Development and application of a framework for managing school buildings: A case study in New Zealand

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Abstract:

Managing school buildings is critical for any community because the buildings are not only supposed to provide a pleasant and safe environment for staff and students, but they are also a clearly visible representation of the education system. Therefore, it is important to ensure that school buildings are well managed through their life cycle. However, managing school buildings is challenging due to various reasons. This study aims to develop a framework that can help solve challenges in managing school buildings and illustrate the benefit of this framework using schools in New Zealand as a case study. The primary data of this research was collected through 34 semi-structured interviews with schools' top managers in two phases: Phase 1 (16 interviews) to identify the challenges that schools are facing in managing their buildings; Phase 2 (18 interviews) to verify and validate the new framework for managing school buildings in NZ. The findings reveal that building maintenance in NZ lacks a shared vision, competent people, resources, information management, and performance evaluation. The findings of this study contribute to the broader discussion of managing existing buildings by promoting communication, training, information collection, and lesson sharing. This study also proposes recommendations on how to implement the framework to achieve effective and efficient management of school buildings. Findings of this study can be used as guidance for school stakeholders to manage their buildings effectively and can be adjusted to be used for other types of buildings.

Keywords: school building, maintenance, asset management, ISO 55000

1. Introduction

1.1 Research background

Any organisation, large or small, in any sector, public or private, needs to understand why asset management matters and the value maintenance management brings to its business. Asset management for built assets involves balancing operations, maintenance, economics, and engineering to provide the most cost-effective and sustainable solutions over their whole life cycle (The Institute of Asset Management, 2015). Maintenance is an essential and critical part of asset management which helps guide the physical performance of the assets and aims

to optimise the management of physical assets throughout their life cycle (Komonen and Despujols, 2013). Maintenance management contributes to an organisation's physical and financial well-being by extending the life span of existing buildings and maximising their life cycle costing (Krstić and Marenjak, 2017). Polenghi et al. (2021) argued that maintenance is a pillar of asset management, and it is not only aiming at achieving the organisation's objectives but also influencing and determining their long-term strategies.

The understanding of the principles of asset management has developed significantly over the last decade and several approaches, standards, and models have been developed worldwide. The UK based Institute of Asset Management (IAM) collaborated with relevant stakeholders and experts in the field developed a publicly available specification (PAS 55) for the optimised management of physical assets which was first published in 2004 and updated in 2008 (PAS, 2008). PAS 55 was a widely accepted standard for asset management in many sectors globally. In 2014, it was replaced by the ISO 55000 series developed and published by The International Standards Organization (ISO). This series consists of ISO 55000, ISO 55001 and ISO 55002. The first document, ISO 55000, provides an overview of the standard with a definition of principles and terminologies of asset management. ISO 55001 contains the requirements for asset management and ISO 55002 contains the guidelines to apply ISO 55001 (International Organization for Standardisation, 2014). ISO 55001 asset management requirements are consistent with the fundamentals of asset management in the form of clauses in different group of requirements including organisational environment, supporting elements, planning, implementation, evaluation and improvement processes. ISO 55000 described the benefits of adopting the standards and asset management objectives can be achieved consistently and sustainably over time. Various studies have analysed the added value and the need to implement ISO 55000 framework in asset management including maintenance management (Albalghouni et al., 2018, Ruiter, 2015). The ISO 55000 allows organisations to develop asset management approaches that match their specific needs (Blackett, 2015)

Another set of international standards for maintenance management is the European Standard, CEN/TC319/WG10, maintenance within physical assessment. This standard introduces physical asset management as a framework to specify the relationship between organisational strategic plans and maintenance management system (The European Committee for Standardization (CEN), 2014). Similar to the ISO 55000 framework, the processes in the CEN maintenance management loop includes objectives and strategies, planning, implementation, reporting and analysis of results, improvement, modification and resources. The CEN-based framework has been developed for production industries such as

hydropower, food and producing goods and services (Roda and Macchi, 2018, Holgado et al., 2015). Since the mentioned standards have similar core processes, this study will examine the application of ISO 55000 framework only for managing built assets in schools.

Amongst built assets, school buildings are considered fundamental elements for the development of any community. The buildings and infrastructure are not only supposed to provide a pleasant and safe environment for staff and students, but they are also a clearly visible representation of the education system that can either increase or diminish the public's confidence in the education system (Abdelhamid et al., 2013, Trachte and Herde, 2015, Wijayasundara et al., 2020). Failure to maintain school buildings may lead to budgetary reductions in future investments in the public education system (U.S. Department of Education, 2003).It is crucial to ensure that school buildings are well maintained through proactive management. In order to identify the effective ways to maintain school buildings, research has focus on different aspects of school asset management. Studies ranges from improving performance and conditions of school buildings, focusing on thermal comfort, indoor air quality (Fisk, 2017, Bennett et al., 2019, Kanama et al., 2023), building condition and student's performance (Korsavi et al., 2022), energy performance (Di Giuda et al., 2015, Grassie et al., 2023, Mohamed et al., 2021), condition assessment (O'Reilly et al., 2019), refurbishment and renovation (Guo et al., 2014, Pereira et al., 2015, Bugenings et al., 2022, Elkhapery et al., 2021), and maintenance management processes (Mostafa et al., 2021, Le et al., 2020, Le et al., 2022). Many of these studies is the persistence of a poor quality maintenance management practice in public schools due to limited budget, lack of holistic management framework and major knowledge gaps in the current state of school buildings condition (Lavy and Bilbo, 2009, Dickerson and Ackerman, 2016, Ibrahim et al., 2016, Herath et al., 2023).

1.2 Understanding ISO 55000 framework

ISO 55000 framework contains requirements that any asset management system must have that encourage proactive maintenance of assets (Ihemegbulem and Baglee, 2016). ISO 55000 framework provides an international standard for the development of an asset management framework that is based on global asset management practical experience and methods (Konstantakos et al., 2019). However, the series mainly contains guidelines on "what you must have", so organisations need to determine the best way "how to achieve" the standards themselves (Van den Honert et al., 2013). Therefore, the application of ISO 55000 framework in asset management varies across organisations depending on their business, resourcing strategy, asset management objectives, leadership and availability of competent people

involved. Thus Heitz et al. (2016) developed an asset management decision-making model based on the general concept of ISO 55000 that considers both the cost and the value contribution of an asset in an asset portfolio in an electrical supply network. At the same time, Saunders (2016) developed a central management framework for asset management for the renewable energy industry that aligns with ISO 55000 requirements to optimise asset performance. Using a similar approach, Roda et al. (2016) developed an effective value-based asset management system for a production company to quantify asset value.

