National Gallery of Victoria
  - Melbourne Museum
  - Melbourne Science Works Museum
- Oklahoma (USA)
  - Science Museum Oklahoma
  - Oklahoma City Museum of Art
- San Francisco (USA)
  - Exploratorium
  - California Academy of Sciences
  - Aquarium by the Bay
- Toronto (Canada)
  - Ontario Science Centre
  - Aga Khan Museum
- Los Angeles (USA)
  - California ScienCenter
  - Griffith Observatory
- New York (USA)
  - Spy Scape
  - American Museum of National History
  - 9/11 Memorial Museum
  - Guggenheim Museum
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