A Framework for Request for Proposal (RFP) for Construction of Modular Classrooms

by

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Abstract

Modular classrooms have been increasingly used to accommodate fluctuations in student enrollment in schools. Request for proposal (RFP) is a tool to communicate with the bidders specifying the main requirements of the project. The RFP communicates the requirements for coordination between stakeholders such as responsibilities, risks, and criteria associated with the project. The RFP also presents the selection criteria against which the proposals will be evaluated. However, the effectiveness of the RFP depends to a high degree on the clarity and objectivity of the requirements and selection criteria introduced in the RFP, which might inhibit potential bidders from submitting a proper bid. Besides, the lack of knowledge on the part of contractors regarding the construction of modular classrooms contributes to cost overruns and project delays. Lessons learned from current practice is a useful approach to identify the challenges with the current practice and to suggest improvements to the current state. This thesis seeks to establish a better practice for the RFP process for modular classrooms by developing lessons learned from current practice. Alberta Infrastructure, as one of the leading public owners of modular classrooms, has procured more than 3,000 modular classrooms to date. Therefore, this research analyzes the procurement process used by Alberta Infrastructure as a case study to propose improvements. The research presents the findings in two parts: 1) lessons learned from current RFP practice, and 2) proposing a framework for evaluating selection criteria in the supply stage of modular classrooms. Recent RFPs, site visits, focus group meetings, and workshops with bidders were conducted. The lessons learned can be used as a guideline for owners of modular classrooms to set up the RFP process for future projects related to modular classrooms.

Keywords: Modular classrooms, Request for Proposal (RFP), Selection criteria, Benefits and challenges.

Preface

Parts of this thesis have been submitted to the "Construction Innovation: Information, Process, Management" journal in the emerald publication and is under review at the time of writing.

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To my dear parents

Without whom none of my success would be possible

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List of Abbreviations

AI	Alberta Infrastructure
IMR	Infrastructure maintenance renewal
MASH	Municipalities, publicly funded academic, school boards, health and social service entities
PO	Purchase order
RFI	Request for information
RFP	Request for proposal
RFQ	Request for qualification
SC	Selection criteria

Chapter 1: Introduction

1.1 Research motivations

Increasing enrollment, coupled with decreasing school budgets poses a challenge with respect to classroom space at some schools. Furthermore, new classrooms ideally would be installed during the months when class is not in session, typically a period of just two or three months in most jurisdictions. Therefore, the schedule available for installing classrooms is limited (Schmold 2010). Due to the lack of information on the requirements and responsibilities of each stakeholder during the construction process, school expansion projects may end up with cost overruns and delays (Smith and Quale, 2017). Consequently, many school districts in North America have turned to the use of modular classrooms to relieve this problem. These classrooms may be referred to as temporary, portable, or modular classrooms (CHPS 2006). According to the MBI's reports, there are over 550,000 relocatable modular buildings with an estimated value of $6 billion operating in North America, of which 33% are dedicated to the education market (MBI 2011; 2018; 2012; 2010). The construction reports conclude that up to 36 % of the K-12 school sector is covered by modular construction (McGraw Hill Construction 2011; Rice and Smith 2017).

Modular classrooms deliver three advantages compared with traditional classrooms: saving time (Choi et al., 2019; Edelman et al., 2016; Kyrö et al., 2019), saving cost (Eastman and Sacks, 2008; Kamali, 2019; Smith and Rice, 2017) and improving access to building materials and skilled labour (Hardiman, 2011; Kamali and Hewage, 2016; Li et al., 2017). Modular classrooms are a solution to the dual challenge of rapid population growth and demographic fluctuations, as they can be built and relocated in a short time (Rice and Smith, 2017; Smith and Quale, 2017; Southern, 2016). Modular classrooms are built off-site without disrupting school operations, which is an enormous advantage for school districts (Hammad et al. 2019; Sharafi et al. 2018). Furthermore, many school districts grow quickly as new neighbourhoods are developed and young families with school-aged children move in. When the children grow up and move out of the family home, the school population decreases. In these cases, the modular classrooms can be removed from schools that do not require them any longer and transferred to schools that are facing rapid growth. Although this can be challenging when the two schools in this hypothetical scenario do not have the same owner (Brinkø et al., 2015; Brinkoe and Nielsen, 2017), it is a promising option for public facilities such as classrooms, clinics, etc. (Kyrö et al 2019).

For institutional construction projects such as a school expansion, the selection criteria (SC) used in the procurement process represent an important component of the request for proposals (RFP), where a strategic framework is provided in the RFP shaped by the distinctive needs of the client, project, and external environment. The framework should specify the specific authorities, responsibilities, and relationships of key participants in the project (Luu et al., 2005). In this regard, recent studies conclude that using a suitable procurement system will have a significant effect on the success of a construction project (Xia et al., 2011).

Alberta Infrastructure (AI), as the owner of modular classrooms in Alberta, is responsible for accommodating the needs of 67 school boards across Alberta. Demographic trends impact the rate of enrollment in each school which might influence the total number of modular classrooms required for schools (AI 2013). Therefore, AI needs to develop an RFP to invite bidders to bid on several unknowns, since at bidding time the total number of modules, the timing of demand, and the location of the modules are all unknown variables. This research aims to focus on these uncertainties, e.g. time, and location, by developing lessons learned from modular classrooms procured by AI as a case study.

RFPs that are based on traditional construction methods do not consolidate the unique requirements of modular classrooms into the conditions provided in RFP. As such, using traditional contracting methods to procure modular classrooms may create ambiguities and losses due to a lack of proper risk management in the RFP. Moreover, due to ambiguous criteria in the RFP, most of the proposals get rejected, as they are found to be incompliant with the selection criteria (Akmam Syed Zakaria et al., 2018). Therefore, the evaluation process must be designed in such a manner that it is compatible with the type of project; otherwise it inhibits communication among the key parties and may detract from the efficiency of the process itself. Using clear criteria that establish effective communication between owner and bidder, creativity is increased and suppliers are encouraged to participate (ADA 2017). The RFP should also solicit the owner's requirements, and detail the anticipated terms and conditions specifying the responsibilities of parties throughout the project.

The owner uses the RFP to manage the risk of the project by determining the main requirements and required deliverables from the bidder (Molenaar and Vanegas 2000). Understanding the type of risks and challenges that may occur during the construction of the project is an effective approach to properly allocate and manage the risk.

Lessons learned from the current practice of procuring modular classrooms will provide the industry with valuable knowledge regarding the issues and challenges involved and how they could be addressed. This information will assist owners in determining the selection criteria, performance specifications, and terms and conditions according to the particular requirements of modular classrooms. In addition, the lessons learned may establish a knowledge base for contractors to be able to manage the risks associated with each stage of construction of modular classrooms. Lessons learned are also helpful for future improvements to the current process, which could be applied to future modular classroom projects.

1.2 Research objectives

The research presented in this thesis focuses on the development of a framework for developing the request for proposal (RFP) for modular classrooms so that the RFP process is reflective of the modular context.

The research is based on the following research questions:

1. How can an RFP and selection criteria be developed to motivate competitiveness and fairness?
2. How can an RFP be developed to accommodate the needs, given the financial model in which the government locates all the capital funding in one ministry (e.g., AI)?
3. How can an RFP be developed to accommodate uncertainties and risks (i.e., the number of modules, location, and timeline of the project)?

In order to verify the research questions, this research encompasses the following objectives:

- identify the current RFP process of modular classrooms;
- identify challenges experienced by bidders in the process of bidding on RFPs for modular classrooms;
- develop improvement strategies to be applied for future RFPs;
- develop a framework for public owners of modular classrooms to select the evaluation criteria used in the RFP in the procurement stage;

1.3 Thesis organization

This thesis is organized into five chapters. Chapter 1 (Introduction) presents research objectives and motivations and gives an overview of the research. Chapter 2 (Literature Review) reviews the most recent studies relevant to the main topic of the research. The literature review is organized into the following sections: 1) lessons learned; techniques and tools used in the literature review, 2) issues in RFPs, 3) the performance requirements specified in the RFPs, 4) procurement processes, and 5) selection criteria. Chapter 3 (Proposed Methodology) describes the methodology used in the research as well as the techniques and methods used to collect and analyze the data. The validity of the research has been elaborated upon in this chapter. The proposed methodology is divided into two main steps: 1) lessons learned from the current RFP of modular classrooms, and 2) the development of an evaluation framework for a better practice to determine the SC in the RFP of modular classrooms. The data analysis highlights relevant knowledge about the main requirements of RFPs for modular classrooms in North America, and also outlines the most common SC used in the RFPs for modular classrooms in the North American context. Chapter 4 (Lessons Learned) examines the lessons learned from the current RFP of modular classrooms. The lessons learned are described in two stages: 1) understanding the current state of the modular classroom using a case study, and 2) identifying issues encountered by bidders of modular classrooms. In the first section, a process map is included to indicate the stages, tasks, resources and key parties involved in the life cycle process of modular classroom focusing primarily on the procurement and installation stages. The chapter is also explaining the responsibilities of the owner and contractor at the procurement stage. In the second section, the issues are identified by conducting focus group meetings, reviewing requests for information (RFIs), site visits, two rounds of workshops (one with bidders and another with facility managers). The results highlight lessons learned from the current practice regarding RFPs for modular classrooms. Chapter 5 (Evaluation framework for RFP) uses the lessons learned to develop an evaluation framework to assist public sector owners of the modular classroom in specifying their requirements in the RFP by focusing on the SC. The results can be used in future practice to evaluate the SC used in the RFP. Chapter 6 (Summary and Conclusion) summarizes the research, research contributions to both academia and industry, limitations of the current research, and discussions about future works.

Chapter 2: Literature Review

2.1 Overview

The primary purpose of the literature review is to identify the current knowledge regarding modular classrooms and the RFPs for modular classrooms that provide the basis for this thesis. This chapter will be presented in the following sections:

- Lessons learned in the construction industry: As the research uses the lessons learned to develop a framework for the request for proposals, the research explores previous studies that endeavoured to identify tools and methods used to develop lessons learned from current practices in the construction industry. Then, a summary of the previous lessons learned from modular construction is presented according to economical, environmental, and social aspects.
- Issues with the RFPs: Identify different types of issues and problems that impact the efficacy of the communicativeness of the RFP by exploring disputes between the owner and bidders in the construction industry.
- High-performance modular classrooms: Identify the definition and the requirements of high-performance modular classrooms and their specifications by comparing practices related to high-performance modular classrooms in several jurisdictions in Canada.
- Identify the different stages and terms associated with procurement processes in the construction industry.
- Explore the most common selection criteria used in recent RFPs in the construction industry focusing more specifically on modular construction.

In order to investigate the recent studies, a combination of keywords was searched in different document categories using search databases such as Science Direct, Taylor & Francis Online and Emerald Insight. The results were categorized according to the relevance to the topics mentioned above. The following keywords were used in the searching of relevant documents:

"modular building", "offsite construction", "relocatable modular building", "benefits", "challenges", "classrooms", "lessons learned", "guidelines", "procurement process", "selection criteria", "bidding guideline", "request for proposal", "high-performance", "framework", "regulations".

2.2 Lessons learned

This section presents the literature regarding the lessons learned in the construction industry that respond to the following questions:

- What is the meaning of lessons learned?
- What are the benefits of applying the identified lessons learned to the project?
- What are the steps and tasks involved with the developing of lessons learned?
- What types of tools and methods should be used to ensure the effectiveness of developing lessons learned?
- What are the challenges inhibiting the efficacy of lessons learned?

Lessons learned are based on the knowledge gained from previous experiences while performing a project and are used with the aim of enhancing performance in future projects (PMI 2004). Thomas (2011) defines lessons learned as a "way of learning" that is beneficial to the project according to the aspects of quality, value, and importance. Tanja (2016) defines lessons learned as 1) an experience gained in a project, 2) knowledge based on experiences, 3) learning obtained on a project, 4) behavioural components based on applying a lesson on a project to determine the lessons learned, and 5) a text or document that can be transferred between projects to be applied in the future projects. The definitions of lessons learned are different based on how people and organizations refer to lessons learned (W. H. Thomas 2011) and this term should be defined according to the specific scope of the research. The term lessons learned in this thesis refers to developing a documented knowledge of the current practice that aims to enhance the performance of future projects.

Due to the recurrence of critical mistakes in the construction practices, the members of the project team have to spend time creating something that already exists. Developing lessons learned is a promising method for preventing an organization from repeating the same mistake while also allowing them to access to a better practice (Gibson et al. 2007). According to Paranagamage et al. (2012), lessons learned can provide the following motivations to the construction industry: 1) avoiding repeating mistakes by learning from past projects, 2) achieving past success in future projects, 3) gaining a competitive edge over other industries, and 4) encouraging innovation. According to the interviews with building professionals in Malaysia, applying lessons learned on a project can improve the performance of future projects in terms of both time and cost (Yap and Lock 2017). Love et al. (2016) use lessons learned as a tool for reducing the occurrence of reworks, and conclude that lessons learned should be more widely adopted as a tool for reducing rework in construction projects.

To ensure the proper structure of lessons learned is achieved, Gibson et al. (2007) suggest the following steps for capturing lessons learned: lesson collection, lesson analysis, lesson implementation, resources, maintenance, improvement, and culture. Thomas (2011) proposes ten steps for capturing the lessons learned: 1) foundation, which includes acquiring the required resources, systems, and facilities; 2) identification of the lessons by observing and selecting them; 3) collection of the lessons by classifying and gathering the lessons; 4) repositioning of the lessons by organizing and storing them according to their attributes such as their project name; and 5) distribution and sharing of the lessons learned for future projects. Tanja (2016) categorizes the elements of lessons learned as follows: 1) participants who contribute to the development of the lessons learned because the information can be captured from the individuals (e.g. by conducting interviews), or in a group-based setting (e.g. workshops and focus group meetings); 2) output of the process (e.g. the collected lessons); 3) the environment in which the participants collect the lessons learned, which might have different physical and social contexts; and 4) instruments used in the process of capturing the lessons learned; and 5) the purpose and the time available during the process of capturing the lessons.

In order to make sure that effective sharing and management of knowledge are congruent, recent studies endeavour to identify the common tools and techniques used to gain the lessons learned in the construction industry. These techniques can be classified as shown in Table 2- 1.

Table 2- 1. Methods of capturing lessons learned

Method	Description	Reference
Brainstorming sessions	Solving the problems by using the knowledge available in the mind of experts	(Egbu et al. 2003)
Face-to-face interviews	A meeting with face-to-face interactions conducted to share the knowledge	(Al-Ghassani et al. 2005)
Post project reviews	A debriefing session held after a construction project in order to identify the mistakes and successes	(Al-Ghassani et al. 2005)
Interaction with supply chain	A network that links the key members of a project to share and coordinate with each other in order to achieve a better performance	(Asad, Khalfan, and McDermott 2003)
Data/ text mining	Use of project data such as time and cost of the project to establish a useful knowledge and information	(Chimay, Charles, and Patricia 2005)
Intranet	A private network which inhibits external access to the system	(Tan et al. 2010)
Knowledge mapping	An approach used to analyze the knowledge areas and discover gaps of knowledge, where knowledge mapping enables members of the project to visualize the different concepts of related knowledge	(Chimay, Charles, and Patricia 2005)

This thesis uses the categories provided by Yap and Lock (2017), to identify the different challenges within the process of lessons learned in the construction projects. The challenges can be divided into three groups based on the main cause of the challenge, as follows: 1) challenges related to employees, 2) challenges related to organizations, and 3) challenges related to the culture of the employees.

Challenges related to employees:

- The enthusiasm of staff: Individual experts may not be willing to share their experience with others (Ardichvili, Page, and Wentling 2003).
- Employees' lack of time: As Williams (2007) suggests, the lack of time employees have at the end of the project is one of the critical challenges inhibiting the development of lessons learned. The employees are engaged with other projects and do not afford the time to document the lessons learned.
- Lack of self-confidence: Some of the employees, especially junior employees with less experience, are not confident enough to share their knowledge because they think their knowledge might lack accuracy and may mislead others (Ardichvili et al. 2003).
- Lack of trust among staff: Employees are afraid they might lose a chance at earning a promotion if they share valuable knowledge (Mason and Pauleen 2003).
- Incompetency of personnel: Some employees may be unable to utilize the tools and techniques required to capture and learn the lessons learned, as described above. Therefore, they may acquire incorrect knowledge or acquire knowledge through inefficient means (Tan et al. 2010).
- Transfer of personnel from the project team: High staff turnover occurs frequently in the construction industry, which causes the knowledge in the organization to become fragmented (Kasvi, et al. 2003).

Organization-related challenges:

- Restrictions on sharing: Employees are discouraged from sharing their knowledge if there are rules that restrict sharing as set by the company (Ardichvili, Page, and Wentling 2003). Also, as company policy, some companies have restricted their employees from sharing information outside the company due to competitive trends in the market (Polyaninova 2011).
- Lack of incentives: Motivating employees by introducing a reward structure is one of the significant factors in the success of a knowledge sharing process (Tan et al. 2010; Bresnen et al. 2002).

- Poor management of time and resources: Poor time-management and allocation of resources cause difficulties in managing knowledge. To save time and resources, most companies opt out of implementing lessons learned as they believe them to be unnecessary (Hartmann and Doree 2015; Polyaninova 2011).

Culture-related challenges:

- The language used in the organization: This might lead to insufficient communication as employees come from different countries and are not familiar with English (Tan et al. 2010).
- Bureaucracy and hierarchical issues: Senior staff find it hard to accept the opinions of junior staff members (Kamara et al. 2002)
- Absence of technology: Due to limited budgets available in many traditional construction companies, there is a low acceptance and adoption rate for the latest technologies, which may lead to increased efficiency (Polyaninova 2011)
- Lack of guidelines available: According to Carrillo et al. (2004), the lack of proper standards and guidelines for documenting the lessons learned is one of the critical challenges in capturing the lessons learned. Williams (2007) also agrees with this result.