Regarding maintenance management, da Silva et al. (2019) developed a novel framework for maintenance management by translating the technical requirements set out in the ISO 55000 standard to the maintenance stage of asset management through five main processes: "Define scope", "Plan actions", "Implement actions", "Evaluate performance" and "Improve process". Although challenges of adopting the ISO 55000 framework for asset management have been identified (Nowakowski et al., 2017, Albalghouni et al., 2018), results from a survey conducted by Alsyouf et al. (2021) revealed that ISO 55000 framework has a positive effect on critical perspectives of an asset management framework (financial, customer, business processes, and learning and growth). The findings indicate that organisations that adopt ISO 55000 framework can improve the performance of their system. Therefore, this study aims to develop an ISO 55000-based framework for improving performance of managing school buildings. A detailed explanation of ISO 55000 standards will follow.

Figure 1 illustrates the requirements of ISO 55000 framework to build a successful asset management system. The requirements were categorised into six aspects of the asset management system of an organization, including the organizational environment, planning processes, operational processes, support requirements, evaluation processes, and improvement processes. The groups of requirements are discussed according to the requirements of the ISO 55000 framework below:

- Organisational Environment

This part lists the requirements for developing asset management objectives. All external and internal issues which affect asset management, such as regulations, and the specific organizational context, are identified. The stakeholders' needs and expectations are also prioritised to understand what they expect from asset management. Then, an asset management policy is developed to provide a set of principles for managing the assets.

- Support Elements

ISO 55000 framework provides a list of factors that can facilitate the intended asset performance of the organisation. Thus, it is suggested that the organization should identify all resources needed to deliver the asset management plan, for instance, the budget, people, and equipment, and pinpoint any constraints between the organization's capabilities and the resources needed. Among the resources, competence is one of the critical support elements. Competence refers to the knowledge, skills, experience, and attitudes of people involved in asset management activities. The organisation needs to identify its current competencies and any further training requirements. Furthermore, a communication plan covering all internal and external communications is one of the support elements to ensure that the correct information will be transferred to the right people at the right time. The organization needs to decide which information needs to be collected, recorded, and managed to help the organization analyse the current situation and make informed decisions.

- Planning process

The organisation establishes its asset management plans to achieve its objectives and describes the structures, roles, and responsibilities necessary to achieve them. Identification and assessment of related risks and opportunities are also considered in this stage, and any planned changes should be assessed before the change is implemented.

- Operation process

The organisation determines which activity will be outsourced and how to control the outsourcing process. For other activities implemented within the organization, all criteria for the required processes, including inputs, outputs, as well as control elements and mechanisms, need to be established. The top management of the organisation considers which is the most effective delivery method to achieve the intended outcomes under the resources allocated.

- Evaluation process and Improvement process

The purpose of monitoring and evaluating the performance of assets and asset management is to ensure that the processes have been carried out as planned and that the outcomes meet the stakeholders' expectations. The information collected in these processes aims to improve asset management performance. The organisation will determine what needs to be monitored and measured, when to monitor and which methods and criteria to apply. The processes will generate lessons when incidents occur and how to minimise the effects.

Preventive actions will be developed to avoid the same issues in the future. Further measures to improve the effectiveness of asset management are considered.

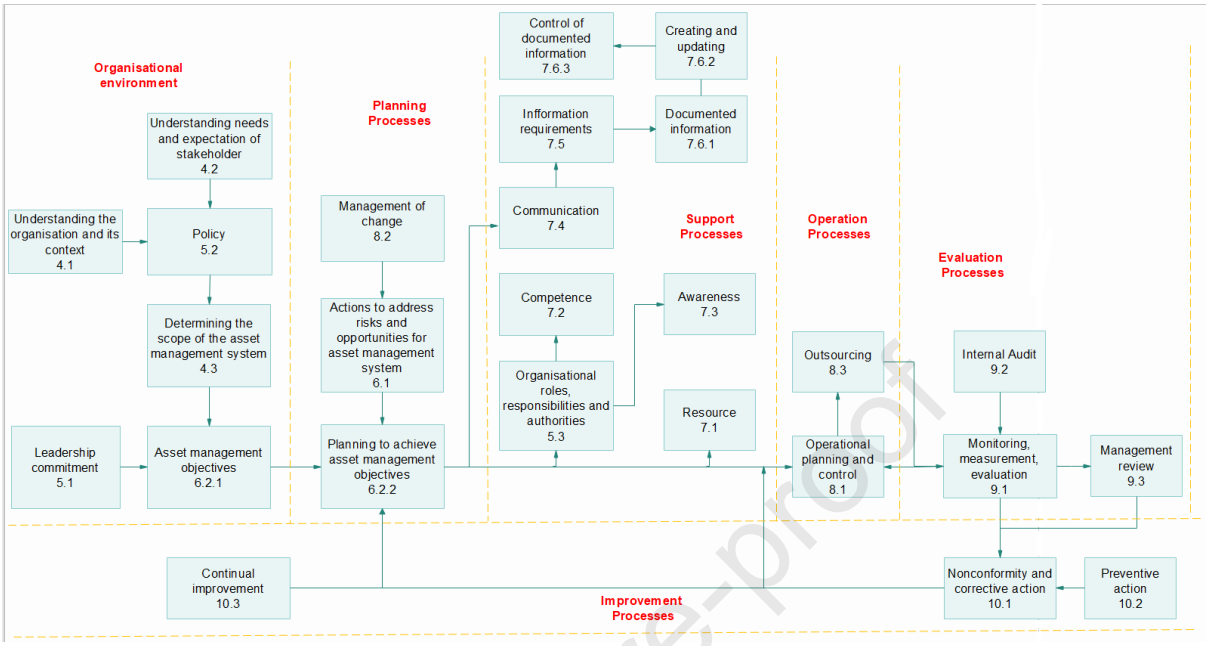

Figure 1: ISO 55000 requirements. Adapted from Lifetime Reality Solution (2014)

1.3 Managing school buildings in New Zealand context

The school property system in New Zealand (NZ) is owned by the Ministry of Education (MoE) and it is the second largest social property portfolio in NZ, with nearly 2,100 state schools and more than 15,000 buildings. Among them, more than 33% of buildings were first built more than 50 years ago (MoE, 2019) and nearly one billion NZD of capital expenditure was spent on school property in 2018/2019. Each state school in NZ is required to develop a short-term and long-term property plan, called the 10-Year Property Plan (10YPP), to identify capital projects and maintenance work to ensure that the school property is fit for purpose (Controller and Auditor New Zealand, 2017). According to guidance on the Ministry of Education's website, building maintenance work in state schools are covered by one of three funding sources from the MoE: 5-year agreement funding (5YA), property maintenance grants (PMG), and operational grants (OPG) (The Ministry of Education (MoE), 2021). Once the 10YPP is approved, 5YA funding will be signed off every five years for schools to implement the identified projects.

Regarding short-term maintenance, PMG is funded annually for schools to spend on painting, minor replacement, minor repairing, and minor ground and site maintenance such as replacing a small section of a broken water pipe or minor repairs to floor covering. PMG is

calculated based on the size of the school, such as the total area of buildings. The operational grant covers day-to-day expenses such as cleaning, rubbish disposal, pool chemicals, grass cutting, utilities (heat, light, water), maintenance of furniture and equipment, and repairing damage caused by vandalism. The operational grant is calculated based on the number of students enrolled in the schools each year.