According to Yap and Lock (2017), face-to-face interaction is the most crucial technique in collecting lessons, and organizational-related challenges are one of the critical challenges faced in the process of collecting knowledge, which is consistent with the result of another study conducted by Shokri-Ghasabeh and Chileshe (2014). These challenges may be realized in the process of determining lessons learned when the collection of data is required.

2.3 Lessons learned from practicing modular construction

This section identifies the lessons learned from the literature and categorizes the potentials and challenges of practicing modular construction identified in the literature within three aspects of economical, social and environmental characteristics as the three main pillars of sustainability (Fernández-sánchez and Rodríguez-lópez 2010). These lessons are compared with the lessons learned from modular classrooms in this thesis.

2.3.1 Economical lessons from modular construction

The economical aspects of practising modular construction are as follows:

1) the total cost can be reduced due to the following reasons:

- The materials are purchased in bulk to be used in multiple projects, which provides some discount on the cost of material (Cartwright 2011; Haas et al. 2000). This benefit necessitates the centralizing of the procurement for a factory rather than purchasing from small suppliers (Bertram et al. 2019).
- The lower cost of construction due to standardization and using more automation techniques in the factory, which leads to 20 % saving cost (McGraw Hill Construction 2011)
- Increased cost savings can occur in the production of modules when there is a high level of repeatability and high level of labour intensive activities involved with the modules such as accommodation modules and modular classrooms when a 20 % of saving cost occurs (Bertram et al. 2019).
- The cost of labour can be saved up to 25 % due to the reduction of numbers of labourers on-site (Haas and Fagerlund 2002)
- The project schedule is reduced due to the ability to perform simultaneous activities in the construction process; the preparation of the site can be performed during the production. These co-occurring activities allow the project to reduce 30% to 50% of the time at the completion of the project (Hardiman 2011; Smith 2010). The reduction of the project schedule leads to a reduction of the cost of the project by up to 20% (Cartwright 2011; Haas et al. 2000; McGraw Hill Construction 2011; Southern 2016).
- Most of the work is conducted in a factory, which means the risk of exposure to extreme weather is reduced resulting in less disturbance on site and completion of the project within the schedule resulting in cost savings (Cartwright 2011; Haas et al. 2000)
- The ability of the modules to relocated to be reused can significantly reduce the cost of the project (Kyrö, Jylhä, and Peltokorpi 2019)
- The cost of rework in the project is reduced as the design has to be completed before starting the production of the modules (Rice and Smith 2017; Bertram et al. 2019).
- The process of supervision of the labourers in the factory is improved due to the working condition in a controlled environment (Choi, Chen, and Kim 2019; Sharafi et al. 2018). This improvement leads to higher productivity (Nick Blismas and Wakefield 2009) and reduction of needs of labourers in the production stage, which reduces the cost of labour of the project (Eastman and Sacks 2008).

- Due to the reduction of energy consumption, improvement of air quality, and improvement of the product quality, the cost of maintenance and operation is reduced (O'Connor, O'Brien, and Choi 2015; Sharafi et al. 2018). This reduction is confirmed during a survey among the contractors where the majority of the contractors prefer modular construction due to lower maintenance and operation costs (Sharafi et al. 2018).

2) The overall cost of the project can be at a premium due to the following reasons:

- The need for using additional materials for transporting the modules from the manufacturer's site to the installation site (Smith and Rice 2017).
- The high cost of transportation because of the cost of required permits and lead cars (Smith and Rice 2017).
- The often lengthy amount of time required in order to obtain the approvals, which leads to an additional cost (Smith and Rice 2017).
- The low tolerance of the materials used in the modules (Bertram et al. 2019).
- The need to have more stable modules to be stable during transportation (Bertram et al. 2019).
- The increasing cost to the project due to the change orders, which increases the cost up to 8 % (Office of Legislative 2014).
- The higher design cost, which may occur due to lack of experience with modular construction (Bertram et al. 2019).
- The initial cost of implementing modular construction due to the expensive cost of the types of equipment required in the production stage (Durdyev and Ismail 2019; Ferdous et al. 2019). Consequently, there are limited numbers of manufacturers and a limited amount of expertise available in the market, which creates a monopoly for the current bidders in the market, reducing the number of alternatives available to the owners (Mohamad, Zawawi, and M.A.Nekooie 2009; Kamali and Hewage 2016; Mao et al. 2013). Similarly, having limited capacity due to the expensive cost of investment and fewer manufacturers in some places are other barriers to adopting modular construction from the owner's perspective (Blismas et al. 2011; Durdyev and Ismail 2019; Wuni, Shen, and Mahmud 2019).
- The time required to get the approvals and permits required for the transportation of the components may delay completion of the project, which in turn increases the project cost and time (Velamati 2012; Haas and Fagerlund 2002; Smith and Rice 2017; Wuni, Shen, and Mahmud 2019).

- The total cost of a project can increase by up to 10% in locations with restrictive transport regulations (Bertram et al. 2019). Also, the cost of transportation is highly dependent on the distances between the factory and the site. which has an impact on the cost of the project when there is a large distance between the site of the project and the factory site (Choi, Chen, and Kim 2019; Mohamad, Zawawi, and M.A.Nekooie 2009; Rice and Smith 2017).
- A substantial initial investment is required for installing and setting up the modules on-site; the cost of cranes and other equipment required for the installation is one of the critical barriers at this stage (Durdyev and Ismail 2019; Ferdous et al. 2019; Mao et al. 2013; Rahman 2013; Wuni, Shen, and Mahmud 2019). Sometimes high cranage costs must be incurred to handle the installation of the large-sized structural components (Durdyev and Ismail 2019; Nick Blismas and Wakefield 2009). In particular, this risk can be triggered when the site layout is restricted due to urban conditions (Azhar, Lukkad, and Ahmad 2013).
- A lack of detailed information pertaining to the connection of the modules to each other is one of the critical barriers in the assembling stage (Ferdous et al. 2019). Low tolerances between two components can increase fitting problems on site (Nick Blismas and Wakefield 2009; Sharafi et al. 2018), which points to the importance of having highly skilled labourers to deal with lower manufacturing tolerance (Durdyev and Ismail 2019; Blismas et al. 2011; Rahman 2013; Kamali and Hewage 2016). In the case of large modular units, the risk of incidents at the installation stage is reported to be higher and should be addressed by using specific instructions (Nick Blismas and Wakefield 2009; McGraw Hill Construction 2011).

2.3.2 Environmental lessons from modular construction

- Less raw material is used in modular construction due to the ability of modular buildings to be relocated and reused when needs change (Hardiman 2011; Edelman et al. 2016).
- Reduction in the amount of waste generated of up to 15 % due to the high quality of production by using automation techniques such as BIM (McGraw Hill Construction 2011).
- The level of indoor air quality is improved in modular classrooms since the module is mostly completed in a controlled area using dry materials, which reduces the existence of moisture inside the building (Hardiman 2011).

2.3.3 Social and cultural lessons from modular construction

- There are fewer disruptions to adjacent buildings and surroundings due to reduction of installation time on site (Hardiman 2011; Edelman et al. 2016).
- The safety of the workers on site has been increased due to the reduction of installation time on site (McGraw Hill Construction 2011).
- The ownership of the modular buildings should be changed as they are relocated to a new place, which may pose a challenge when the owner is in the private sector (Brinko, Nielsen, and Meel 2015; Concordia University and MBI 2015). However, this challenge has some potential benefits for the public sector (Brinkoe and Nielsen 2017).
- The safety of workers increases by 80% as they work in a controlled area inside the factory (Lawson et al. 2011), which reduces the probability of exposure of the workers to extreme weather (Hammad et al. 2019).
- The productivity of the workers is high as they work in a repetitive process, which means the labourers get skilled relatively fast. Therefore, fewer defects or product damage occurs (JL Celine 2009; Cartwright 2011).
- The learning process of labourers is quick as the labourers perform repetitive activities that improve workforce stability (Quale et al. 2012; Chiu 2012) and make the labourers feel more secure in their jobs (Li et al. 2017).
- The risk of delay of the completion of the project is minimized due to the reduction of exposure to weather extremes (Jaillon 2009; Na 2007).
- The results of a survey show that the end-users of the portable classrooms in Finland were worried about the safety conditions of their children since there is no surface between the ground and the floor of the modules. They also worried about the surface materials, gates, dangerous spaces such as voids in the foundations; an incident happened during a ball game, causing the ball roll under the building followed by a child fetching the ball. They maintained that they have some difficulties with the indoor air quality due to the poor ventilation inside the units (Edelman et al. 2016).

2.4 RFP issues

One of the critical factors affecting the performance of a project is the lack of proper understanding and managing of the RFP (Ronald Ciotti 2018). The probability of a dispute occurring between the parties of the project can increase if a proper understanding between the owner and contractor is not established. A review of the recent disputes in the construction industry concludes that incompleteness of the contract documents is one of the main causes of a dispute occurring. Cheung and Pang (2013) believed that the ambiguity of contract documents is the main contributor to the incompleteness of a contract. This result is consistent with the findings of research conducted by Hamie and Abdul-Malak (2018). Ambiguities in an RFP can be seen in following elements: specifications (e.g., lack of dimensions provided in the specifications about the building), process (e.g., lack of clear information about the evaluation process of the bids), and terms and conditions (e.g., using inconsistencies in the language and ambiguous definitions) (Randolphlaw 2019). In case of facing ambiguities by bidders in the process of bidding, the bidder is expected to issue a request for information (RFI) from the owner rather than making an assumption. The case of "Hensel Phelps Construction Co. vs. U.S., 1963" represents a situation where the bidder makes a wrong assumption facing an ambiguity in the specification of the RFP which led to a dispute between the owner and contractor (B. H. R. Thomas, Smith, and Mellott 1994). The remainder of this section explores the elements of specifications, process, terms and conditions in the RFPs that may contain ambiguity.

Specifications: The specifications in the RFP describe a list of performance requirements that are set by the owner according to the main objectives of the project. According to Molenaar and Vanegas (2000), the performance required for the project needs to be clearly explained. The RFP needs to clearly specify the parameters to measure and evaluate the performance of the project. The owner can specify the required minimum and maximum level of the parameters for each indicator of performance. The performance parameters fall into the following groups: 1) physical and non-physical compatibility and response, 2) functional performance, 3) formal and physical performance, 4) cost, 5) time, 6) risk, 7) safety and security, 8) constructability, operability and maintainability, 9) quality and reliability, and 10) sustainability. These parameters are affected by 1) specific characteristics of the project such as type of the project, 2) objectives of the project, 3) the scope of the project defined by the purpose of the RFP, 4) physical and non-physical context of the project (e.g. site conditions, availability of labourers), and 5) risks of the project stemming from the construction process and activities associated with the project.

Process: The RFP should specify the procurement steps, relationships, and regulations governed over the contractual life cycle of the project. The RFP should clearly describe the three stages as detailed below. In order to reduce the ambiguities of the RFP, the owner should make sure that the RFP is clear and only have one interpretation throughout these three stages.

1) The bidding stage is when the bid is open and the bidders can request information and the owner can respond to the enquires through issuing an addendum to the RFP. The information related to this stage should clearly explain the relationships between the bidder and the owner in the bidding phase and the selection criteria based on which the evaluation of the bids occurs. One of the legal issues in the procurement process of RFPs, especially when the type of contractor selection is “best value”, is that there is always a possibility of dissatisfaction of some of the bidders with the outcome of the bidding process, which leads to filing a protest against the owner. This issue is more problematic when the evaluation process, including selection criteria and their weighting set in the RFP, is not transparent (Shane et al. 2006). The transparency in the best value procurement process is achieved by reducing the subjectivity of the evaluation process and stating a clear description of the selection of the bidder. Another reason for bidding protests is the existence of mistrust between the owner and the bidders due to the presence of bias in the selection process (El Asmar et al. 2010). El Asmar et al. (2010) suggests the following as the main causes of creating distrust between the owner and the bidders: (a) evaluator’s power in determining the score associated with the criteria in the evaluation of the bids, especially when the grading system is qualitative; (b) misunderstanding on the part of the owner from some of the selection criteria; and (c) weighting of the criteria which creates a bias in the evaluation process.

2) The contract administration stage is when the owner monitors the progress of the project, which forms the basis for the timing of when the contractor receives the payments. The RFP should specify the relationships, steps, and the performance required of the contractor. The RFP should also define the measurement systems determining the performance requirements of the project (Ruparathna and Hewage 2013).

3) The post-contractual stage is when the contractor completes and delivers the project to the owner. The RFP should determine the responsibilities of the contractor in this stage and the process upon which the completeness of the project is measured (Ruparathna and Hewage 2013).

2.5 High-performance modular classrooms

High-performance modular classroom refers to a comfortable classroom where the indoor conditions are within the comfort range of the students, the required level of illumination is provided, and the level of noise does not disturb the teaching activities. High-performance modular classrooms are easy to maintain and the rate of energy usage to achieve the comfort condition is efficient (CHPS 2006). This section identifies different characteristics of high-performance modular classrooms across North America and categorizes them into two sections: (a) design of the high-performance modular classrooms, and (b) the performance requirements of modular classrooms as required by public RFPs. Different designs of high-performance modular classrooms are compared and then the performance requirements of three public RFPs of modular classrooms are analyzed. The performance requirement of the RFP is one of the critical elements where the owner specifies the main requirement of the modular classrooms and the bidder may be incompliant to the RFP if the bid does not comply with the specifications.

Among modular classrooms in the construction industry, there are some recent examples of manufacturers willing to challenge the current thinking with new, affordable models that provide increased quality, higher energy efficiency and more windows for natural daylighting, improved material selection, and improved durability. Within the category of construction trailers and industrial accommodations, one example on the market is 'reMOD' produced by a partnership between modular manufacturer Williams Scotsman and Shipping and Logistics company (Jackson 2015). In the American market, there are several examples of new, innovative modular classroom designs which emerged out of a competition called SAGE (Smart Academic Green Environment) classroom by Portland State University in conjunction with Blazer Industries, Pacific Mobile Structure, Sprout Space by Perkins Will, Triumph Modular, and SEED classroom (Sustainable Education Every Day) by Method Prefab. These models are some of the successful examples of modular classrooms within the constraints of limited budgets, requirements for flexibility, relocatability, and good quality construction, which benefits the end-users. The following different models of modular classrooms are identified in Figure 2- 1:

- SPROUT SPACE [Perkins Will & Triumph Modular]
- SAGE (Smart Academic Green Environment) Classroom [PSU, Blazer Industries and Pacific Mobile Structures]
- SEED classroom (Sustainable Education Every Day) [Method Prefab]
- MOBEE- Portable Classrooms (Canadian Example- Ontario)
- ReMOD- Green Construction Trailer [Williams Scotsman and Skanska]

SAGE Classroom **SEED Classroom** **Sprout Space**

Figure 2- 1. A summary of different modular classrooms in the current practice in North America

The present research found three recent RFPs procuring modular classrooms across Canada that were available online: Alberta (AI 2017); Toronto, Ontario (OECM 2017); and British Columbia, (Partnerships 2010). Section 2.5.1 below compares the performance requirements of RFPs of modular classrooms in the context of these three RFPs to identify the main requirements of modular classrooms and the different indicators of performance used among the RFPs. All the requirements in Section 2.5.1 are extracted from the three RFPs issued by public owners of modular classrooms in the provinces of Alberta, Ontario, and British Columbia.

2.5.1 Special requirements

Alberta: The modules should be compliant with LEED Silver certification. The acceptance testing of the modules (e.g. air leakage test approval) should also be provided in the bid's package. A design service life of 50 years is required when the design of the modules is prepared.

British Columbia: The modules should be designed for a life cycle of 40 years capable of being disassembled and re-assembled over the course of their life. The RFP incorporates the Wood First Act indicating that if there are alternatives available to select the building material, wood must be used according to British Columbia Building Code requirements.

Toronto: The RFP seeks to select the bidders to supply, deliver, and commission modular classrooms. The RFP does not specify the required life cycle of the modules.

2.5.2 Area and functional requirements

Alberta: Modular classrooms should provide a clear area of 75 m^2 for classrooms. A corridor space should be used to connect the module with other modules and the school core buildings. The wall between the classroom and the corridor and the wall between the classroom and the mechanical room should be 60-minute fire rated. The RFP requests that the bids provide minimum on-site construction for the assembling of the module to the school building.

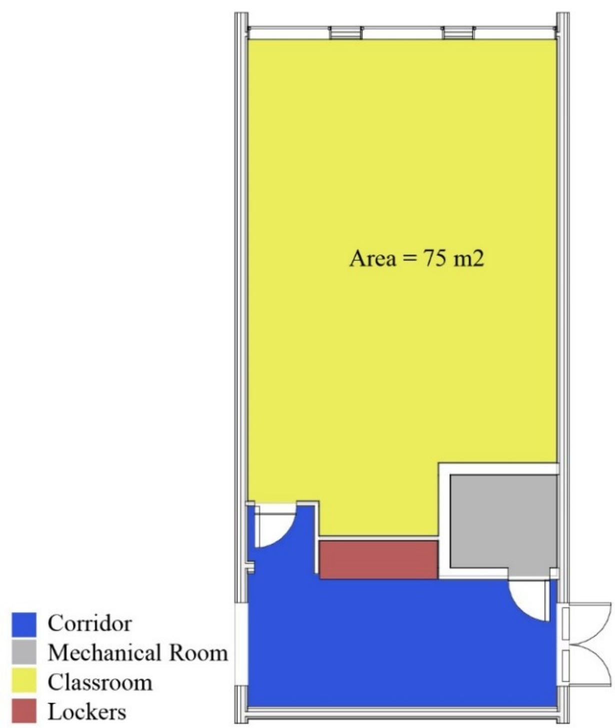


Figure 2- 2. Functional requirements of modular classrooms

British Columbia: The modules consist of two main elements: a) teaching area, and b) a servicing area including washrooms, storage room etc. The servicing area should be accessible from the corridor or the classroom. The modules should provide about 90 m^2 for the teaching area and 18–20 m^2 for the servicing area (Figure 2-4). The modules can be designed using various dimensions; however, there is a restriction due to transportation constraints. The RFP suggests the bidders design the teaching area in a range of 6.70 m and 7.90 m in width and between 2.75 m and 3.05 m in height. These dimensions are clear interior spaces inside the modules. The minimum space required for the service area is suggested as 6.70 m in width and 2.44 m in height. The bidder should provide millworks including the teacher's cabinet, coat hooks provided for 30 students with two height hooks, cubbies for 30 students and sink/ kitchen counters as illustrated in Figure 2-3 below.

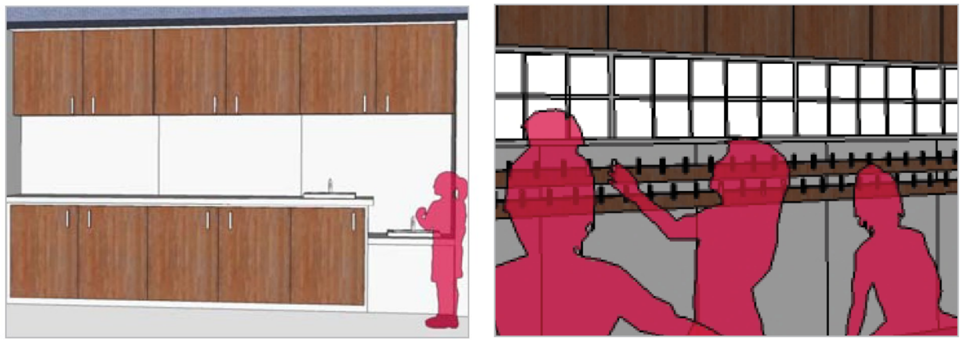


Figure 2-3. functional requirements in modular classrooms in British Columbia (Partnerships 2010)

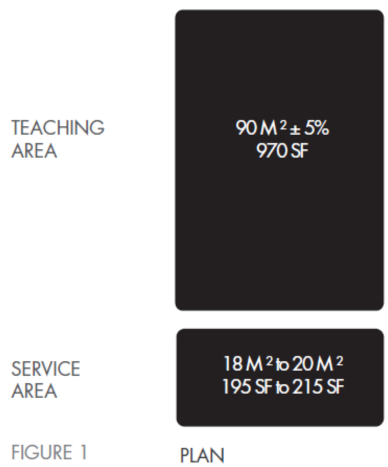


Figure 2-4. Proposed dimensions of modular classrooms in British Columbia (Partnerships 2010)

Toronto: The RFP requires modular classrooms to meet the requirements of the Ontario Building Code (OBC). The exterior dimension of the module should be 7.31 meter (24 feet) by 9.75 meter (32 feet) with a minimum height of 2.43 meter (8 feet). The modular classroom must be manufactured in two halves to streamline the transportation of the module, which must be made using steel frame construction.

2.5.3 Structural requirements

Structural requirements specify information about the stability of the building including the design load, and the required structural performance of the buildings.

Alberta: The structure of the modules should be such that it is able to be moved three times over the first 30 years of operation in response to accommodating enrollment changes in schools. Pressure equalized rain screen insulated structure technique (PERSIST) is the system for the wall and roof suggested in the specifications of the RFP. Wind load is 1.02 kPa and the snow load is determined based on the type of the module: the standard module is 3.6 kPa for the regions with regular snow, and 10.75 kPa for the heavy-duty module for regions where there is a high level of snow load expected. The occupancy load for the classrooms and the corridors is 2.4 kPa and 4.8 kPa, respectively.

British Columbia: The structure of the module should comply with the following codes: 1) the British Columbia Building Code, 2006; 2) CSA A23.3-04 Design of Concrete Structures; 3) CSA S16.1-2005 Design of Steel Structures; 4) CSA 086.1-2005 Engineering Design in Wood. To ensure the structural durability of the module against relocating to any location in British Columbia, the RFP suggests the design loads as the following:

1) the snow load will differ based on the location of the modules as 3.0 kPa is suggested for Vancouver and the Lower Mainland, and 8.0 kPa for all other locations across British Columbia;
2) wind pressure of 0.75 kPa; and
3) the design dead load should not less than 0.85 kPa.

The modules may be requested to be delivered with a foundation as illustrated in Figure 2-5; however, school boards may request to exclude the foundation from the modules. The foundation design must be resistance against lateral loads such as wind, earthquake, etc. The foundation can be made from screw jacks or concrete support pedestals; however, it should be approved by an engineer.

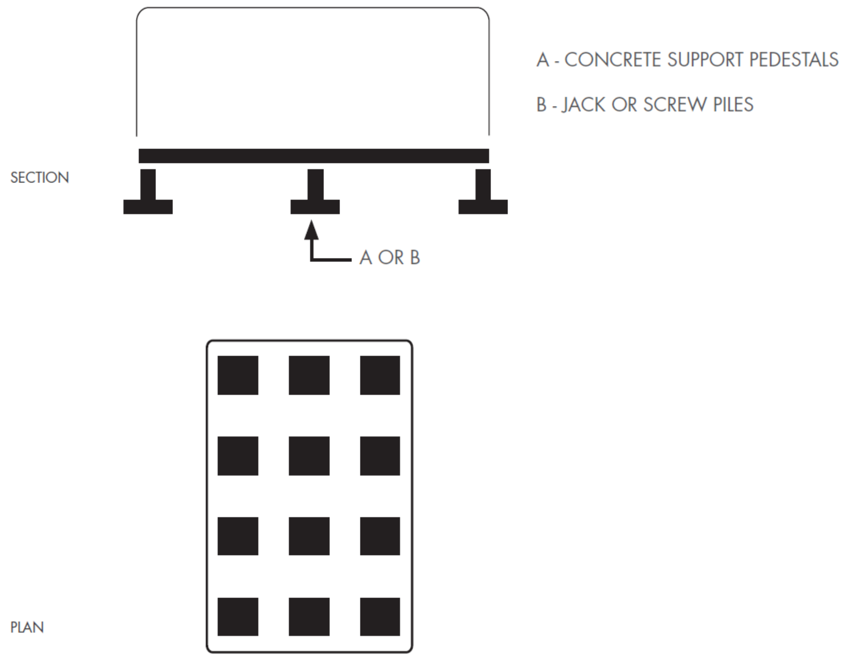


Figure 2- 5. Foundation layout of the modular classroom (Partnerships 2010)

Toronto: The structural requirements of the modules can be categorized as follows:

- provide the foundation of the modular classroom including the required number of concrete pads (3.5-inch × 18-inch × 18-inch) and 8 semi-solid block piles as well as 4 Duckbil anchors; and

- consider the following requirements as the design load: minimum snow load of 3.10 kPa, minimum rain load of 0.40 kPa, floor load of 50 pounds square feet (PSF) live load and earthquake and wind load as determined by OBC requirements.

2.5.4 Acoustic requirements

The quality of the acoustics inside the classrooms can significantly impact the concentration of the students, which influences the process of learning. To ensure a high level of speech intelligibility, a significant level of attention is required to improve the acoustical characteristics of the classrooms. The RFPs have specified performance requirements to ensure the modular classrooms meet the acoustical characteristics.

Alberta: The RFP evaluates the performance of the acoustics according to the following: 1) a quiet background noise level is provided due to operating of heating, ventilation and air conditioning ("HVAC") and plumbing systems, 2) a low level of reverberation (0.6 seconds with 500 Hz, 1000 Hz and 2000 Hz) is provided, 3) a sufficient level of noise isolation is provided between the instructional space and the adjacent spaces such as washrooms, corridors, etc., 4) an adequate level of isolation is provided from outside noises such as traffic, aircraft, etc.

British Columbia: The modules should be provided with one-inch fabric wrapped acoustic panels on the walls and ceiling to provide sound attenuation.

Toronto: Non-combustible acoustic tiles should be installed in the ceiling of the modules as part of the suspended system.

2.5.5 Building envelope requirements

The building envelope system of high-performance modular classrooms integrates with other systems to enable the modules to provide thermal, visual, and acoustic comfort to facilitate the learning environment with a high level of durability. The objective of the required performance of the building envelope is to reduce the life cycle cost of owning, operating, and maintaining the modules by controlling the level of insulation, the rate of glazing, and the air leakage control from inside the module. The following performance requirements are suggested by RFPs to ensure proper quality is associated with the building envelope of modular classrooms.

Alberta: The building envelope should be checked for any air leakage and much satisfy the requirements of air leakage tests as demonstrated in ASTM E779-10 coupled with the exceptions and additions introduced in the U.S. Army Corps of Engineers Air Leakage Test Protocol for Measuring Air Leakage in Buildings (Zivov and Bailey, 2012). The envelope should provide a continuous air barrier at door openings or at corridors depending on the type of module. An effective thermal resistance rating (RSI) should be provided as set out in the National Energy Code for Buildings 2011 for the envelopes. The RFP specifies the required performance according to the following categories:

- Roofs: Design the roof with the minimum slope of 1:50 meeting Alberta Roofing Contractors Association Ltd (ARCA) requirements. The structure of the roof should be designed to prevent the penetration of water into the structural system. This penetration is tested according to the following requirements: 1) a second layer of defence in the roof should be provided to preserve the roof structure, wall assemblies, and occupied space against water penetration; 2) a drainage system should be designed to prevent draining of water over the wall. The minimum thermal resistance of 5.3 m^2xC/W should be provided for the roof assembly.

- Walls: The cladding system of the wall should be easily painted enabling the schools to match the colours to other sections of the school. PERSIST is suggested as an acceptable system for the walls with acceptable RSI of 3.5 m^2°C/W. The rain system cladding should be provided according to National Research Council Canada (NRC) "Rain Screen Principals" as an acceptable approach suggested by the RFP.

- Floors: Design the resistance of the floor to be moved and cleaned easily with a minimum RSI of 5.3 m^2°C/W.

- Windows: The bidder is required to provide sealed glazing units of 6 mm glass interior and exterior panes with a low emissivity coating to maximize the solar heat gain coefficient of 0.38 by maximizing the level of visible light transmission (VLT) with a minimum of 60 % VLT. The acceptable window should be resistant with an RSI of 0.45 m^2°C/W.

- Doors: All doors should include a 50 % transparent glazing area to be used by students. The glazing surface should be a minimum of 4 mm tempered safety glass. Sheet steel faces should be used for doors with thicknesses of 1.6 mm for exterior doors and 1.2 mm for interior doors.

British Columbia: The RFP specifies the building envelope's characteristics as follows:

- Interior opaque walls: The RFP requires half of the area of the opaque wall surfaces of the teaching space to be wood while the other half is made by durable washable vinyl wrapped gypsum wallboard panels. The opaque walls located in the washroom area should be made by white fibreglass reinforced plastic (FRP) panels from floor to ceiling. A minimum of 50 mm batt insulation should be installed on the interior walls for sound absorption. To install sinks and washroom accessories, a 12 mm plywood backing installed behind the finished panels.

- Interior Floors: The interior floors in the teaching areas should be installed with a layer of marmoleum with solid vinyl with 3.2mm thickness. The colour and pattern of the solid vinyl should be pre-approved by the owner. Other materials should be suggested by the bidder and approved by the owner before the evaluation process. The interior floor in the service area should be installed with a tarkett layer of 3.2 mm thickness, which should be provided in different colours and patterns by the bidder through a menu list and school boards will select one based on the cost associated with each. The finished floor should be 100 mm extended up the wall surface.

- Interior ceiling: The design of the interior ceiling in the teaching area should feature wood in the ceiling. If required, the exposed fasteners should be organized in a regular pattern. The interior ceiling for the service area can be either suspended 16 mm painted gypsum wallboard or suspended T-bar both provided with a washable surface finish.

- Exterior walls: The exterior walls should provide an R-value of 30 and should include: continuous air barrier, non-combustible exterior sheathing and 25 mm air space with one of the following options as the exterior cladding selected by school boards: 1) a combination of wood siding with an anti-graffiti coating, 2) upper half of the wall with combination of wood siding with an anti-graffiti coating and lower half with masonry panels comprised of brick preassembled into the panels that are applied into the structure of the modules, 3) upper half of the wall with combination of wood siding with an anti-graffiti coating and lower half with Hardi Plank or approved equivalent.

- Roof performance: The roof should have an R-value of 40. All vapour and air barriers should be continuous from wall to roof assemblies. The bidder should provide a 10 years warranty of roof as required by the Roofing Contractors Association of British Columbia (RCABC).

- Floor performance: similar to the roof with the R-value of 30 and all the air barriers should be continuous and uninterrupted.

Toronto: The RFP specifies the followings as the performance requirements for requirements of building envelopes:

Exterior Wall: All exterior and interior walls must be 1-hour rated fire resistance from both sides. The cladding system should be vertical steel siding using 26 gauge with baked enamel paint finish (the colour should be determined by the owners). The wind barrier of the Typer brand or equivalent should be used in the exterior walls. The exterior walls should be insulated with a minimum insulation value continuous to the exterior of the building. Construction of the wall should include gauge galvanized metal girts and Type X or equivalent mould resistant paperless wallboard. A layer of vapour barrier should be used by 6 mm polyethylene material. Skirting of the modules is required to connect the exterior envelope of the module to the ground, which should be 3/8 inch thick pressure treated plywood secured to the frame of the wood. Six skirt vents should be provided to ensure proper ventilation below the module.

- Roof performance: The roof must consist of two poly-modified bituminous systems, an insulation layer, and a vapour barrier.

2.5.6 Indoor air quality (IAQ)

The quality of air inside the modules is a critical measurement ensuring the health and performance of the students and teachers in the classrooms. Proper integration of natural and mechanical ventilation systems should be used to achieve a superior indoor air quality inside the modular classrooms. The RFPs suggest the following performance to ensure proper IAQ is obtained in the modular classrooms:

Alberta: Modular classrooms should be equipped with a ventilation system designed for a maximum of 30 students per classroom to filter the air with a minimum efficiency rating of MERV 13. The IAQ of the modules should meet the requirements of LEED version 4 (V4). The modules should be provided with heat recovery ventilator on exhaust air with a minimum efficiency of 60 %.

British Columbia: A ventilation air unit should be provided near the center of the teaching area in the modular classroom as illustrated in Figure 2-6. The level of ventilation should follow ASHRAE 62-1989 for occupancy of 25 students providing 20 cubic feet per minute of fresh air per person with a minimum exhaust level of 15 air changes per hour.

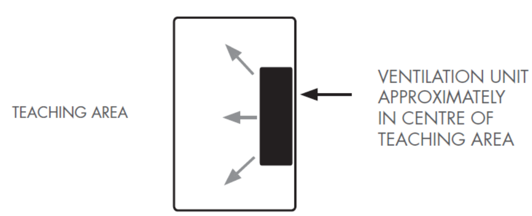


Figure 2- 6. location of the ventilator unit in the teaching area (Partnerships 2010)

Toronto: No such requirements are included in the RFP.

2.5.7 Visual comfort

Visual comfort is a significant component influencing the learning process in modular classrooms. The following specifications are required by RFPs to enhance the process of learning inside the classrooms by improving visual comfort.

Alberta: The RFP suggests the following strategies: 1) utilizing an appropriate design to integrate the natural and electric lighting systems, 2) avoiding an excessive level of lights to balance quantity and quality of the light system using appropriate strategies in the design process, 3) control and eliminate glare. The design should meet the daylighting and views credits of LEED V4.

British Columbia: The RFP encourages the bidders to use the glazing wall to introduce natural daylight in order to reduce the required artificial lighting, which leads to a reduction of energy consumption. As illustrated in Figure 2-7, half of the glazing area should present indirect/reflected daylighting as the other half provides a view from inside the teaching area to the outdoor area, which should be equipped with an operable window placed no higher than 1.675 m above the finished floor. The windows inside the teaching area should be located in a way to improve natural ventilation inside the modules. According to the RFP, between 10–15 % of the floor area should be glazed in the exterior walls.

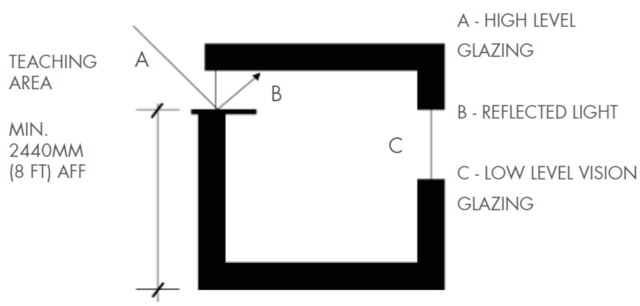


Figure 2- 7. Glazing area requirement for modular classrooms (Partnerships 2010)

Toronto: No such requirements are included in the RFP.

2.5.8 Lighting

Alberta: This section of the RFP is categorized into three sections: 1) interior lighting system, 2) lighting controls, and 3) exit lighting and signage. The design of the lighting system should follow the latest standards provided by the Illuminating Engineering Society (IES), specifically ANSI/IES RP3 – standard practice on lighting for educational facilities. The lighting system should provide an illuminance range of 380 and 450 lux average at a work plan height of 750 mm, whereas the maximum illuminance should not exceed 450 lux. The maximum and minimum illuminance rates in the classrooms should not exceed the ratio of 3:1. The lighting system should provide occupancy sensors for the full area giving an on/off switch for manual control of three zones of exterior window wall row, presentation wall row and remainder luminaires.

British Columbia: The RFP specifies the average lighting levels according to the IES guidelines as follows: 500 lux for classrooms and 300 lux for the service area. Emergency lighting and exit signs should be compliant with the BC Building Code. The exterior lighting should include two vandal-resistant wall-mounted luminaires. Luminaires in the teaching area should be controlled by an occupancy sensor for turning off the lights when the room is unoccupied.

Toronto: No such requirements are included in the RFP.

2.5.9 Electrical

This section reviews the requirements related to communication systems, fire protection infrastructure, and other systems requiring power supporting the achievement of a high-performance learning environment.