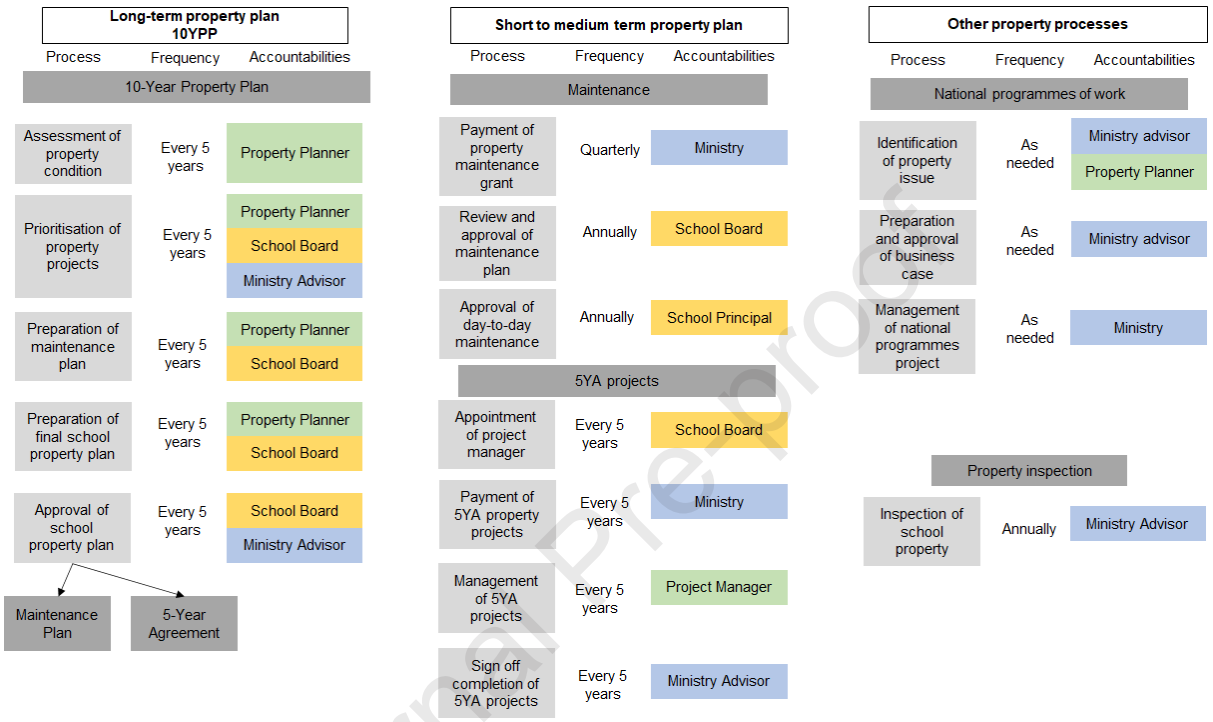

Figure 2: Managing school property in NZ. Source (Controller and Auditor New Zealand, 2017)

Figure 2 illustrates the activities and relationships of the people involved in managing school property in NZ summarised by Controller and Auditor New Zealand (2017). The MoE has developed a semi-devolved property management model in which they operate in partnership with schools to deliver school projects. The funding mechanism, responsibilities, process and procedures are published, and guided the people involved to do their jobs and ensure effective and efficient management of school assets. There are three different strategies in the process in three columns: long-term property plan, short to medium-term property plan and other property processes. In each column, processes, frequency of process, and accountabilities are presented. Some processes are implemented by one party, while others require the collaboration of different parties. In the current process, schools employ external consultants (project managers and property planners) to deliver specific tasks, with guidance and support of the Ministry property advisors. Project managers and property planners are external specialists and need to be pre-approved by the MoE to ensure that the

consultants meet all legal and the Ministry requirements and have an appropriate skill level for the job.

1.4 Problem statement

The School Property Strategy 2030 (SPS2030), it is estimated that, by 2030, 100,000 additional student places are needed in some areas in New Zealand. The strategy also highlighted the effective management of school buildings is crucial for every school and wider communities (The Ministry of Education (MoE), 2021). However, the SPS2030 and previous studies acknowledges that managing school buildings is facing many challenges and threats due to different building ages, building designs, inconsistent maintenance practices and lack of resources (MoE, 2019). Therefore, developing a novel model which can improve current practices and optimise the investment is vital.

This study aims to address the issues by first identifying and exploring the challenges faced by school managers to then develop a new framework that can improve current practices and help school achieve the school property strategy. Findings of this study can provide insights into the problems so that stakeholders can review their management system to identify the needed improvement process. The framework can be used as a guideline for any school to help them manage their school buildings effectively. The results of this study can be adapted and used by any organisation who wants to improve their asset management.

2. Research method

As illustrated in Figure 3 below, this research study has three objectives, namely to identify the current challenges school managers face, develop a new framework to address these challenges, and validate the new framework. As understanding the challenges required in-depth insights into the reality of managing school buildings, a qualitative data collection approach using a combination of interviews with experts and a literature review was chosen (Fellows and Liu, 2021, Creswell and Creswell, 2017). The interviews covered a range of themes that had emerged as relevant from the literature survey. Moreover, the semi-structured format offered the freedom to explore new ideas and delve deeper into issues that were raised by school managers. This method has been used widely to achieve similar objectives in previous studies (Azlan et al., 2016, Xaba, 2012). The new framework was developed based on the findings from the first part. The similar qualitative design has been applied to similar studies in this field (Abuimara et al., 2021, Hauashdh et al., 2022, Galvin, 2015).

The primary data of this research was collected through semi-structured interviews with schools' top managers. Interviews were conducted in two phases: phase 1 interviews were designed to identify the challenges that schools are facing in managing their buildings; phase 2 interview sought to verify and validate the proposed framework for managing school buildings in NZ. Once the challenges had been identified, a new framework was developed to minimise the challenges. How the framework was developed is discussed in Section 4. While there are other ways to validate the framework such as using a case study or action research approach, time restrictions meant that it was not possible to run through an entire cycle within the scope of this project. Therefore, this study used the semi-structured interviews with experts for the framework validation. Interviews have been successfully used for validating frameworks in fields such as construction, health, and education (Phung, 2020, Domingo, 2011, Bao and Lu, 2021, Silverio-Fernández et al., 2021).

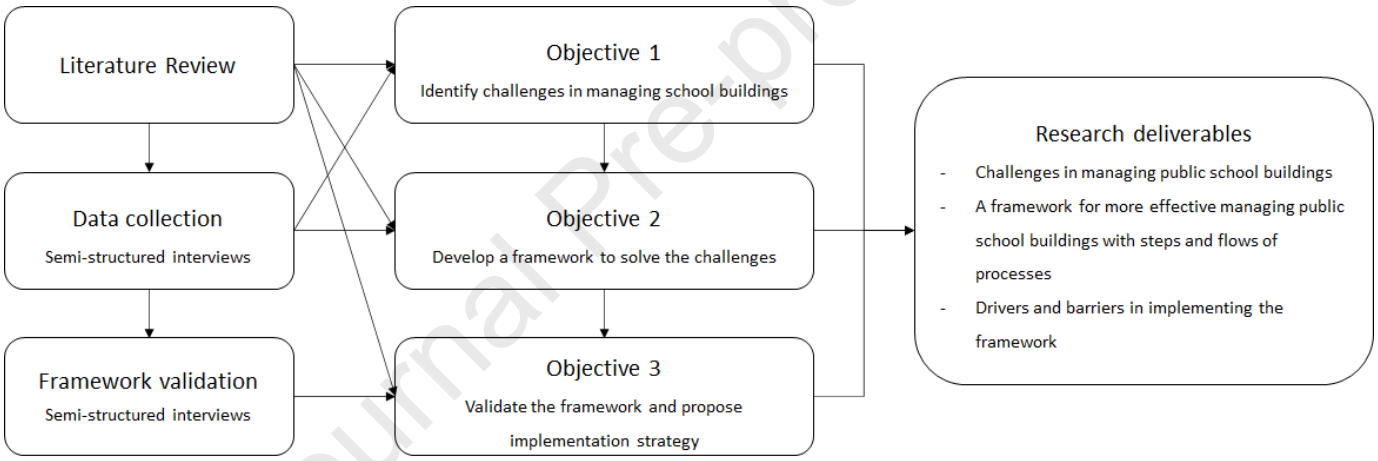

Figure 3: Research design

Purposive sampling was used to select the participants representing schools in this study. Purposive sampling aims to produce a sample that can be logically assumed to be representative of the whole population (Lavrakas, 2008). A list of chosen schools was prepared with specific criteria, including the school's size, location, and number of students enrolled each year. An invitation to participate in this study was extended to principals and executive board of trustee members who were responsible for property matters at their schools. Data collection was stopped when no new information or concept emerged during the interviews suggesting that information saturation had been reached (Creswell, 2013).

In the first phase, sixteen participants from nine secondary schools and seven primary schools agreed to participate in the research. The summary of the participants involved in the interviews, including their role, years of experience, is presented in Table 1. All participants

were executive members of school boards and were involved in the decision-making process of managing school property. Ten had over ten years of experience in school property management, and only two interviewees had less than five years of experience in this field. The semi-structured interviews were conducted face-to-face for three weeks, and each interview took about 45 minutes to one hour to fully explore the current process in place of managing school buildings and identify challenges in managing school buildings in NZ.

Table 1: Background information of interviewees in phase 1

No	Code	Title	Year of experience	School type	School size (students)
1	P1	Principal	Over 10 years	Primary	201-500
2	P2	Principal	5-10 years	Primary	201-500
3	P3	Principal	2-5 years	Primary	201-500
4	P4	Executive board member	5-10 years	Primary	Up to 200
5	P5	Executive board member	5-10 years	Primary	201-500
6	P6	Executive board member	5-10 years	Primary	Up to 200
7	P7	Principal	5-10 years	Primary	201-500
8	P8	Principal	Over 10 years	Secondary	501-1000
9	P9	Principal	Over 10 years	Secondary	501-1000
10	P10	Deputy principal	Over 10 years	Secondary	501-1000
11	P11	Deputy principal	Over 10 years	Secondary	Over 2000
12	P12	Executive board member	Over 10 years	Secondary	1001-2000
13	P13	Executive board member	2-5 years	Secondary	Over 2000
14	P14	Executive board member	Over 10 years	Secondary	1001-2000
15	P15	Executive board member	Over 10 years	Secondary	1001-2000
16	P16	Principal	Over 10 years	Secondary	501-1000

Based on findings in the first phase, an ISO 5000 based framework was developed to help solve the problems and improve the performance of managing school buildings. This framework was validated in the second data collection phase using semi-structured interviews. For this stage, 18 school managers were recruited from the list with a similar sampling technique used in phase 1, targeting different schools. The profile of the participants in the second phase is presented in Table 2. Thirteen interviewees were principals with the highest responsibility for school building maintenance at schools and eight principals had over ten years of experience managing school buildings. Eight participants came from secondary school and ten of them served at primary schools. The validation interview template consisted

of two parts. The first part was a confirmation of the identified challenges and a description of the new framework. The second part aimed to examine the clarity and appropriateness of the proposed framework to solve these challenges and identify a suitable strategy to implement it. All interviews in phase two were conducted online and lasted between 40 and 70 minutes.

The audio-recorded interviews from both phases were transcribed manually. Due to the open-ended nature of the interview questions, the interviewees gave long, unstructured answers, and similar concepts emerged at different places within the transcript. Each transcript was read several times and organised appropriately in order to generate a sense of the information. Interviews were transcribed verbatim, but grammar mistakes were corrected to ensure the readability of the quotes without changing their meaning. The data analysis followed the steps of thematic analysis suggested by Braun and Clarke (2006) as follows:

- First, the whole data set was thoroughly read to shape initial concepts from the data.

- Next, initial codes of data were developed. Any feature concepts/ideas in the text the researcher noticed were labelled in the coding.

- Thirdly, a list of the different codes was sorted into potential themes, and all the codes within the identified themes were collated.

- Step four involved reviewing and refining the themes coded in relation to the entire data set until the list of themes, the relationship between the themes and the story they tell was finalised.

- Finally, the themes were defined and named.

Table 2: Background information of interviewees in phase 2

No	Code	Title	Year of experience	School type	School size (students)
1	V1	Executive board member	Over 10 years	Secondary	1001-2000
2	V2	Executive board member	5-10 years	Secondary	501-1000
3	V3	Executive board member	Over 10 years	Secondary	1001-2000
4	V4	Principal	Over 10 years	Secondary	501-1000
5	V5	Principal	Over 10 years	Secondary	1001-2000

6	V6	Principal	2-5 years	Secondary	201-500
7	V7	Principal	5-10 years	Secondary	501-1000
8	V8	Executive board member	2-5 years	Secondary	Over 2000
9	V9	Executive board member	5-10 years	Primary	501-1000
10	V10	Principal	Over 10 years	Primary	201-500
11	V11	Principal	2-5 years	Primary	Up to 200
12	V12	Principal	Over 10 years	Primary	201-500
13	V13	Principal	2-5 years	Primary	Up to 200
14	V14	Principal	Over 10 years	Primary	501-1000
15	V15	Principal	Over 10 years	Primary	Up to 200
16	V16	Principal	Over 10 years	Primary	Up to 200
17	V17	Principal	Over 10 years	Primary	501-1000
18	V18	Principal	2-5 years	Primary	201-500