Alberta: The RFP specifies the following as the main requirements for the lighting system in modular classrooms:

1) power and communications should be provided on the external walls from floor to ceiling space every 1220 mm;
2) wall-mounted devices should be used in classrooms, mechanical rooms and corridors;
3) convenience power including single circuit receptacles at the TV and video projection locations, ten receptacles on five circuits for computer workstations, ten general receptacles with a minimum of two on each wall;
4) provide proper communications to the school building including provision of Wi-Fi equipment, an overhead paging outlet, an outlet for an intercom station, and a junction box to connect the communication outlets in modular classrooms with school; and
5) provide a fire alarm system that is able to connect to the school and generate audible and visual signals.

British Columbia: All the interior walls in the teaching area should have access to power and data as a critical service providing flexibility for students in the teaching area. The modular classroom should include an electrical service panel board installed in an electrical service closet.

Toronto: All electrical equipment must be approved by the Canadian Standards Association group or Underwriters Laboratories Canada (ULC).

2.5.10 Thermal Comfort

Alberta: The RFP requires the modules to meet LEED requirements for thermal comfort: 1) in cold seasons, providing an indoor temperature of 22 °C when occupied and 18 °C during unoccupied hours and relative humidity of 30 % at 0 °C and 15 % at -35 °C; 2) in warm seasons, providing a maximum temperature of 25 °C; and 3) the thermal conditions should meet the following conditions:

- the temperature fluctuation of maximum 1 degree Celsius during heating and cooling modes

- the horizontal fluctuation temperature should not exceed 2 degrees Celsuis between 300 mm and 3,000 mm from the exterior wall at desk height. Similarly, the vertical fluctuation temperature between 200 mm and 1,700 mm above the floor at any point above 300 mm from the exterior wall should not exceed 2 °C.

British Columbia: The indoor temperatures should be as follows: classrooms should be 23.8 °C in the hot seasons and 21.5 °C during the cold seasons.

Toronto: No such requirements are included in the RFP.

2.5.11 HVAC/mechanical control system

The HVAC system design must be capable of communicating with the building envelope to meet the comfort condition inside modular classrooms. High-performance HVAC systems are essential to ensure the thermal comfort and indoor air quality while reducing operational costs of modular classrooms. Below are the performance requirements specified by RFPs to ensure the quality of modular classrooms is achieved.

Alberta: For each module, an HVAC system should be installed according to the following performance specifications: the system must maintain the temperature, humidity, acoustical requirements mentioned in the previous sections. The plumbing and drainage systems should be designed according to the National Plumbing Code. Depending on the type of required specifications, the module shall or shall not be equipped with an individual control system. The control system enables the occupants to specify the inside temperature of the classrooms. The control system may not be provided in the module if the owner requests it.

British Columbia: Sinks and top sets are provided by school boards, and bidders are not required to install them; however, the bidder is required to install the plumbing, drainage, sprinkler pipes and venting ducts to accommodate the estimated fixture layout. Roof penetrations due to the connection of mechanical equipment are not allowed. The intake and exhaust air should be moved through the exterior wall. The HVAC system consists of a ventilator for providing heating and cooling to the teaching space. The ventilator should be a vertical air source heat pump such as Airdale classmate HE series, or approved equivalents. The HVAC system should provide all ductwork distribution, diffusers, grilles, insulation, and controls as required. A control system should be installed to connect the module to the existing building. The control system uses occupancy sensors to turn off the HVAC systems if the classroom is unoccupied. When no occupancy is found for 30 minutes, the control system turns off the ventilator. During the weekly schedule, the room should be controlled to an unoccupied set-point temperature of 19 C when the outside temperature is below 19 and 26 C when the outside temperature is above 26 C.

Toronto: A unit ventilator should be used in the modules for heating and cooling purposes and should be located between the windows. The bidder is responsible for installing the following related to the HVAC system: insulated ductwork and diffuser, relief dumper, and CO_2 and occupancy sensors. The HVAC system must comply with OBC (Ontario Building Code) and ASHRAE (American Society of Heating, Refrigeration, and Air Conditioning Engineers) requirements specified for air changes in the modular classrooms.

As discussed, the RFPs used for the construction of modular classrooms may differ in terms of requirements and main performance of the project; however, the RFPs have several similarities, as follows:

1- One of the main requirements of high-performance modular classrooms is to have a separate and independent mechanical system that allows the modules to operate properly during the year without the need for other buildings. This requirement enables modular classrooms to be installed outside of the school buildings without having any physical connection.

2- A controls system is critical to be used in the modular classroom to enable the modules to manage the consumption of energy during unoccupied times. This requirement ensures the energy efficiency of the modules compared with the traditional type of modular classroom.

3- To facilitate the process of connection of the modules to each other and to the school building, it is essential to standardize the dimensions of the modules. This requirement is introduced by developing different types of modules, which can reduce the cost and time of installation of the project.

4- The RFPs specify the performance required for the construction of modular classrooms rather than specifying the type of material and technology required for the project, which increases creativity and encourages the bidders to use innovative techniques in order to enhance the performance of the project.

5- To guarantee the applicability of the RFP to all the locations across the province governed by the owner, the RFP introduces different types of modules in terms of structural requirements. Different types of modules can be used according to the snow load and their place in the construction site.

2.6 Procurement process (stages, selection criteria and RFP, criteria type)

Procurement activities span from the identification of requirements to project closeout, making it a perfect model for integrating organizational strategic directions. The literature in this section can be divided into two groups:

- Studies that aim to develop or integrate the process of procurement from the contractor's perspective; such as the development of an advisory system to assist the contractor to know whether to bid or not (Urquhart and Whyte 2018), which can function as a guideline for contractors to estimate the best bid price based on the specific requirements of the project.
- Studies that have a primary purpose of developing a guideline for owners of the projects, which identify the stages of the procurement, assist the owner to specify the main requirements of the project in the RFP etc.

This thesis seeks to take lessons learned from the owner's perspective; therefore, the literature that is relevant to the main topic of the thesis is reviewed.

According to previous studies, the activities involved in the procurement process could be grouped into four stages: pre-contractual phase, contractual phase, contract administration and post contractual phase (Figure 2-8). These stages can be applied in each case of bidding (Office of Procurement Ombudsman 2018; Ruparathna and Hewage 2013). Laryea and Hughes (2010) investigated 670 hours of the bidding process in two leading U.K. construction firms. They concluded that the activities in the bidding process mainly include desk works, calculations, and meetings. They identify all the stages of the bidding into three stages of the initial stage (conduct a preliminary study), middle stage (bid or not decision), and final stage (update prices and submit the bid). They investigate how risk impacts the price of the bid from the contractor's perspective (Laryea and Hughes 2010).

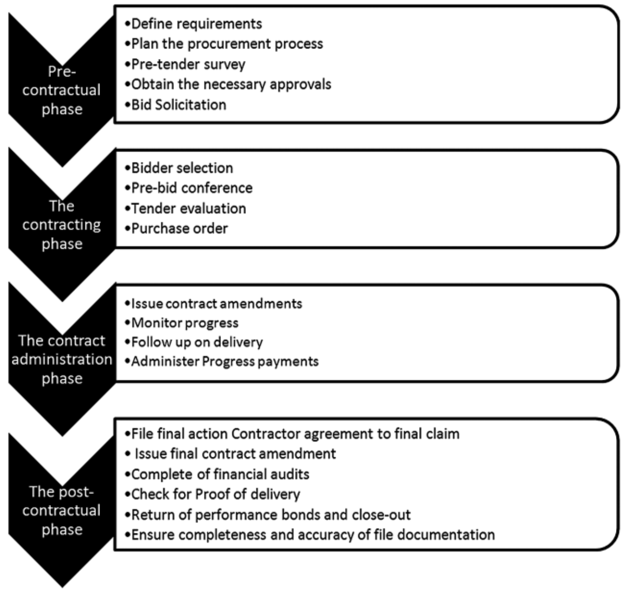


Figure 2- 8. Different phases of the procurement from the owner's perspective (Ruparathna and Hewage 2013)

However, in published literature, there is still a less clear view of procurement as a process in a construction project (Ruparathna and Hewage 2013). Consequently, project owners or representatives find it onerous to determine the differences between the various options available (Miller et al. 2009). Osipova and Eriksson (2011) identified procurement as a method for project risk management. A selected procurement method directly affects the risks of contracting parties, which is eventually highlighted in the contract price. They used a series of interviews with clients, contractors and consultants involved in 11 Swedish construction projects. They concluded that the type of project delivery method, the form of payment, and the use of collaboration could impact the risk associated with a project. Ruparathna and Hewage (2013) presented a comprehensive review of traditional and emerging procurement practices in the construction industry. They analyze each procurement by separating it into three segments: processes, methods, and policies (low bid, qualification, value-based). The strengths and weaknesses of traditional procurement methods are reviewed. According to past studies, there is a lack of compiled knowledge of construction procurement practices, which makes it onerous for project owners or representatives to determine the differences between the various options available.(Ruparathna and Hewage 2013). The various types of methods used in selecting the bidder can impact the performance of the project. Therefore, the thesis identifies these methods in the evaluation process of bidders.

2.6.1 Selection type [Best Value & Low Price]

Lowest bidder selection has been the underlying philosophy for contractor selection for the RFPs under study, as this is the preferred method in public projects (Ioannou and Awwad 2010). However, relying on the lowest price as the basis for evaluating options is one of the major causes of project delivery problems. It can result in schedule delays, compromised quality of work, and increased actual costs, and it incentivises unqualified contractors to submit lower bids (Art Chaovalitwongse et al., 2012). Alleman et al. (2017) compares the use of qualification-based selection versus best value (BV), which is a combination of cost and qualification criteria, for selecting contractors of highway projects that use the construction-manager-at-risk delivery method. Their results show that the use of BV procurement poses a risk to innovation and increases the need for negotiation. Qualification-based selection is found to be less complex and to result in more highly developed designs at the time of selection (Alleman et al., 2017). Liu et al. (2018) compare the benefits and disadvantages of low bid and BV selection methods, devising a pattern for selecting contractors, called geometric graph analysis model (GGA), based on the attributes of quality and price. The method they propose is a combination of low price and BV using multi-linear optimization.

2.6.2 Evaluation Process [Single step & Two steps]

Ramsey et al. (2016) conclude that evaluation processes with 2 steps—request for qualifications (RFQ) and RFP—cost 4 % less than one-step evaluation processes to administer. Hasnain and Thaheem (2016) review more than 60 papers related to contractor SC in BV procurement methods, concluding that past performance, quality control, and health and safety are the most important selection criteria. Gransberg and Barton (2007) investigate RFPs of public design–build projects using content analysis to understand the criteria and their frequency. Their results show that price and qualification are the most important criteria in school projects. They also conclude that, if the owner wants to improve creativity, they should shift more weight to the technical criteria (Gransberg and Barton 2007). Similarly, Xia et al. (2011) analyze and review 97 RFQs of Design–Build projects in the United States using a content analysis approach. The study found experience, project management approach, and organizational capacity to be the most highly valued categories. They also conclude that owners need to adjust the relative weightings of the qualification criteria according to the varying characteristics of different projects (Xia, Skitmore, and Zuo 2011). In a further investigation, they analyze and review 94 Design–Build RFPs in order to identify the SC for design–builders and compare the relative importance using content analysis, finding the most important criteria to be price and experience (Xia et al. 2013).

2.6.3 Summary

As discussed, each project has specific requirements and the RFPs should be issued accordingly. The benefits of implementing modular construction point to a need to update the current procurement process along with its unique characteristics. This means to revise two main parts of the RFP including selection criteria and main rules and responsibilities defined in the RFP. Proper use of selection criteria in the evaluation process can save time and cost and reduce the amount of risk the key parties take on for the project. To be aware of the risks and challenges in the process of supplying modular classrooms, having historical records of last practices is useful. Taking lessons learned from current practice will improve the RFP by identifying the benefits, opportunities, and strengths of the current process to make sure these will continue in the future and also by identifying the challenges, issues, and constraints, it improves the current process by proposing mitigation strategies and techniques for better communication. Improvement of the current process could be realized based on the stages introduced in Figure 2-8.

Chapter 3: Methodology

This section introduces the data collection methods and then describes the proposed methodology to achieve the main goals of the thesis. Figure 3- 1 illustrates the methodology used in the research. A framework for evaluating selection criteria used in the RFPs of modular classrooms is also presented.

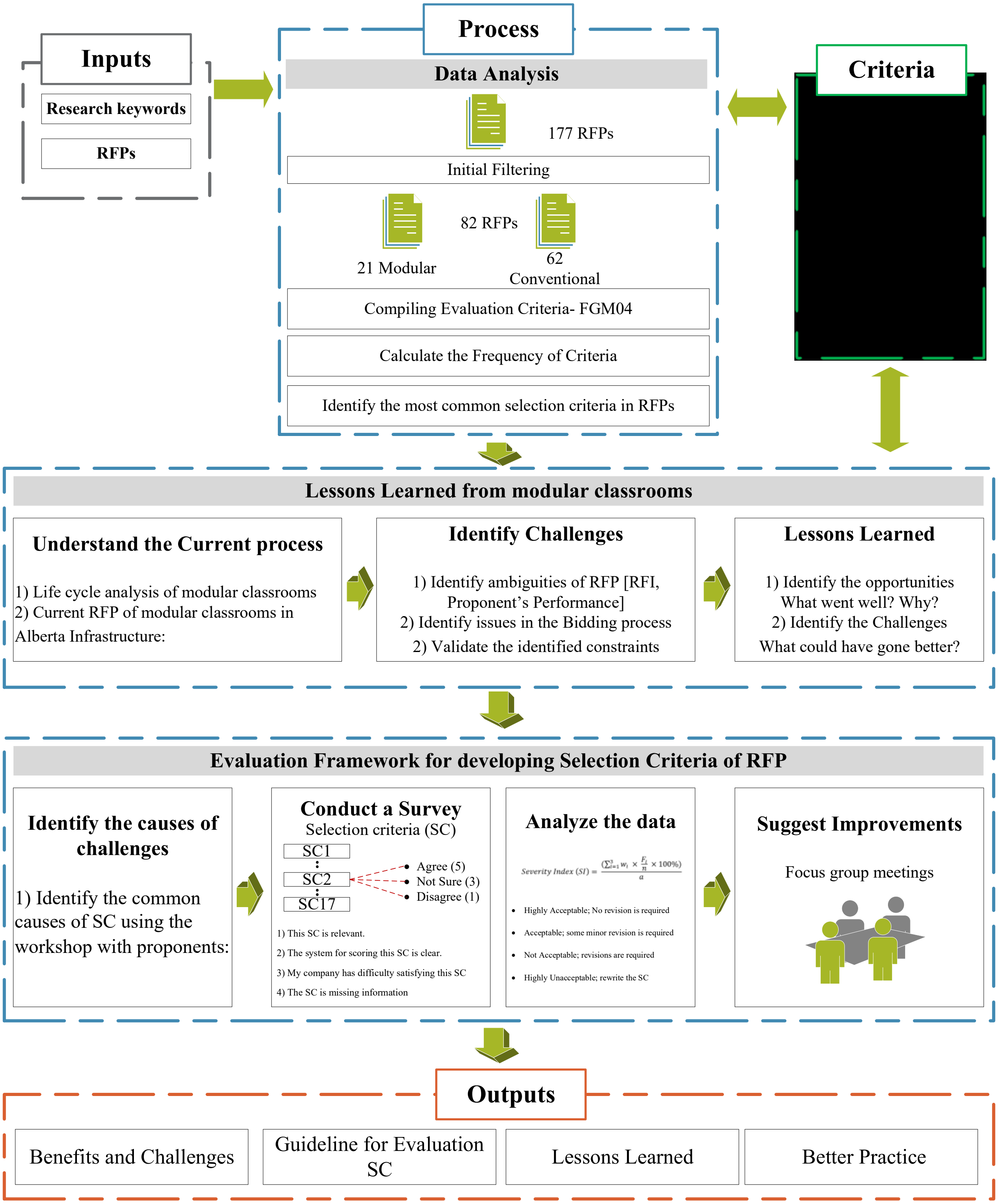


Figure 3- 1. Proposed methodology and framework

3.1 Data collection

In order to capture lessons learned, this thesis uses the following resources.

3.1.1 Literature Review

The literature review is an effective method to establish a better understanding regarding a particular topic and the findings and methodological features related to the topic. The literature review is conducted using recent academic publications and from worldwide websites.

3.1.2 Data Analysis

To analyze the recent issued RFPs, the research reviewed 177 RFPs to understand the most common selection criteria used in public RFPs across North America. It also further elaborates on the evaluation process of 3 modular classrooms RFPs issued in Canada.3.1.3 Procurement performance evaluation of 14 bidders

To establish a better knowledge of challenges and ambiguities encountered by bidders who participated in the procurement of modular classrooms in the supplying stage, the RFIs, amendments, and evaluation results of an RFP in which 14 bidders participated are reviewed and analyzed. Around 2010, Alberta Infrastructure, the owner of modular classrooms in Alberta, issued an RFP and invited the bidders to bid. A total of 14 bidders participated in the RFP, but only 4 bidders qualified. This research evaluates the performance of all 14 bidders based on each SC to understand the difficulties that bidders faced for each SC.

3.1.4 Workshop

A workshop for the owner and the bidders involved in the procurement process of modular classrooms was held at the University of Alberta. Around 157 bidders were invited by Alberta Infrastructure to discuss the challenges they encountered in satisfying each of the selection criteria. The workshop aimed to respond to the following objectives:

- understand the challenges faced by contractors submitting their proposal, and
- identify the common causes of each challenge related to the SC.

Contractors involved in the procurement process of modular classrooms were invited to address their issues with the current selection criteria used in the RFP for supplying modular classrooms.