3 Challenges in managing school buildings

3.1 Lack of a shared vision

The success of school building projects relies on the collaboration and communication between school, the MoE, and external consultants. However, interviewees commented that schools, the MoE and external consultants have different priorities in relation to property maintenance management at schools. Six participants complained about a lack of maintainability consideration due to inappropriate designs of the MoE- lead projects at their schools. P4, P10, P12, and P14 stated that maintainability had been neglected during the design and construction stage, resulting in difficulties in maintenance operations and extra costs for their schools. P4 and P10 also felt that the design contractors used the same layout and design for schools despite differences in setting and context for each school. This may lead to difficulties in maintenance for some schools. As a result, the tasks may be completed, and the external consultants are no longer involved, but their decisions and actions still impact subsequent tasks, but at this point. This can lead to problems and difficulties in optimising the building management at that school. This highlighted that the shared vision of participants should not only focus on a specific task but also consider objectives over the entire life cycle of school properties. Ten participants raised the issue as they found the long-term plans that their external consultants developed for their schools were inappropriate because the consultants lacked an understanding of school building characteristics and operations as well as end-users' requirements. They felt that plans and projects tended to be aimed at achieving cost effectiveness rather than long-term goals. In the implementation

phase, the Ministry advisors and project managers sometimes had different priorities, which can confuse the school boards. P13 provided an example of the types of communication issues that schools face:

"...my project manager and ministry advisor do not work well together around property projects. This makes difficult conversations when trying to move forward with projects, and the two will not sit in the same room. Each gives me separate advice, and I am then required to work backwards and forwards between them...".

3.2 Funding mechanism issues

There are two different funding streams (5YA for major renovation, refurbishment, retrofitting and PMG for maintenance) for managing school buildings and all interviewees complained about how annual maintenance and renewal funding is allocated to schools. Eight participants mentioned that the maintenance of the school property is not effective due to the inappropriateness of the existing formula-based funding model. The current funding system is based on the number of students enrolled and the size of buildings, so it has not been adjusted to respond better to different property types, ages, conditions, and purposes. However, school buildings in NZ range from new to 50-year-old buildings. Some very old buildings with critical issues may need to spend more money on their maintenance than is justified by their size and students compared to a new school.

P4 commented that "the allocation of funding is not equitable. Lack of upgrading continues in old schools, and the money is not sufficient to bring the property in old schools up to required standards". Schools often have to add other sources for the PMG, such as extra income from international student fees and fundraising from the community. However, this is not a suitable way to keep the properties safe and well.

"... an example in 2016, there were toilet blocks that needed new flooring and we could have waited another 12 months and put it onto our 5YA. Then we did not want to wait one more year, so we just paid for it ourselves..." (P2).

"..school board increasingly has to look to their fundraising to cover the work that the 5YA does not cover. The estimate and the real cost do not meet school needs..." (P5).

In terms of the 5YA funding, although the budget is estimated based on the condition assessment and actual needs of schools, issues of using this fund still exist. Schools sometimes have to use the PMG for 5YA and then need to use other funds for maintenance, leading to

an imbalance of funding for regular maintenance. P8 mentioned the issue: "...because for years we were spending property maintenance money (PMG) fixing leaky roofs and find money to replace the roof. So, we spent a lot of money maintaining this, while the roof actually would be 5YA to replace years ago, but it just did not happen..." (P8).

"...schools are not funded sufficiently for property maintenance, so we are taking money from the money that's been allocated to the school for teaching and learning programs to maintain the property. My personal view is we would not be able to maintain the school on what the Ministry gives us..." (P9).

Although schools can apply for more funds for the additional cost and a maximum of 50% of the allocated budget can remain available for two years, the preventive and condition-based maintenance plan has not been implemented successfully. Two participants said, "it usually takes months or years for the extra fund to be provided". It may cause a delay in the project and generally influence the maintenance programme.

Another concern noted during the interview is that although all schools have to follow the Ministry's processes and guidelines, schools may have their own way of using the property maintenance grant (PMG). The PMG is a part of the operational grant, and schools receive it yearly, so they put aside a certain amount of money for cyclical maintenance (mainly exterior painting) each year, and after 7 to 10 years, they can use the money for the painting. However, P15, P9, and P1 reported that "PMG does not have enough for that". P2 reported that "some schools just use money in PMG, which needs to be set aside for painting or other work in future years for reactive or other things such as learning purposes". P5 and P9 mentioned that most of the PMG at their school was used for their caretakers' wages and ground maintenance, and "it usually exceeds the amount of money that we get for PMG" (P9). Due to the maintenance funding being spent on other purposes, a deferral of maintenance will occur, reducing the quality of properties and increasing maintenance costs in the long run.

3.3 Lack of competence

All the primary principals in the interviews pointed out that while they all agreed that building management is important, but it is the most pressing management task. They find it difficult to stay on top off other tasks because most of school principals and boards are not specialist in property and maintenance management. P5 claimed that "dealing with property matters is the burden on our school board", while P1 stated that "it would be great for school boards if maintenance management can be centrally managed by a regional agency or the Ministry". Therefore, in the existing model, the success of property projects and maintenance

management depends mainly on the capability of external consultants This is especially true for new principals, as P3 pointed out:

"...as a beginner principal dealing with the whole management of the school and then property on top has been a very hard task, and I have just survived the year and paid very little attention to the property, being very reliant on the experts around me and putting trust in their knowledge..." (P3).

However, according to P4, "there is a lack of competent and qualified property planners and project managers". Not only P4 mentioned these challenges, P8, P10 and P15 agreed that a lack of capabilities of people involved is one of the main barriers to the effective management of school properties.

Another issue in human resources is the frequent turnover of some key participants. MoE advisors change regularly as P14 and P11 noted that they have been working with many MoE advisors over the years. These changes cause projects to slow down since it takes time for the new staff to understand the schools' context and property conditions to provide valuable advice.

During the interviews, the participants expressed that their schools try to schedule their maintenance tasks at suitable times, usually during school holidays, to avoid interrupting school life. However, as P1 pointed out, sometimes schools cannot find a project manager (PM) for 5YA projects or local service providers for maintenance tasks during the school breaks, as it has become a peak season for PMs.

3.4 Lack of information management

In the current model, school board, MoE regional advisors and external consultants need to work together to maintain school buildings. The key parties, however, are based at different locations and offices, and as a result, the school building maintenance is a fragmented process that could only work if there was effective information management and exchange to ensure the information needed is kept up to date and accurate. However, eleven participants reported experiencing difficulties getting historical information on school building projects.

At the national level, the information system is operated and managed by MoE. For 5YA projects, a centralised condition assessment system was developed to collect data on the condition of school properties. P5 mentioned during the interview that "you can see how much is being spent in the system, we can show these are the projects that have been

completed and what is still on hold". This system was designed to monitor the budget as it provides both schools and the Ministry with information on the property status and cost of maintaining the property on a school-by-school basis. However, it is usually kept in reports of external consultants and contractors. P11 pointed out that the high turnover of MoE advisors and external consultants further contributed to a loss of both explicit and tacit knowledge due to the lack of a formal feedback collection among the stakeholders.