3.1.4 Survey

This research uses a survey to gather professional perceptions of the constraints, challenges, and opportunities in the context of the current practice of procuring modular classrooms in Alberta. Therefore, a multi-choice questionnaire was circulated amongst the modular mailing list, including original respondents of the RFP. The survey was conducted among the bidders involved in the construction process of the modular classrooms in Alberta. All the bidders were invited by Alberta Infrastructure (Owner). The survey is included in Appendix 1. A total of 21 responses were received.

3.1.5 Focus group meetings

This thesis sought the opinions of industry experts to validate the findings through focus group meetings that followed the steps proposed by Morgan et al. (1998). Prior to conducting each meeting, a list of questions was developed according to the main objective of the session. Questions fall under two main categories: questions to evaluate the findings obtained from the last sessions, and questions asked to acquire more information. The recommended number of participants of focus group meetings is 8–12 (Morgan and Krueger 1998). All the participants have demonstrated involvement in all phases of modular classrooms. All these focus group meetings are recorded, and the minutes of meetings are used to collect, interpret, and analyze the required information. A total of 15 rounds of focus group meetings were conducted including 6 technical managers in the RFPs of modular classrooms, 3 modular professionals, and 3 procurement experts in modular construction. The main objectives in conducting the focus group meetings were to understand the current RFP, validate the identified challenges, and develop the improvements to the current RFP.

3.1.6 Site visits

In order to accurately capture lessons learned of modular classrooms and elements of modular classrooms, two site visits were conducted to modular classrooms. One of the site visits was to an existing modular classroom to see the challenges encountered in the process of operation. Another site visit was conducted in the process of installation and connection of modules.

3.2 Process

This thesis consists of two phases. Phase 1 includes lessons learned from the current practice of modular classrooms. The results present the opportunities and challenges faced by contractors and facility managers. Phase 2 uses the lessons learned to develop a framework for evaluation of selection criteria used in the supplying stage of modular classrooms. The results also suggest some improvements to be used in future RFP. A detail explanation of these phases has been explained as follows:

3.2.1 Phase 1: Lessons learned from the current RFP of modular classrooms

As it is illustrated in Figure 3- 1, this phase consists of three steps:

1) Understand the current practice of RFP

First, a life cycle analysis of modular classrooms is explained using a focus group meeting. The supplying stage of modular classrooms, as the most critical stage, has been further explored using process mapping technique. Then, the current process of RFP including its evaluation process, selection criteria and contract administration process, will be reviewed. The obtained information is evaluated using weekly focus group meetings.

2) Identify the challenges encountered in the process of modular classrooms

To investigate challenges faced by bidders in the bidding process, one of the RFP process issued in Alberta is used as a case study. Request for information (RFI) records and the results of the performance of bidders associated with each SC have been further explained.

3.2.2 Phase 2: Develop a framework to select the selection criteria (SC)

Figure 3- 1illustrates the methodology used in this research. First, the study identifies the most common SC used in the last RFPs as it is presented in section 3.3. For the purpose of verifying the identified constraints and processes, pilot interviews with professional experts are carried out. To establish a comprehensive knowledge of current issues and challenges, the information obtained serves as the basis for in-depth interviews conducted as part of a workshop with school board representatives.

Identifying the causes of issues with SC of RFP

A workshop is held involving owners/operators, suppliers, and end-users of modular classrooms held for the purpose of understanding the main issues with the current SC faced by prospective bidders. The main objective is to evaluate the identified challenges and issues from the interviews and literature review and subsequently identify the causes of each issue and constraint. The results of the workshop are used to design the survey.

The workshop feedback leads to the identification of the following issues with the RFP process:

- Clarity: Some requirements are viewed as ambiguous, especially when the word “similar” is used to describe a requirement. These are found in both the technical requirements and experience sections. Statements such as “similar experience,” “similar building,” and “similar wall type” are cited.
- Capability to meet the experience, history, capacity, and critical personnel requirements: Some respondents report feeling restricted by the requirement to provide proof of manufacturing experience and capability and also provide information about their manufacturing facilities.
- Lack of Objectivity: One of the issues identified in the workshop is that some of the criteria have unclear grading systems that lack objectivity.
- Relevance: Some of the criteria used in the current practice are perceived to be irrelevant to modular classrooms.

Conducting the Survey

To investigate the issues identified in the workshop, a multiple-choice questionnaire is circulated among representatives of the leading modular suppliers in Alberta, including the respondents to the original RFP. The primary purpose of the survey is to gather professional perceptions regarding the constraints, challenges, and opportunities in current practice with respect to the SC for modular classroom projects. The survey is designed in such a way as to solicit the perception of respondents of the evaluation criteria and sub-criteria in the RFP based on four categories:

- C1: Relevance to criteria (as a basis for pre-qualification of bid proposals),
- C2: Scoring clarity (clarity in the scoring system),
- C3: Difficulty satisfying requirements (as described in the issues identified in the workshop),
- C4: Lacking objectivity (incompleteness, vagueness, or any perceived impediment to objective, quantitative evaluation of respondent’s bid based on the stated criteria)

Each respondent is asked about the relevance, clarity, and difficulty to meet the criteria, is asked to identify any missing information in the criteria, and finally is invited to give any general comments they may have pertaining to the criteria. A total of 21 survey responses have been received to date. Participants are presented with four statements regarding the SC as shown in Table 3- 1:

Table 3- 1. Survey statements pertaining to the selection criteria

Statements	Agree	Not sure	Disagree
This criterion is relevant.			
The system for scoring this requirement is clear.			
I anticipate that my company may have difficulty satisfying this requirement.			
This requirement is missing information that would make it a more objective, quantitative evaluation.			

Statistical Analysis As illustrated in Figure 3- 1, the study uses a 5-point ordinal Likert scale to score each criterion. In keeping with best practice for a scoring system in ordinal scales, it is based on the rank order of criteria where the exact difference between two points is not known. For example, point 5 (Agree) represents a better definition of the criteria than point 1 (Disagree); however, the difference between these two points cannot be quantified. Johnson and Bhattacharyya (2014) concluded that non-parametric methods (clarity, relevance, etc.,) should be used to rank the items (SC) when a descriptive statistic (Yes, No, Not Sure) is to be selected. The study thus uses the following equation to calculate the severity index (SI) in keeping with the literature in this domain (Idrus and Newman, 2010):

$$Severity\ Index\ (SI) = \frac{(\sum_{i=1}^{3} w_i \times \frac{F_i}{n} \times 100\%)}{a} \qquad \text{(Equation 2)}$$

where *i* is a criterion's score (1 = Disagree, 2 = Not Sure, 3 = Agree) assigned by the questionnaire respondent; w_i is the weight of the assigned score (Agree = 5, Not sure = 3, Disagree = 1); F_i is the total frequency of score *i*; *n* is the total number of completed questionnaires, and *a* is the highest weight that can be assigned, which is 5 in this study. SI values range between 20 and 100; a positive SI is indicative of a higher degree of satisfaction while negative SI indicates less ambiguity such as difficulty and lack of objectivity. Consequently, each SI is assigned an importance level according to the following groups:

	Positive SI (Relevance, Clarity)	Negative SI (Difficulty and Lack of Objectivity)
▪ Highly Acceptable; No revision is required	SI > 80 %	SI < 50 %

- Acceptable; some minor revision is required 70 % < SI < 80 %   50 % <SI< 60 %
- Not Acceptable; revisions are required   60 % < SI < 70 %   60 % <SI< 70%
- Highly Unacceptable; remove the SC   SI < 60 %   SI > 70 %

The recommendations to the SC to improve the level of SI captured from expert knowledge collected from focus group meetings with owner and bidders of modular classrooms are provided per each selection criteria.

3.3 Data Analysis

3.3.1 Selection Criteria

The main objective of reviewing existing RFPs is to identify the most common SC and similar ways of applying these criteria in other RFPs. One hundred seventy-seven public RFPs are found online, and their respective evaluation processes, SC and grading systems analyzed. As search criteria for the RFPs, the following keywords are used: "Supplying," "Modular Construction," "Classroom," "RFPs." Of 177 RFPs, 82 are found to be relevant and their selection criteria reviewed. The following criteria used to determine the relevancy of the RFPs:

- Relevance to the supply stage of modular classroom procurement

- Relevance to building a facility

- Relevance to public sector projects

All the RFPs are from North America and have been issued over the past decade (2005 onward). The specifications of these RFPs are categorized in Table 3- 2.

Table 3- 2. Detailed information about the RFPs

Project Type		Project Delivery Method		Criteria Type		Selection Type	
Residential	15	Design Build (DB)	41	Quantitative	53	Best Value	53
Educational	41	Lease	8	Qualitative	19	Low Price	29
Hospital	1	Integrate project delivery (IPD)	5	Both	10		
Commercial	17	Construction Manager @ Risk (CMR)	24				
Urban	8	Public Private Partnership (P3)	2				
Total	82	Design-Build Finance Maintain (DBFM)	2				

To gain a better understanding of the most common SC used in RFPs, a content analysis method is used to extract, interpret, and analyze the SC used in 82 RFPs found online using the search criteria described above.

The SC are classified into 5 categories—technical, qualifications, schedule, project management, and price—in keeping with the methodology described by Gransberg and Barton (2007). To convert any qualitative criteria to quantitative in order to calculate the overall score, the algorithm proposed by Gransberg and Barton, as represented in Table 3- 3, is used.

Table 3- 3. The algorithm used to convert qualitative criteria to quantitative (Gransberg and Barton 2007)

Selection Type	Factors	Point distribution (S_i)
Low Price	Price equals all factors combined	If there are 5 other factors: • Price = 50% All other factors are assigned the remaining 50%: • Factor A= 10% • Factor B= 10% • Factor C= 10% • Factor D= 10% • Factor E= 10%
Best Value-qualitative	All factors are assigned as equal	If there are 5 factors: • Price= 20% • Factor A= 20% • Factor B= 20% • Factor C= 20% • Factor D= 20%

To filter the initial results captured from the RFPs, focus group meetings are conducted involving 4 bidders involved in the process of modular construction. The main objective of these meetings is to identify any criteria that overlap. The results are categorized in Table 3- 4, where "Repetitions (R_i)" is the sum of a given criterion is either quantitative or qualitative form, while "Importance (I_i)" represents the total level of importance based on the overall score (S_i) of all the criteria among the 82 RFPs under study, as expressed in Equation 1.

$$I_i = \frac{S_i}{\sum_{i=1}^{n} S_i} \qquad \text{(Equation 1)}$$

It should be noted that "Average" here indicates the average weighting of each criterion used in an RFP and is calculated by dividing the total score (S_i) by the number of repetitions (R_i). "Rank," meanwhile, rates each criterion according to its level of importance (I_i) within the two groups of sub-criteria and the five main criteria.

Table 3- 4. The results of reviewing 82 RFPs

i	SC	Criteria	Quantitative	Qualitative	Repetitions (R_i)	Total Points (S_i)	Importance (I_i)	Average (S_i/R_i)	Rank
1	P1	Bidding cost (+29 Low price)	35	8	71	2586	28.14%	36.42	1
Price						**2586**	**28.14 %**		**2**
2	T1	Proposed Methodology for Design	15	3	18	270	2.94%	15.00	10
3	T2	Sustainability of Design-LEED Plan	9	4	13	176	1.91%	13.54	11
4	T3	Technical Design objectives	5	1	6	49	0.53%	9.80	25
5	T4	Understand Local Assets	5	1	6	62	0.67%	10.33	21
Technical						**557**	**6.06 %**		**4**
6	Q1	Organizational Experience	48	16	64	1198	13.03%	18.91	3
7	Q2	Interview	8	1	9	140	1.52%	15.56	12
8	Q3	Past Project Performance	45	16	61	1315	14.31%	21.21	2
9	Q4	Financial Capacity	10	11	21	294	3.20%	14.00	7
10	Q5	Manpower and Equipment	15	8	23	306	3.33%	13.30	6
11	Q6	References	17	8	25	271	2.95%	10.84	9
12	Q7	Insurance	0	7	7	59	0.64%	8.43	23
13	Q8	Financial Background/stability	5	5	10	110	1.20%	10.80	15
14	Q9	Compliance with agreement and Regulations	4	2	6	87	0.95%	14.50	18
15	Q10	Financial Strategy/Plan	4	5	9	125	1.36%	13.89	14
16	Q11	Background History	3	5	8	71	0.77%	8.88	20
Qualification						**3976**	**43.26%**		**1**
17	S1	Schedule Management	19	7	26	472	5.14%	18.15	5
Schedule						**472**	**5.14%**		**5**
18	PM1	Suitability of Proposal	13	6	19	277	3.01%	14.58	8
19	PM2	Value Add- Innovation	2	3	5	90	0.98%	18.00	17
20	PM3	Warranty	3	4	7	61	0.66%	10.17	22
21	PM4	Quality Management System	5	3	8	75	0.82%	9.38	19
22	PM5	Safety Plan	7	3	10	107	1.16%	10.70	16
23	PM6	Customer Support	6	1	7	130	1.41%	18.57	13
24	PM7	Project Management Plan	27	17	44	810	8.81%	18.00	4
25	PM8	Cost Management	3	2	5	50	0.54%	10.00	24
Project Management						**1600**	**17.41 %**		**3**

Although most of the criteria in the RFPs are found to be quantitative rather than qualitative, there are a few exceptions, such as Q7, Q4, Q10, Q11. The results show that while bidding cost (P1) has the highest importance level among the sub-criteria, the total importance of qualification (43.26 %) is higher than other criteria such as price (28.14 %), a finding which underscores the importance of qualification among the main SC. It should be noted in this regard that, although Gransberg and Barton (2007) conclude that price has the highest level of importance, the results of the present study show qualification to be more critical, which may be due to the fact that most of the RFPs under study are based on best-value as the type of selection.

3.3.2 Comparative analysis of evaluation process of RFPs of Modular Classrooms

This section explores the different sets of selection criteria used for the supply stage of modular classrooms. Four RFPs are identified across North America: British Columbia, Ontario, Alberta and Florida (USA). All these RFPs have been used to procure modular classrooms. For each RFP, the selection criteria, the grading system, the RFP process, payment term. and the process governed in the stage of bidding and post bidding has been identified and analyzed. Figure 3- 2 represents their evaluation processes as well as the selection criteria and the type of criteria used per stage. Further investigation of each RFP will be provided to identify the unique conditions associated with each process.

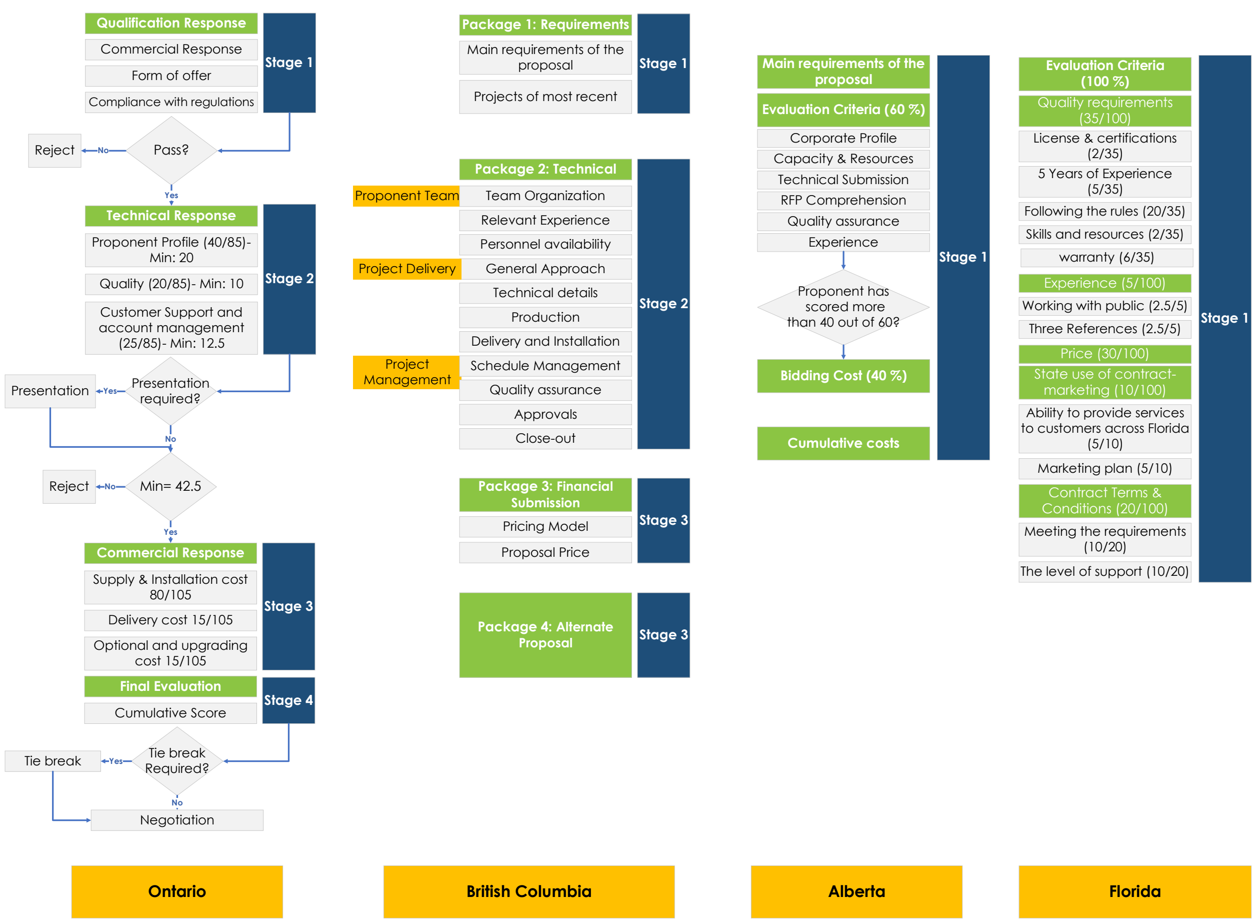


Figure 3- 2. Evaluation Process of current public RFPs of modular classrooms over North America

Toronto Ontario Education Collaborative Marketplace (OECM): The RFP invites bidders for design and supplying modular classrooms. The criteria type used in the RFP includes both quantitative and qualitative criteria.

The RFP is issued to invite from prospective bidders for the supply and installation of portable classrooms on an as-and-when-required basis. The purpose of the RFP is to select the supplier capable of meeting the following conditions:

- will be capable of providing the modules in a timely manner and be able to demonstrate value for money;
- provides client professional and responsive customer support and account management; and
- reduce the costs of competitive procurement processes related to the modules on an ongoing basis.

The selected contractor must enter into two agreements:

- Between the owner and contractor: The master agreement is between the selected bidder and the owner's representative. The term of the agreement is intended to be for three years, however. the owner has the ability to extend the contract duration for a maximum of two years (for a total of five years).
- Between clients, governed by owner, and contractor: Clients participating in the agreement (school boards, college clients, university clients) will execute a client-supplier agreement (CSA) with a supplier and negotiate their unique requirements with the supplier and mutually agree to additional terms and conditions in a way that terms would be consistent with the master agreement.

The contractor is supposed to provide a warranty for the modules against defect in materials and workmanship for a minimum of 12 months from the date of installation and substantial completion. Roofing and structural components are warranted for a minimum of 36 months from the date of installation. Payment terms are net 30 days.

The whole process consists of 4 main stages however, the bidder is expected to submit the completed proposal before starting the first stage and is not able to change the proposal once the bid is closed; at the first stage, the bidder must ensure that all qualification requirements have been addressed satisfactorily in the proposal in order to proceed to the second stage. Stage 2 includes the evaluation and scoring of each eligible proposal on the basis of the bidder's technical responses. A bid that meets or exceeds the minimum thresholds will receive a pass in this stage and proceed to the next stage of the evaluation process. The bidder must demonstrate their understanding of the RFP deliverables by providing responses validating its capabilities.

Following evaluating the technical responses, the highest-scoring proposals or all bidders may be invited to a presentation. Within the presentation, the bidders are asked to address their capabilities as they relate to the deliverables such as exhibiting the capabilities of its products, implementation plan, and exhibit how the product brings value and savings to clients.

The approved bids proceed to the next stage based on which the commercial responses are evaluated. Evaluation of the bids is based on the relationship of the bidder's rate in comparison to other bidder's proposed rates.

Stage 3: At this stage, the scores from the last stages will be totalled for each bidder. The bidder with the highest-scoring proposal may become the preferred bidder and invited to negotiations. In the case where two or more of the highest scoring proposals achieve a tie-score, all bidders may be invited to negotiations or the tie may be broken by selecting the proposal with the highest score in the technical response.

The negotiations may include resources agreement terms and conditions, additional references, and rates and final offer. The selection type of this RFP is the best value type and the type of evaluation criteria is a combination of both qualitative and quantitative through three stages.

Florida Panhandle Area Educational Consortium: Bidders are asked to provide their related experience in terms of providing, constructing, transporting of modular buildings to schools and other government entities. The bidders are asked to describe the staff's experience with appropriate licensing and credentials to perform all work associated with the installation or construction of modular buildings. The scope of the RFP is to establish a term contract for the rental, lease or purchase and placement, or relocation of the modular classroom. The selection criteria are quantitative, and the type of evaluation criteria is the best value.

- Quality requirements
  - The bidder must specify all the required licenses and certifications required for the business.
  - The bidder must provide at least 5 years of experience in the construction, leasing and sale of modular buildings/ classrooms.
  - The bidder should clearly demonstrate the resources, skills and certifications of their staff to construct, deliver modular buildings/classrooms.
  - A comparative analysis of warranty proposed by the bidder during the review process.

- Previous Experience
    - Provide evidence of experience working with public entities.
    - Provide evidence of at least three references willing to offer comments relative to the experience of working with the company or individual.
- Pricing: The relative ranking of the contractor's pricing proposal compared to other RFP submissions. The price must be provided based on two options of leasing and purchasing.
- Regional/ State use of contract-marketing: this requirement will be evaluated based on the following conditions:
    - The extent to which the bidder has demonstrated the ability to provide products and services to eligible customers in all 67 of Florida's school boards.
    - The extent to which the respondent has a marketing plan and willingness to execute it.
- Contract Terms and Conditions; this requirement will be evaluated based on the following conditions:
    - Providing the required documents, adherence to formatting, and met all of the terms and conditions outlined in the proposal.
    - According to a comparative analysis of the questionnaire as well as the level of support and participation of the bidders in the PAEC Florida Buy program.

British Columbia: The purpose of this RFP is to invite interested bidders to prepare and submit proposals for design, production, delivery, installation, commissioning, and associated work for modular classroom solutions. The selection criteria are qualitative and the type of selection is the best value.

The owner will provide funding to school boards for the purchase, delivery, and installation of each modular classroom. The selected bidder will enter into a 1) master agreement with the owner, and 2) modular classroom contract with the designated school boards.

The selected bidder would be responsible for site inspection, design and production, delivery, installation and commissioning, including connection to services and utilities, permits and approvals.

Financial requirements required for the RFP include as following:

- Compliant with the affordable ceiling cost, which is stated by the owner and the bidding costs are evaluated based on that.
- Performance bonding
- Pricing model form based on whether the bidder specifies the cost of the modules based on different conditions of purchasing or leasing.

Evaluation of proposals:

The evaluation process may be required reference checks relevant to the project, background investigations and interviews or presentations for more clarifications which might occur if the owner requests.

The current RFPs of modular classroom clearly represent similarities including:

- All the RFPs have the best value as the type of selection, which is more compatible with the requirements of modular construction where life cycle cost should be taken into consideration rather than the cost of construction.
- Two RFPs are using quantitative selection criteria, while one is qualitative. The RFP used in Ontario uses both quantitative and qualitative selection criteria during the evaluation process. It was found that the quantitative type of selection criteria is more common and might be more explicit as it is more widely used, while the use of qualitative criteria increases the subjectivity of the evaluation process.
- As it is consistent with the findings of the literature review, the evaluation criteria of RFPs could be divided into four similar groups of qualification, technical, project management, and schedule.
- Three RFPs consider the bidding cost of the proposals that have obtained the majority of the scores related to selection criteria, while only one RFP (Florida) evaluates the proposal cost and other selection criteria once in one stage. It is suggested that the bidders might feel more comfortable to participate at the RFPs where they do not evaluate the bidding cost at the first stage.

Chapter 4: Lessons learned from the current RFP

4.1 Life cycle of Modular classrooms

Figure 4- 1 shows the stages of the modular classroom life cycle. As is illustrated, there are four stages of procurement. In the supply stage, the design is approved by the owner's consultant before commencing production. In case the supplier is new to modular classrooms, the owner asks the supplier to produce prototypes according to the specifications approved in the design stage. If the prototypes are approved by the consultant, those modules can be used as partial fulfillment of the project scope specified in the contract. Following the production stage, the supplier is expected to store the module in the storage place specified in the proposal, until the pick-up date. Transportation of the module can be provided by either the supplier or a transportation supplier hired by the owner and is the subject of negotiation between the owner and supplier. This stage is required only when a new modular classroom is required. The module is then transported to the site and stored in a suitable location until installation. The supplier that has been awarded the installation, which is a separate procurement, is responsible for performing the installation of the module and connecting it to any other modules and to the school core.

In the operation stage, an RFP is issued for maintenance of the module(s) during operation. In the case that a modular classroom is no longer required at a given school due to decreasing enrollment, it may be detached and relocated. The module will be transported and installed at another school, where increased classroom space is required. This stage, the replacement stage, entails finding an eligible bidder according to the specific requirements of the project.

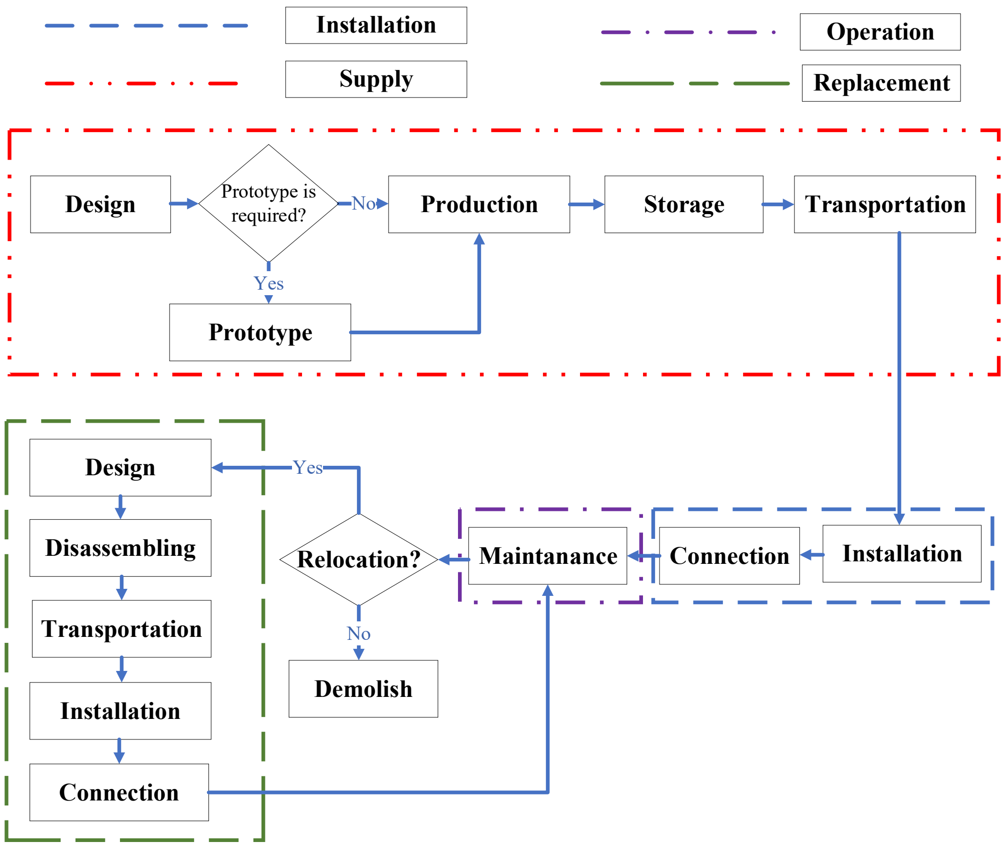


Figure 4- 1. The life cycle of modular classrooms

The research presented in this thesis seeks to identify issues and challenges at the supply stage as one of the most significant stages in the modular classroom life cycle. Therefore, only the current SC used in the supply stage is investigated.

4.2 Current RFP process of modular classrooms in Alberta

To gain an understanding of the current practice, modular classrooms constructed in Alberta, Canada, are selected as a case study. The RFP communicates the intent of the public owner regarding the technical and functional specifications of the modular classrooms. Compliance of bidders to the performance requirements stated in the RFP ensures that the desired energy efficiency, acoustics, comfort, hygrothermal performance, fire rating, and durability of the building are achieved. A recent RFP in the case jurisdiction, however, generated a very low response in an otherwise highly competitive market; also, the poor performance of bidders from the bids received suggests the existence of conditions hindering expected participation by more qualified bidders from the modular construction industry. Out of a total of 14 bids received, only 4 bids were qualified and awarded projects. This was due to the lack of clarity in the evaluation process, in the SC, and in the primary requirements set out in the RFP issued by the owner which deterred prospective bidders from submitting a proposal, leading the owner to cancel the RFP and re-issue it with improvements, which led to increased costs. Based on the identified life cycle, this section identifies the current practice of modular classrooms in Alberta.

4.2.1 Procurement Stage

The procurement process used in Alberta is a combination of issuing RFP and 3–5 years of standing order stage when the orders will be issued by the public owner of modular classrooms and contractors need to deliver the modules.

Every 3–5 years, the owner invites bidders to submit their proposals for the RFP. Each bidder submits its bid according to the specifications and requirements set in the RFP. The specifications specify the performance requirements including the architectural, structural, and mechanical requirements of each unit. To facilitate the process of connecting the units to each other, 13 different types of units are generated. Figure 4- 2 shows different types of units.

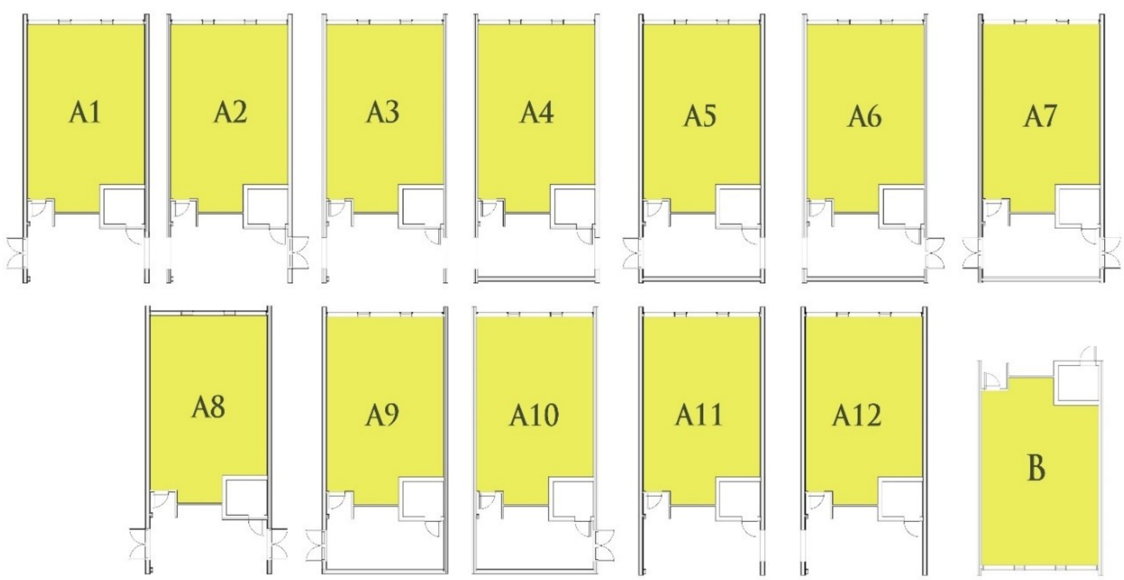


Figure 4- 2. Different types of modular classrooms used in Alberta

Control Systems: Modular classrooms are often set apart from the school building and therefore are not connected to the school's energy management system. Therefore, each module is equipped with a control system that is a secure method for school staff to monitor the energy consumption and comfort levels in modular classrooms.

These systems are programmed to control the temperature and ventilation inside the modules. The program can be reset regularly or on an as-needed basis, enabling the school board to ensure that the modular classrooms are operating efficiently in the maintenance stage. A furnace is connected to the control system that senses the temperatures inside and outside the classroom and then adjusts airflow and heating as required (SPOSA 2005).

In terms of structural loads, there are two types of modular classrooms responding to Alberta's climate zones; standard, and heavy. Standard refers to the regular regions where the amount of snow is normal, whereas heavy is more suitable for those areas having heavy snow. Also, these two models may be used together where the heavy units are placed next to the school core building where there might be more snow due to the slope of the roof of the school core building, while the standard units are used where less snow is expected (Figure 4- 3).

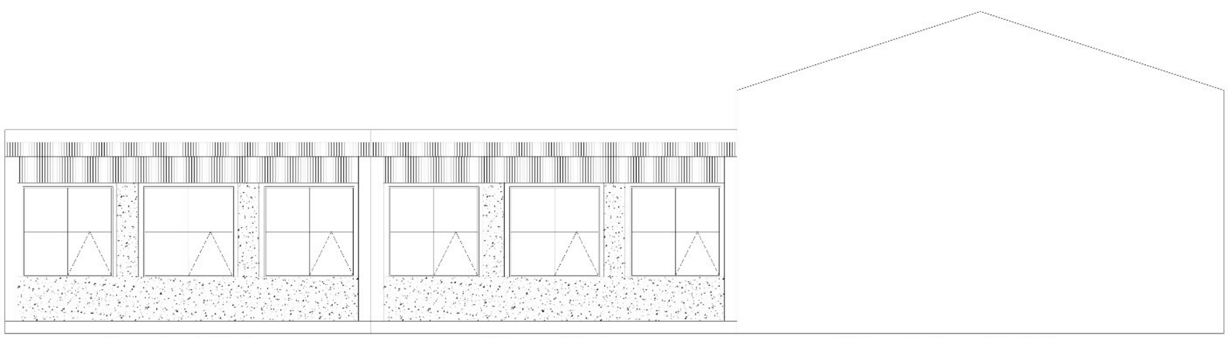


Figure 4- 3. Using different types of units in a school

Evaluation Process: Once the bid is closed, the process of evaluation of proposals starts. Figure 4- 4 shows the evaluation process of modular classrooms in the province of Alberta. The process of evaluation is accomplished in two different sections. The first section includes non-financial criteria and evaluates the proposals according to their team experience, technical documents, the methods used for quality assurance and a summary of completed projects. Table 4- 1 tabulates the selection criteria used for the evaluation of the proposals as well as their respective maximum points. The second section evaluates the proposals according to the proposed bidding cost.

As illustrated in Table 4- 1, the history of the bidder and its key personnel, facility and organization will be evaluated as Corporate profile (SC1). Capacity and resources (SC2) examines the capacity of each bidder and their plan for inspection and delivery of the modules. To be compliant with the technical requirements (SC3), the modules must be able to move at least three times over 30 years and meet the high-performance technical requirements such as design loads, acoustic requirements, indoor air quality etc., as specified in the RFP. LEED standards have been added to the main requirements of RFPs in order to address concerns such as comfort condition, energy efficiency, quality, and durability of the building. To facilitate the process of connecting modules to each other, the control system installed in each module must be consistent and similar to the one introduced in the RFP. The next selection criterion (RFP comprehension- SC4) requests bidders to discuss and specify any challenges and unique requirements as feedback to improve the current RFP. Quality assurance will evaluate each bidder according to the tools and techniques used to monitor the quality over different stages. To evaluate three relevant experience of each bidder based on the completed projects, SC6 is allocated 5 points. Relevant experience is defined as follows:

- experience in assembling and managing multi-disciplinary trades and professionals including design, production, delivery and energy-efficient modular facilities;
- experience in managing performance to meet its contractual obligations under tight timeframes;
- experience in managing fast-tracked projects with highly dependent and integrated activities; and
- experience in working with multiple clients and contractors simultaneously.