At the school level, maintenance data is updated by reports, emails, and verbally in meetings which are then documented manually. Only P11's school has been using a computerised property database; other schools have not used a standard system for information management of maintenance issues and tasks. There is a lack of policies, tools and procedures from the MoE supporting information management at the school level. The property needs of schools are not well considered because of the lack of information management.

3.5 Lack of performance evaluation

The respondents were asked about how project performance was evaluated once a project had been completed. All respondents stated that their schools observe and measure the performance mainly based on maintenance reports submitted by the contractors as "no one in our school does the task as we have no expertise" (P3). Moreover, "no post-evaluation or backup support" was provided according to P1 and P11. The feedback loop between the schools and the MoE is mostly inactive as the review of current 5YA projects will only be done after year three and mainly focus on monitoring the allocated funding.

Another concern that the participants raised in the interviews is the accuracy of the estimated cost of the projects in comparison to the actual cost. Budget estimations are led and calculated by external consultants. Nine participants agreed that the estimation should cover the annual increase in prices over the five years. P9 provided an example: "we only were able to complete two-thirds of our plan because price rises took up the other one-third of the budget". The funding has not been adjusted to reflect the increased costs associated with the school's context. Therefore, not all 5YA projects can be implemented as projected and only some projects can be completed in the scheduled years. Consequently, failure may occur, increasing the reactive and corrective maintenance cost and total maintenance cost as well. Since performance evaluations and feedback on completed projects is not collected by MoE, there is no official channel for schools to communicate their issues, resulting in the maintenance of the status quo/ and as a result no improvements to the process are made

4. A framework for managing school buildings

4.1 Developing a framework for managing school buildings

Findings in the first data collection phase identified four main challenges and an ISO 55000 based framework was developed to solve these challenges. The proposed framework uses the current planning and implementing processes in managing school buildings and further added three more processes: Establish-Plan-Implement-Evaluate-Improve (E-PIE-E is shortened to PIE). The purpose of the first step Establish is derived from the organisation elements and support elements of the ISO 55000 framework to solve the lack of a shared vision issue. Therefore, activities in Establish aim to promote training, understanding, and engagement of the stakeholders, in order to create a shared vision between the stakeholders and enhance the team's capability. The Ministry establishes and develops the strategies (A11), while all people involved have to understand all the policies to do their jobs (A12). Alongside understanding official MoE's policies, people involved also need to understand the specific school context and the school's development plans (A13) in order to produce and develop appropriate plans and implement the approved projects effectively.

Along with the current training courses provided by the Ministry, those involved should attend ongoing training programmes to help them understand roles, responsibilities, accountabilities and communication in the managing school building process. Such training programmes should also provide up-to-date required competencies for maintenance management and reflect the industry best practice standards. Training documents, and reflections on performing the tasks should be stored online, which would enable all stakeholders to access them at any time. The activities in Establish ensure that the people involved in the process share a vision, build the trust with each other, and be ready to perform their jobs.

The Plan and Implement sub-processes proposed in the PIE framework are mainly based on current activities but provide more detail. The first activity of the Plan and Implement sub-processes was added to promote a shared vision among people involved in specific tasks. The key improvement of this Plan process compared with the current model is collecting feedback, evaluating performance, and capturing knowledge after each activity, ensuring accountability for decisions made. Although the proposed model cannot change the current funding mechanism, the activities suggested for the Improve and Evaluate stages can help the Ministry understand the way schools use the budget for their building projects and can adjust their budget accordingly. Hence, data on school building projects should be systematically captured and stored at both the MoE and school levels. The data provides a database of maintenance costs for the occupancy of schools and then can be used to figure out what

factors affect maintenance costs. For example, schools located near a coast or rural schools should receive a larger budget for their maintenance as the weather condition can accelerate natural building deterioration and lack of service providers in their areas. Accordingly, the MoE can use this information to review its policies for funding, such as by considering a school's location in their budget allocation.

The Implement stage captures two types of implementation: property projects (A3) and maintenance work (A3'), as shown in Figure 4. The main difference between the two types of implementation is that the management of property projects tends to require an external project manager who oversee a number of steps, while schools can manage the maintenance work themselves. The proposed framework highlights the connections between 5YA projects and maintenance work because, except for urgent repairs, maintenance work should be prioritised and accompanied by 5YA programmes to maximise the effectiveness of a sequence of work. For instance, if there is a roof replacement project in the 5YA list, schools can consult with the project manager to reschedule gutter clearing/roof checking/minor repairs in their maintenance tasks.

The Evaluate and Improve stages have similar purposes as the evaluation process in the ISO 55000 framework in that both aim to solve the challenges caused by a lack of information management and an evaluation process. The A4-Evaluate and A5-Improve stages can be completed at any stage following the processes identified in Figure 4. The information feedback system should be well organised to detect issues early and react to the issues effectively (A41). The collection of information in a centrally accessible repository would help eliminate information gaps caused by a high turnover of staff. All issues, disputes, defects and responses to them during and after project implementation need to be communicated to relevant stakeholders and recorded in the project file. The MoE's policies regarding performance evaluation guide the team about what needs to be evaluated, when the evaluation will be performed, and the methods of criteria of the evaluation. Evaluation reports can be reviewed in a stakeholder meeting to identify lessons from the completed projects (A43). The feedback collection, performance evaluation and lesson analysis should be performed at the project, regional, and portfolio levels.