Table 4- 1. Selection criteria used to evaluate the proposals

	Evaluation Criteria (Non-Financial Requirements)	60
SC1	Corporate Profile	5
SC1.1	History of bidder: type of services and construction provided and areas of expertise (Provided and relevant =2 pts, provided and partially relevant= 1, not provided=0)	2
SC1.2	Key Personnel's experience: (provided= 1, not provided =0)	1
SC1.3	Identify manufacturing facilities: (provided= 1, not provided = 0)	1
SC1.4	An organization chart that explains how the key personnel are organized, by indicating formal reporting lines and informal lines of communication (provided= 1, not provided = 0).	1
SC2.	Capacity & Resources	20
SC2.1	Capacity and Resources: Provide information about capacity and resources and how they will be managed (fully provided = 5, partially provided = 3, not provided = 0)	5
SC2.2	Manufacturing Capacity: Describe and provide details of their manufacturing capacity per month and information if capacity could be increased (capacity of 16 units and more= 5, 12 units = 4, 8 units = 3, 4 units = 2, 3 to 1 unit= 1, not provided = 0)	5
SC2.3	Prototype design and Manufacturing schedule: A schedule to meet design and manufacturing that lists steps for the prototypes, Inspection and Approval schedule or written approvals for each prototype within 6 last months must be provided (0-3 months = 5, 3-6 months = 4, 6-12 months = 2, 12 + months = 0)	5
SC2.4	Tracking schedule performance: Describe strategies for ensuring the completion date will be met, including tracking and early indication of schedule performing issues should be provided (fully provided = 3, partially provided = 1, not provided = 0)	3

SC2.4	Pre-Inspection & Delivery Plan: Describe and provide the bidder's plan for pre-inspection and delivery and storage of modular classrooms including size and location of storage premises; plan for proper storage and access to storage site (fully provided=2, partially provided = 1, not provided = 0)	2
SC3.	Technical Submission	20
SC3.1	Technical Submission: Bidder should provide a technical submission that includes product specifications and drawings, (fully inclusive of all elements = 10, includes most elements of the requirements but needs further investigation = 5, technical submission provides minimal or little information to assist the submission = 0)	10
SC3.2	Adherence to Performance Specifications (Fully provided=5, partially provided=3, not provided=0)	5
SC3.3	Ensure LEED Comprehended: The approach and steps the bidder will use to ensure the LEED Silver (49 points to be eligible for Silver certification) should be described. (Fully inclusive of all elements and in compliance with LEED requirements = 5, includes most elements of the requirements but needs further investigation = 3, provides minimal or little information to assess submission = 0).	5
SC4.	RFP Comprehension	5
SC4.1	Unique Requirements and Challenges: The bidder should provide a brief analysis of the unique requirements and challenges of this RFP, from the bidder's perspective, based on the information provided in the RFP or which the bidder anticipates. The bidder should present an understanding of the Agreement requirements, identify any special needs or considerations which the Province may not have identified, and suggest approaches for addressing them (Provided = 2, partially provided = 1, not provided = 0)	2
SC4.2	Risk Management: The bidder should describe and identify risks and descriptions of how they might be managed including labour, materials, components, testing, equipment, delivery, warranty and other risks (Fully provided = 3, partially provided = 1, not provided = 0.	3
SC5.	Quality Assurance	5
SC5.1	Quality Assurance Plan: Quality assurance plan for the design, testing, production, delivery of Modular Classrooms and associated work processes including roles and responsibilities related to quality assurance. (Fully provided=3, partially provided=2, minimally provided=1, not provided= 0)	3
SC5.2	Management and quality assurance systems: strategies and skills that will be employed to ensure that the Province's expectations around project scope, time, cost, quality and performance will be met (Fully provided = 2, partially provided = 1, not provided = 0).	2
SC6.	Experience	5
SC6.1	Experience Summaries and References: Bidders should provide summaries and related references for up to three (3) completed projects within the last five years for which the bidder or key personnel have provided buildings and services similar in terms of scope to those in the RFP. (3 projects= 5, 2 projects =3, 1 project = 1, not provided =0)	5

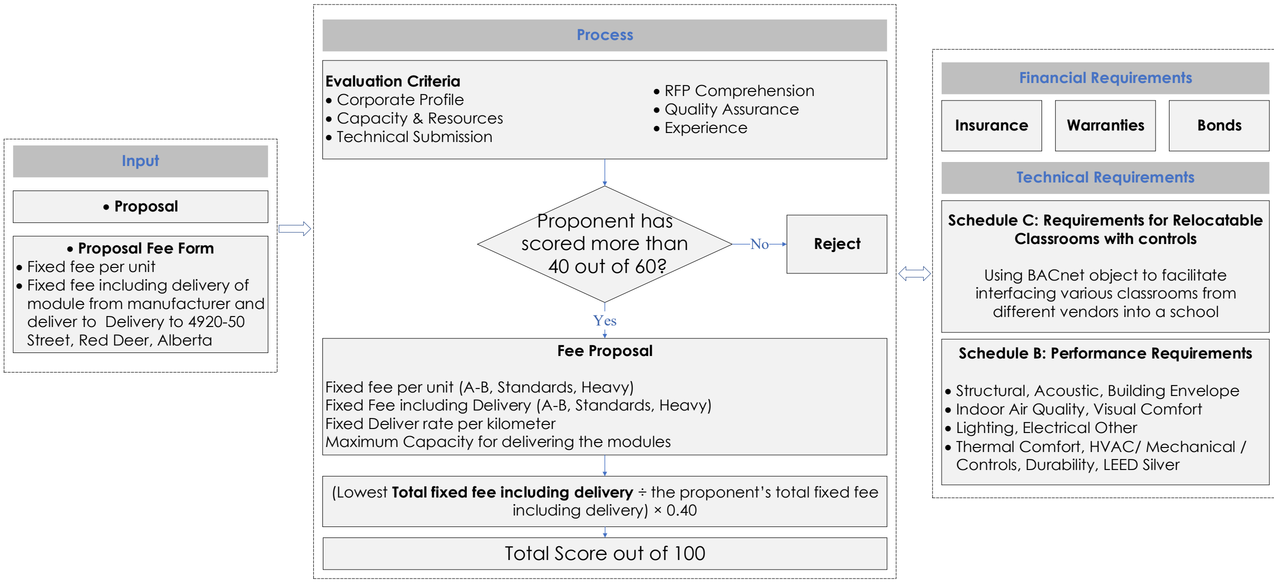


Figure 4- 4. The evaluation process of modular classrooms.

Bidders that get 40 points out of 60 points in the first section will be considered at the second section where bidders propose the price under two different conditions: 1) fixed fee including delivery consists of production and transporting the module to the central point of Alberta from which the distance is equal to the corner points of province; 2) fixed fee per unit, which is only the cost of each module. The bids are evaluated based on the cost proposed in the fixed fee including delivery to the center point of Alberta province as the location of the manufacturer might affect the cost of transportation if the factory is outside the Alberta which makes the bidder responsible for the transportation services. Also, the bidders are required to provide the cost of transportation of the module per kilometre. The algorithm used for calculating the cost of transportation in case of using the first condition (fixed fee including delivery) is illustrated in Figure 4- 5. if the distance between the manufacturing site and the defined location will be X1 and the total distance between manufacturing and school site will be Y, there would be two situations where

- X1 is greater than Y: the supplier is responsible for transporting the module to the school site;
- X1 is less than Y: The cost of the rest of the distance is calculated based on the fixed cost of transportation ($/ft) contractor has suggested in the proposal fee form.

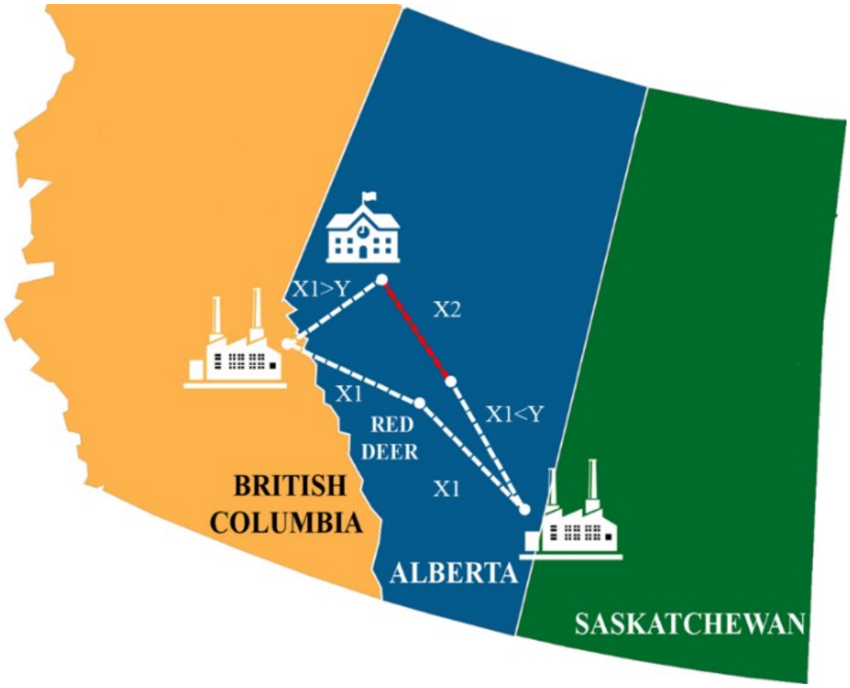


Figure 4- 5. The method of calculating the transportation cost

During the evaluation of proposals, at least 5 bidders may be awarded. The bidders will enter the contract with the public owner. The contract stands for 3 years and can be extended to 5 years if the owner requests. Based on the location of the schools or capacity of each contractor, the owner issues a purchase order to request new modules. The minimum number of units is guaranteed to be 25 modules.

4.2.2 Standing order stage

Meanwhile, 67 school boards across Alberta decide on the type of project they need based on the total numbers of enrollment and the building conditions they have. There are three types of the project defined in the process of modular classrooms.

- Modernization refers to any refurbishments or renovation to the classrooms, for instance, changing the door, windows or repairing a crack. The process of modernization may differ according to the estimated cost of the project. For costs less than $5,000, the school board might ask a vendor from their prepared list to fix the problem. If the project costs between $5,000 and $75,000, the school board is allowed to invite local vendors and award one of them to finish the job. The regulations governed during this stage are defined in the MASH sector (Municipalities, Publicly-Funded Academic, School Boards, Health and Social Service Entities)

(Government of Alberta, Government of British Columbia, and Government of Saskatchewan 2010). Both of these conditions fall under the responsibility of school boards and they do not need to obtain permission from AI. The cost of the project is paid by school boards from the amount of money they get per year based on the number of enrolled students for the maintaining of schools. However, if the cost of the project is estimated to be higher than $75,000, the school board is required to submit the project to the owner, and the owner will decide on the type of the project according to the cost of the project. In the case of approval for modernization, the cost will be provided by the owner from the Infrastructure Maintenance Renewal (IMR) program.

- New Classroom: If a new unit is required, the school boards will submit the request to the public owner. The owner accepts the request in February of each year. Since the cost of all of the requested classrooms is much higher than the total available budget, the owner uses evaluation criteria to award the project with higher preference (Figure 4- 6). It should be taken into account that this process is only applicable when the new modules are supposed to be placed in an existing school. For new schools, the new modules are requested directly by the public owner and no approval is required.

In the case where school boards have funds available to purchase a module, they can order the module directly without getting approval from the owner. School boards should check the availability of the high-performance modular classrooms with the manufacturers and leasing companies and receive competitive pricing. Districts should always identify the need for relocatable buildings as early as possible since high-performance modular classrooms may not always be available on short notice.

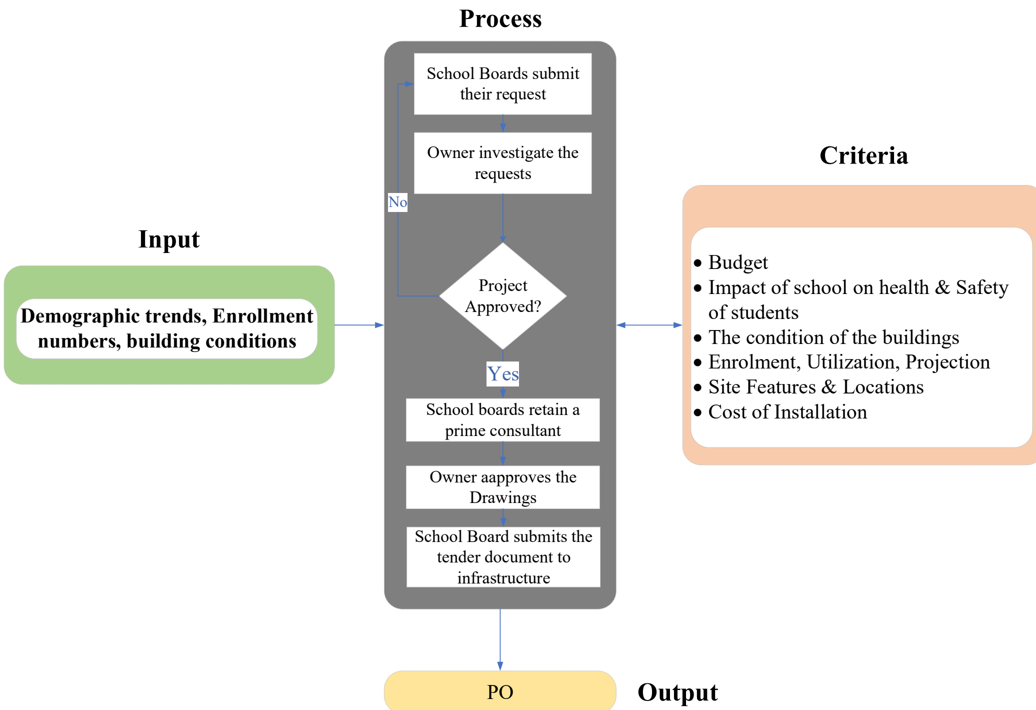


Figure 4- 6. The process of qualifying a new modular classroom

Purchase order (PO): Following approval of the project, the public owner issues a purchase order specifying the detail requirements of modules. While the modules should be produced according to the specifications set in the RFP, some specific adjustments may be requested by the owner on behalf of the school board receiving the module. The adjustments include mill workings, sinks etc., which should be specified based on the school board's needs. Then, the selected bidder of the modular classroom uses the specification to prepare the shop drawings based on which the modules are produced.

As illustrated in Figure 4- 7, different types of modules can be configured based on different locations and site conditions. Vestibules are used to connect the modules to the school core building. The specific number of modules (minimum 25 units) and their specific types (standard-heavy) will be stated in the PO issued by the owner. Furthermore, depending on the project and the receiver school board, the utilities, sprinkler, millworks, and sink might be requested as particular requirements of the module. For instance, in the process of visiting sites, some school boards may ask not to install the ceiling and leave the space as it is illustrated in Figure 4- 8. All these requirements will be specified in the PO associated with the required date of delivery. The manufacturer is expected to deliver the unit by the time specified, otherwise they will be charged $500 per module per each calendar day.

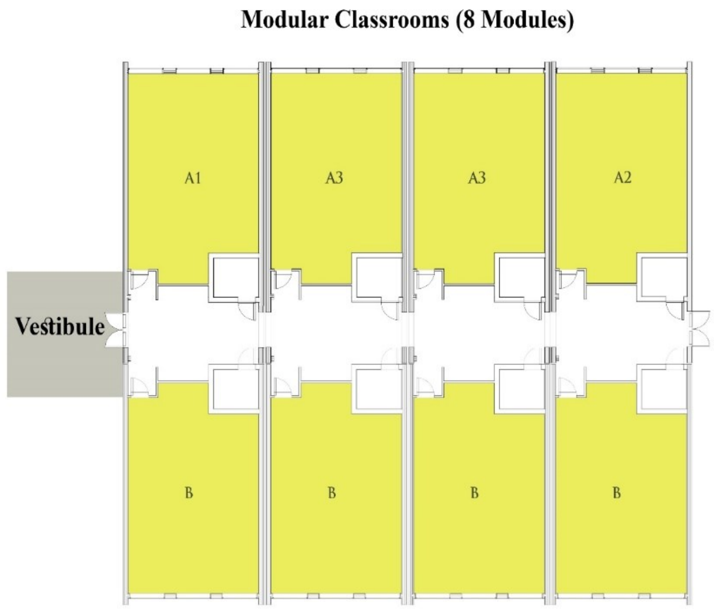


Figure 4- 7. Configuration of different modules by the owner at the time of standing order

Figure 4- 8. Specific Requirements of modular classrooms

4.2.3 Summary

The responsibilities associated with each member of the project should be stated in the RFP issued by the owner. Generally, the selected supplier in the procurement stage is responsible for producing, storing and delivering the module at a place near the school site. Another contractor, selected in the installation stage by the school boards within another RFP, is responsible for receiving the module and connect it to the school building. Coordination between the supplier and the contractor is required to ensure the time and cost-efficiency of the project. The ownership of the module should transfer between contractors as the module delivers to the school. This process ensures the quality of the project as the selected supplier in the procurement stage may not be familiar with the permits and local approvals required for the installation of the module. Figure 4-9–4-12 demonstrates the procurement process of modular classrooms in Alberta.