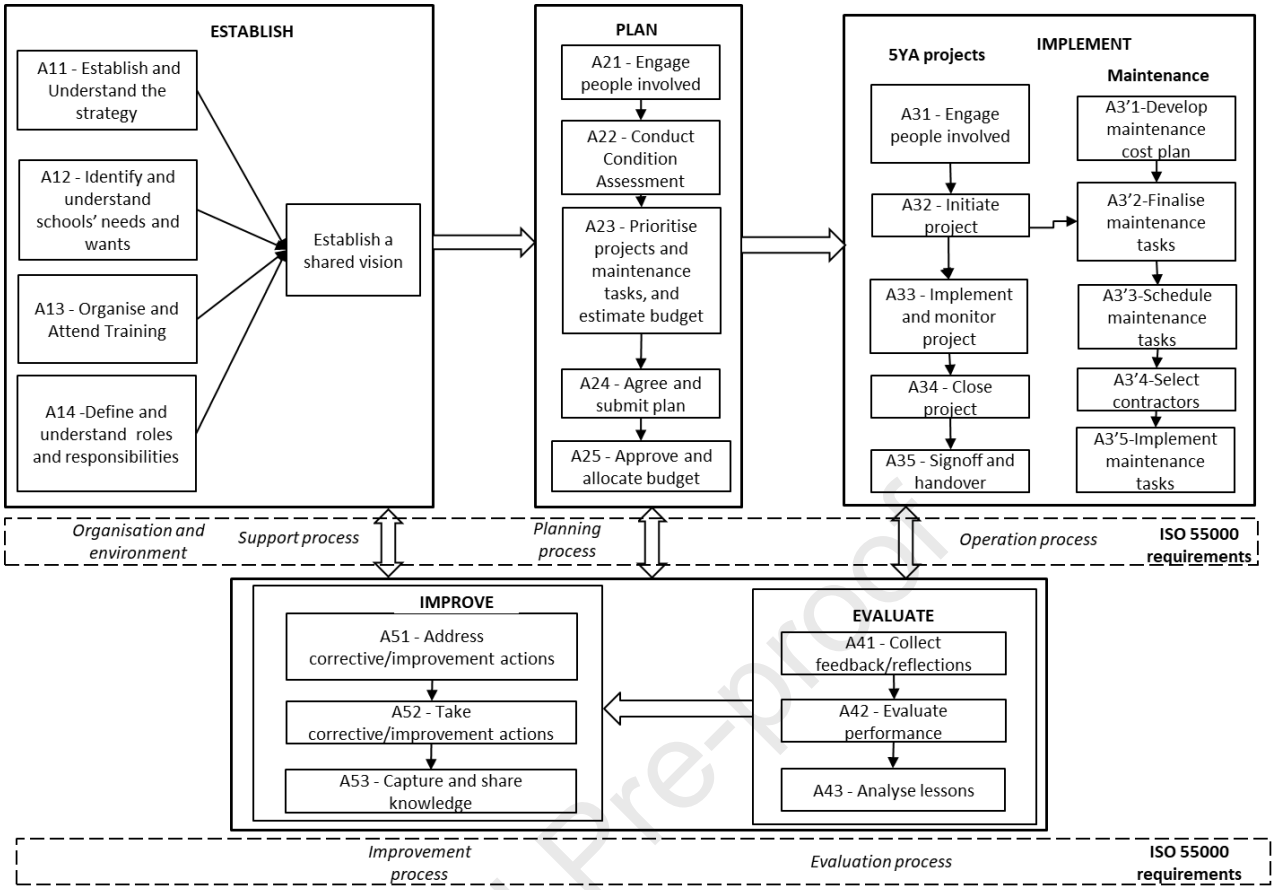

Figure 4: Proposed framework for managing school buildings

Outputs of A4 are identification of corrective and improvement actions (A51). Once lessons and improvement actions are identified, knowledge should be captured by both the school and the MoE (A53). A combined collection of reports, feedback, and lessons could form a knowledge management system for managing school buildings and provide a national database of all the problems NZ schools have encountered with regard to building maintenance as well as the solutions used to address these problems. This proposed database could also help the MoE figure out what schools need the most, what tasks and at what property money should be spent, and quickly respond to any changes needed to implement their long-term strategy. Access to the system would also help schools or the Ministry advisors to compare the maintenance workload at one school with other local schools/teams and find shared resources for solutions. Thus, those involved may share solutions or contacts of contractors with their neighbour schools.

4.2 Advantages and barriers of the PIE framework implementation

In the second phase, to further assess the potential implementation strategy for the PIE framework, participants were asked to discuss how the framework could be implemented. At

the end of the discussion, participants were asked to rate the framework logic and clarity, advantages and barriers to implement the framework. The first question was about the logic and clarity of the PIE framework. The respondents were asked to rate their level of agreement with statements on the logic and clarity of the PIE framework from 1 (strongly disagree) to 5 (strongly agree). The results are displayed in Table 3, which indicates that the majority of the respondents (above 90%) either “agree” or “strongly agree” with the logic and clarity of the framework.

Table 3: Logic and clarity of PIE framework

Statement	1	2	3	4	5
The structure of the proposed framework is clear	0	0	0	77.8%	22.2%
The contents presented in the framework are precise	0	0	5.6%	61.3%	33.3%
It is easy to follow the processes and sub-processes of the framework	0	0	5.6%	61.3%	33.3%

In the second part, participant discussed the questions “What do you consider the main advantages/main improvements of the framework in comparison with the current practice?”. All respondents addressed different advantages and barriers of the proposed framework and their answers were categorised into groups as described below:

Collecting feedback is a fundamental way to improve. The PIE framework encourages stakeholders to collect, review, and evaluate feedback at any stage. The outcomes of this review provide opportunities for improving individual processes where necessary. Ten respondents mentioned “evaluation” as one of the advantages of the PIE framework. V1 reported:

“...I would say the evaluation step is the key improvement as it is important in the framework. In our school, we do some evaluation but not systematically, just verbally in our meetings with school board members....” (V10).

V4 made a similar comment saying that “...evaluation is not actually currently happening, and I think it is the key improvement of the framework...”.

Some interviewees thought that the ongoing training programme included in the Establish section ensures everyone is on the same page. In reporting the above, one interviewee stated:

"...the training staff development makes sure that everybody fully understands the process and their place within the process, and also improve the accountability. I think that is really important...." (R13).

V6, V12, and V17 highlighted that the critical improvement of the framework is critical as it allows prioritising improvement. The continuous improvement requires resources and efforts to follow a strict and planned schedule. Instead of combining multiple steps, the maturity assessment model addresses the most needed improvement areas, which helps both the MoE and schools avoid potential problems caused by the new approach of management.

The respondents were also asked: "How likely is it that you would use the PIE framework to support your school in managing the maintenance?". Ten participants said they would probably adopt the whole framework or steps/processes related to the work they are involved in. Eight participants stated that they would definitely use the framework in order to improve the effectiveness of managing maintenance at their schools. V2, V3, V9, V11, and V14 indicated that they would like to adopt the activities from the Evaluation and Review stages for their internal improvement.

The respondents also discussed the incentives for implementing the PIE framework. The participants proposed that at the school level, a benefit of introducing the proposed framework was that it would help increase awareness of the long-term property strategy among school board members.

4.3 Barriers to implementing the framework

The respondents were asked in the validation interviews if they could see any potential difficulties or barriers to putting the framework into practice. Thirteen respondents commented that human resources, including lack of time, might be a barrier to implementing this framework. "Understanding", "training", "right people", and "more money" were also mentioned many times in the answers to this question. The framework requires people to share the same vocabulary, understanding, vision, and aims for managing school buildings and examples illustrating this point are provided below:

"...we would need to put a lot of effort into the staff development so that everybody is on the same page and has a clear understanding of how the framework works...". (V13)

"... there are not enough resources at the moment. So more work or communication, more collaboration would be very difficult with the number of people they seem to have...". (V15)

"...all the people should be on the same page. And make sure that training is ongoing. So it is not just one off for one person, it has got to be a team and it has got to be reviewed and renewed constantly because people forget and they go back to old ways.....". (V9)

"...the people would need more time to become familiar with the process or more training to do the evaluation…". (V11)

V11, V12, V15, V3 and V5, on the other hand, believed that money would be the greatest challenge for the implementation of the framework as they could see that it takes more time and effort to upskill people and increase communication among them. They also stated that their schools would need more support should this framework be adopted for the management of their properties. V1, V9, V12, V14, and V17 held the view that "resistance to change would be the biggest challenge" for the implementation. Finally, participants commented that, while schools may be interested in implementing the framework as it promises to benefit them, external consultants and MoE advisors may prefer to leave things as they are because the new regime would increase their responsibilities and workload.

5. Discussion

The PIE framework was developed based on requirements of ISO 55000 framework and the current process of managing school property issued by the Ministry of Education. This section discusses the advantages of the PIE framework that help solve the current challenges of school building maintenance in New Zealand, aligning with relevant findings in the literature review. Findings from the interviews highlighted that the stakeholders lack a shared vision for managing school buildings because they are based in different organizations, have different interests, and perform specific short-term tasks. Abdelhamid et al. (2013) also claimed that the goals and objectives of asset management for educational buildings are often unclear enough and not understood by all stakeholders. The importance of a shared vision was highlighted by both Bouchlaghem (2012) Meng et al. (2011) who both emphasised that a shared vision is key for the successful completion of projects. . Therefore establishing a shared vision is the key output of the Establish phase in the PIE framework ensuring that everyone involved understands their tasks and works towards the shared goal of managing school buildings. . Kamarazaly (2014) agreed that by articulating a shared vision, top management can ensure the value and long-term adaptability of educational facilities. Lee and Scott (2008) further emphasised that a shared vision could minimise gaps between the strategic and

operational levels, which would help improve maintenance operation processes. A shared vision can be established by clearly defining roles and responsibilities, mutual understanding, attending training courses, and promoting communication and commitment.

Participants in the interviews also claimed a lack of qualities and skills of people involved in managing school buildings and strongly suggested that there is a need to increase people capability of carrying out their roles in the process. Researchers agreed that the quality of workmanship, including training, awareness, and competence of employees, has a significant influence on the effectiveness and efficiency in the built environment (Oladotun and Edosa, 2016, Adeyeye et al., 2013). Others stated that trained and knowledgeable staff are critical for maintaining high-performance buildings (Lewis et al., 2010). In other words, knowledge, competence and teamwork have a significant impact on asset management outcomes (The Institute of Asset Management, 2015). Organisations should identify the competencies their staff have and what skills they need to fulfil their job so that appropriate education and training can be provided if needed (ISO 55000, 2014). The implementation of the training programmes (A14) as proposed by the PIE framework would provide a long-term professional development program for people involved. It should not be an on-off event but an ongoing program. An online-based training system should be considered due to the different locations of the stakeholders. An online-based training systems could help the MoE to update the information on property management quickly and participants could review the sessions at any time. Such the online-based training system could also act as a communication channel where people involved could share their experiences and improve trust and engagement in the collaboration.

Kelly et al. (2005) suggested that information is essential at all stages of asset management because information can help improve transparency and reduce conflicts (Shelbourn et al., 2007). Accurate and adequate information about the property condition and its performance enables managers to make informed and practical decisions in the planning stage. This view is also shared by Parlikad and Jafari (2016) and Muyingo (2009), who stated that using historical and real-time data can reduce costs, risks, and failure in asset management. Relating information is essential to perform maintenance tasks properly (G´omez-Chaparro et al., 2020) and make decisions for future renewal alternatives such as renovation or refurbishment. Therefore, the MoE and schools should pay attention to the information management of all maintenance work and make the information accessible for other stakeholders if required. However, the interviewees indicated that there is no well-structured data capture guidelines and information management system in the current model. There is also a lack of support for collecting feedback on the delivery school building projects. The PIE

framework proposes to create a project file at the beginning of each project to collect, store and update all relevant information (A32). This file should include all required reports and establish what type of information should be collected, stored, and shared during the project implementation. At the end of each project (A35, A3'5), the data collected can be used for evaluations. At the school level, it is crucial that schools continuously record and update their maintenance information and report this information to the MoE.

Findings from interviews also reveal that there is no official performance evaluation, collection of feedback, or sharing of lessons at the school and regional levels in the existing model. The performance evaluation should be conducted at the project level and implemented at a regional and portfolio level to inform policy makers. These suggestions are consistent with ISO 55000 (2014) and PAS 55 (2008b), highlighting that performance assessment and improvement are critical parts of a management system structure. Previous studies emphasised that issues such as loss of gained knowledge and repetition of mistakes can lead to additional expenses and resource waste in building maintenance (Almarshad et al., 2010, Talamo and Bonanomi, 2015). Therefore, evaluating the performance ensures that the processes have been carried out as planned and that the outcomes meet the stakeholders' expectations. The information collected in these evaluation processes will generate lessons and knowledge supporting decision-making (Jensen et al., 2019). Although there is a centralised system of information at the Ministry level, some interviewees found that the systems is not easy to access, and commented that there is no official guideline on what information needs to be kept, recorded, or monitored, nor is there any actual structure for how property information is managed and shared. The PIE framework proposes the development of a guideline for gathering reports, feedback, and lessons during and after each project (A4 and A5). The collected reports, feedback, and lessons together can build a knowledge management system for managing school buildings. Such a computerised knowledge-based system could provide a data set of problems across all schools in NZ and help manager identify possible solutions. Many researchers proposed a knowledge management system for building maintenance (Fong and Wong, 2009, Lepkova and Bigelis, 2007). Most existing knowledge management systems are web-based applications that collect staff's experiences, decisions, and knowledge. The PIE framework suggests that stakeholders need to communicate to share knowledge. This can be achieved by implementing activities in Establish, A31 and A3'1 in Implement. Jensen et al. (2019) also emphasised that knowledge transfer within an organization relies on the collaboration of the people involved. In the PIE framework, the implementation of activities in the Evaluate and Improve phases would enable the key stakeholders to evaluate their performance, share

best/worst practices, and, thereby, identify what skills are required and what sort of training is needed to develop their staff.

6. Conclusion

This research has investigated challenges in maintaining building properties in the school sector in New Zealand. School managers revealed critical challenges in building maintenance according to their perspectives and experience, including human resources, establishing a shared vision, the collection of information and knowledge, funding mechanisms and ensuring continuous improvement. The findings can help the stakeholders involved in the management of the school buildings better understand the status of their current processes and procedures. The results of a literature review and interviews with school managers were brought together to develop the PIE framework. The new framework is designed to help stakeholders understand the organisational context and to provide a guideline for the whole process by offering detailed activities for each stage. The framework promotes training, communication and sharing among the people involved in order to solve any challenges they may encounter. The data and lesson sharing aspects contained in the new framework encourage the collection of feedback on the project performance so that the owners can update their policies and mechanism accordingly. The PIE framework could be adapted to suit other types of buildings or school buildings in other countries, considering the hierarchy of organisational structure in maintenance management.

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Highlights

- Investigate challenges in managing school buildings
- Develop a new framework to solve the challenges
- Discuss how the new framework can improve the practice of managing school buildings
- Discuss the changes required and barriers to implementing the framework in practice

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Declaration of competing interest

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