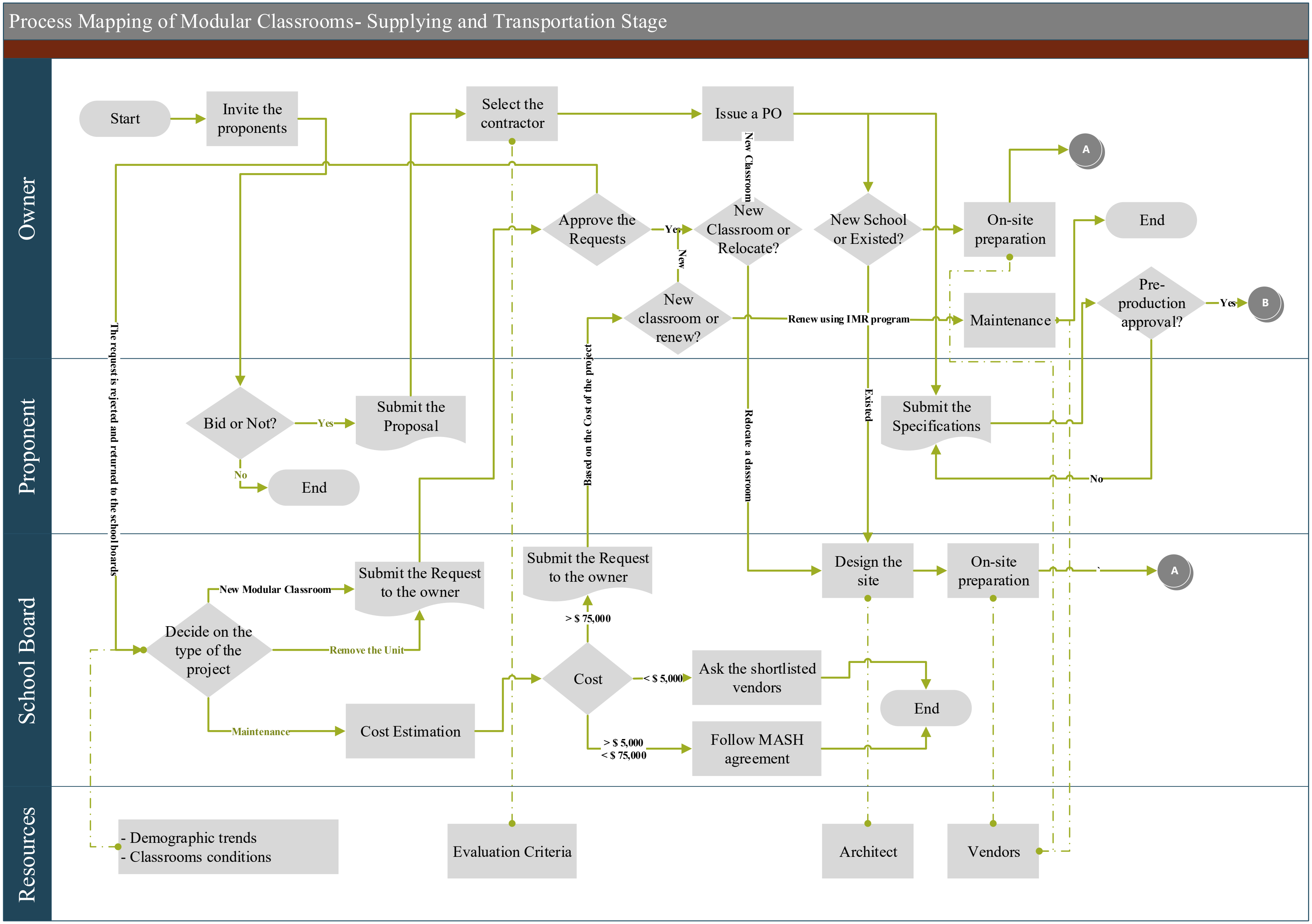


Figure 4- 9. Process mapping of the current process- part 1

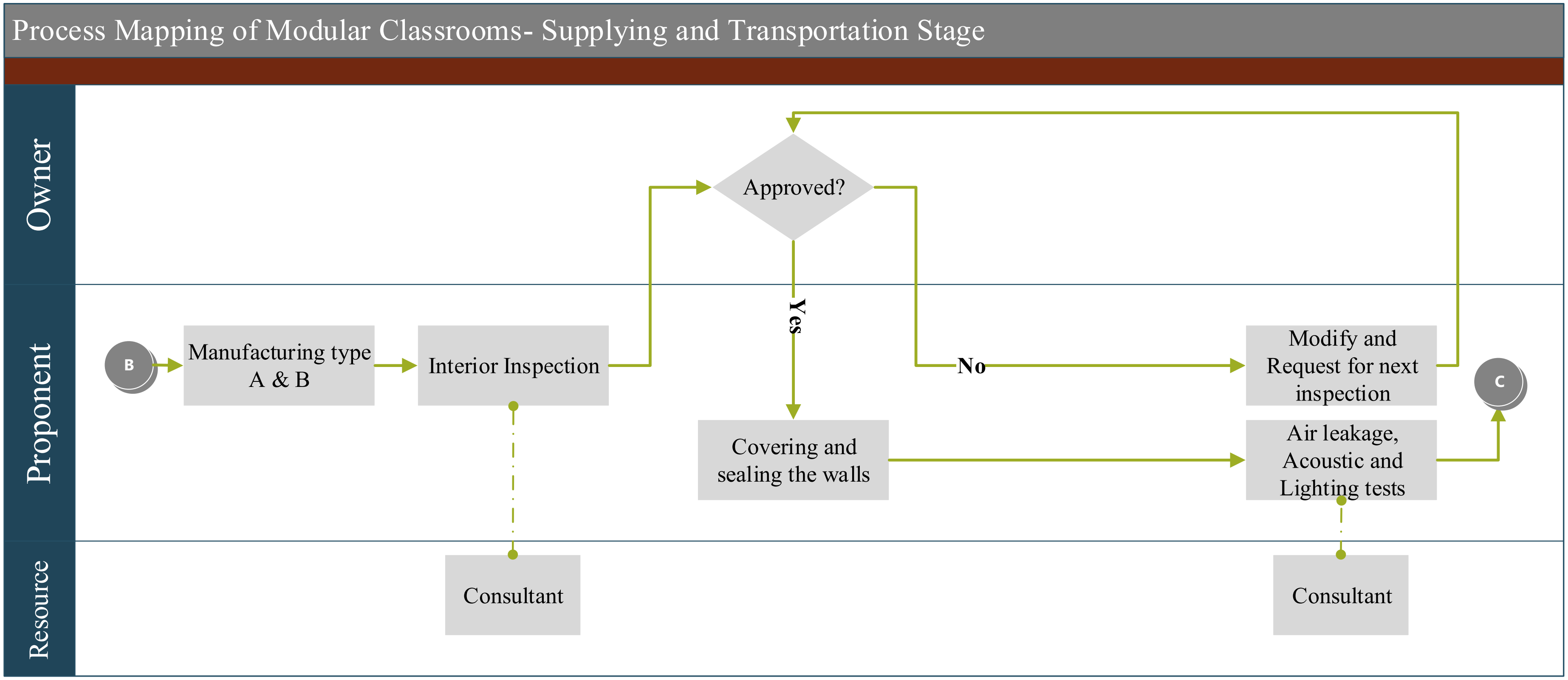


Figure 4- 10. Process mapping of the current process- part 2

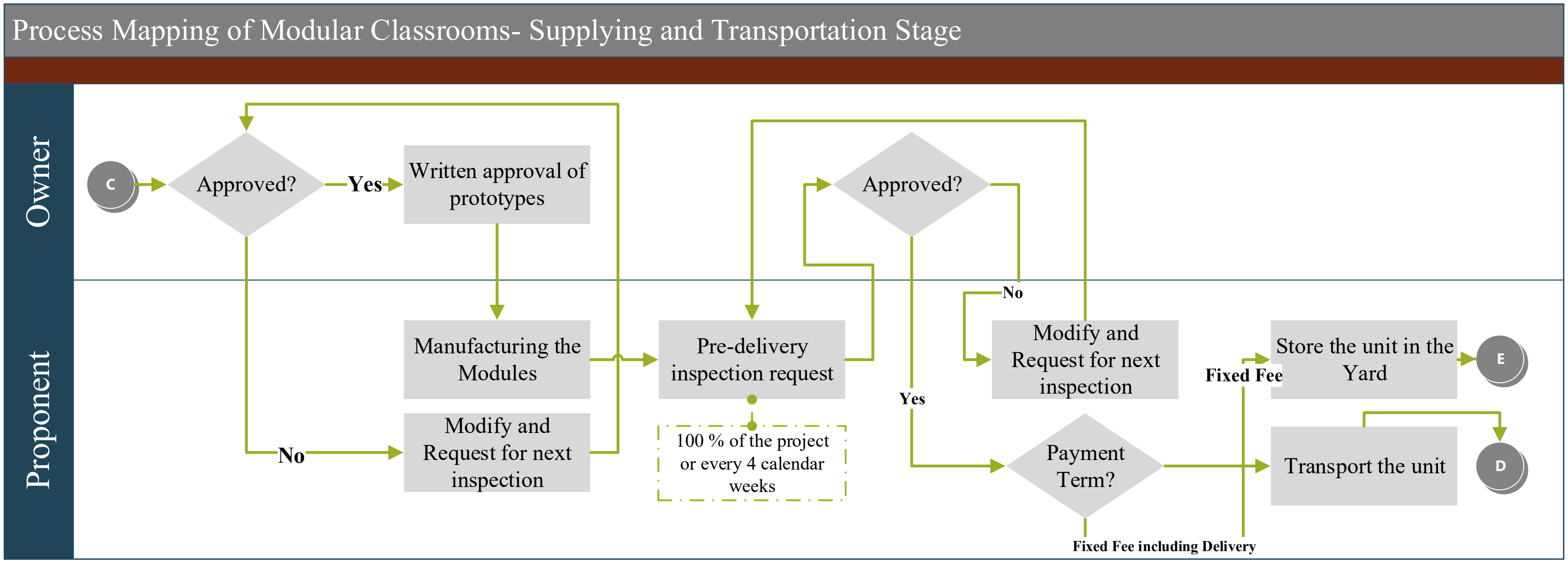


Figure 4- 11. Process mapping of the current process- part 3

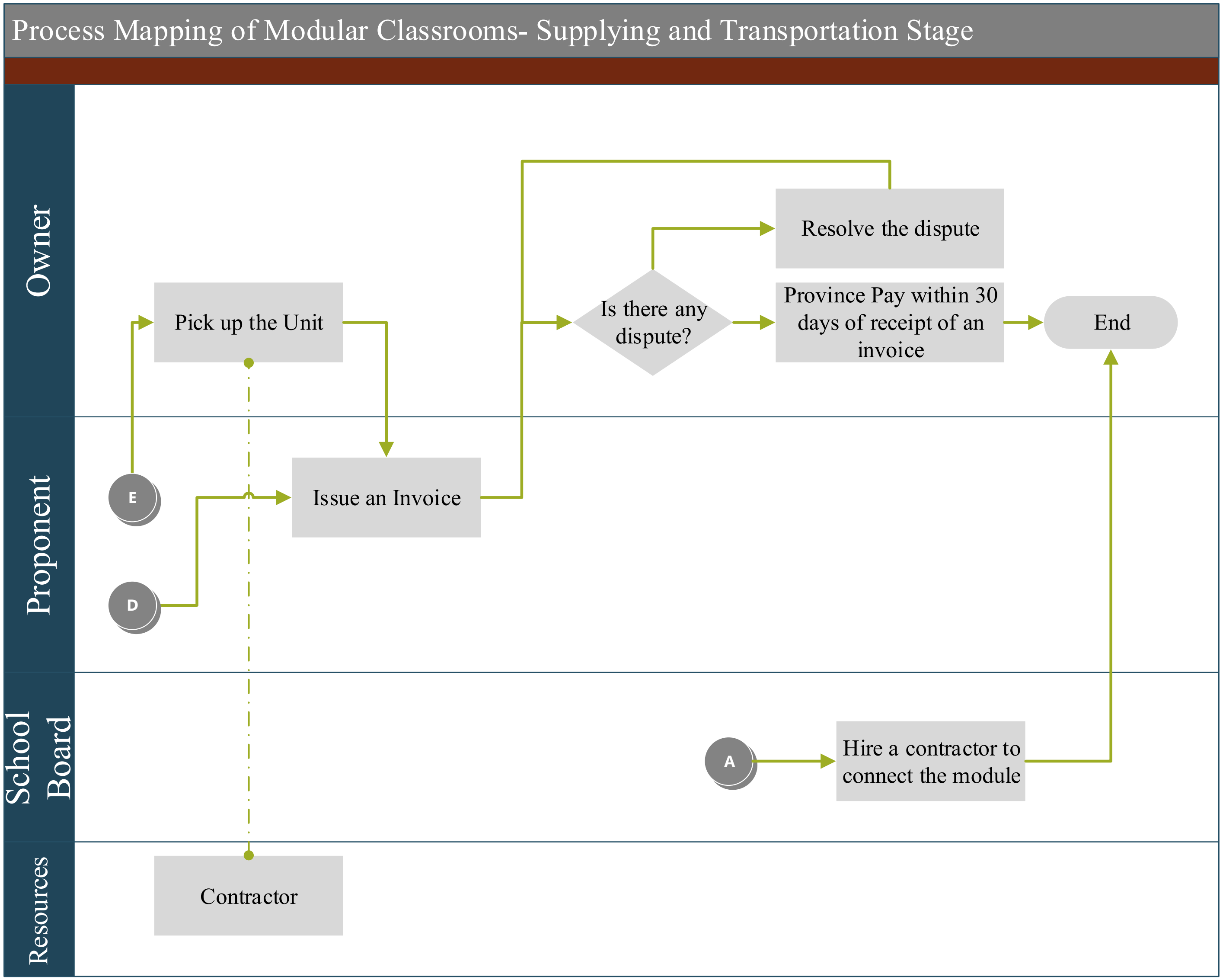


Figure 4- 12. Process mapping of the current process- part 4

4.3 Identify challenges associated with the current practice of modular classrooms

4.3.1 Challenges related to the ambiguities of RFP

In order to identify the challenges experienced by the bidders participating in the procurement process of modular classrooms, the records of Request for Information (RFI) were used. A request for information (RFI) is issued by bidders to the owner when the RFP requirements need more clarification, which can be regarded as one of the frequent contributors to delays in the construction projects (Song, Mohamed, and AbouRizk 2009). When bidders are invited to bid by the owner, they can issue a request for information in the case where there are ambiguities in the RFP. The public owner of modular classrooms responds to the RFI with an amendment to the RFP, which is sent to all the bidders participating in the tendering process. Three RFP amendments, including 60 RFIs, are explored in this thesis to identify the ambiguous areas in the RFP that need more clarification. Also, in order to realize the difficulties bidders face in satisfying the SC used in the RFP, one of the results of the evaluation of bidders is presented and the performance of bidders per SC is summarized.

4.3.1.1 RFI

To categorize the ambiguities gained from the RFIs, the sources of confusion introduced by Roshnavand, Nik-bakht, and Han (2019) are used. All the RFIs recorded and investigated through focus group meetings and those RFIs that lead to the confusion are presented. The results show which areas cause confusion for bidders and should be improved as illustrated in Table 3-4.

Table 2- 2. The ambiguities identified in the RFP

Ambiguity	RFI (Number of times asked)
Poor presentation	- Unclear presentation of transportation of modules in the transportation stage (2)
	- Unclear presentation of calculating the cost of transportation
Missing Information	- Information missing regarding ventilation of modules; can they be dependent?
	- Lack of information about specifications of vestibules that used to connect the modules (3)
	- Lack of information about the dimensions of doors and windows
Ambiguity of Information	- Unclear definition of the wording used in the fee proposal
	- Unclear information about the types of walls in the modules specified in the fee proposal

	- In the RFP it is not clear whether the dimensions are from outside finish to outside finish
	- The interior dimensions are not provided
	- A mistake in referring to Appendix A as there is no Appendix attached to the RFP
	- Unclear about requirements at the installation stage: Different site conditions may require different equipment which impacts the installation cost
	- The RFP uses the word “bidder”, the contract uses “supplier”, and the revised agreement refers to the “vendor” and “dealer”. These all seem to refer to the bidder and should be consistent or each should be defined.
	- Insurance in the transportation stage should not be the responsibility of the manufacturer
	- Unclear how the number of units will be distributed among the types of modular classrooms specified in RFP (4)
	- Unclear about the allocation of modular units to the awarded bidders after the evaluation of proposals (2)
	- Unclear about the schedule of delivery of the modules (2)
Redundant Information	- Contradictory and erroneous information about the page limits of proposals (2)

4.3.1.2 Evaluation Process of a real case:

Table 3-5 shows the results of the evaluation process for 14 proposals received based on the criteria provided in the RFP. Awarded percentage equals to the sum of achieved points among 14 bidders divided by the maximum points (M) associated with each SC. The results show that SC3 (technical submission), SC4 (RFP comprehension), and SC6 (Experience) are awarded the lowest points for all the bidders, with 29%, 50%, and 53%, respectively, of possible points having been awarded.

Table 2- 3. Evaluation Process of bidders according to the criteria

Evaluation Criteria	SC1	SC2	SC3	SC4	SC5	SC6	Subtotal	SC7	**Total**	**Bid price**
Maximum Points (M)	5	20	20	5	5	5	60	40		
Average Points	3.9	13.2	5.9	2.5	3.4	2.6	31.4	33.4		
Awarded percentage (%)	77	66	29	50	67	53	52	83		
Bidder 1	4	12	3	2	4	3	28	N/A	N/A	N/A
Bidder 2	4	20	5	5	4	3	41	32.3	73.3	$180,983.00
Bidder 3	5	15	15	2	5	5	47	27.8	74.8	$214,058.00
Bidder 4	5	19	3	4	5	3	39	39.4	78.4	$151,394.40

Bidder 5	5	13	0	2	2	3	25	N/A	N/A	N/A
Bidder 6	3	12	0	0	3	0	18	N/A	N/A	N/A
Bidder 7	0	0	3	1	1	0	5	N/A	N/A	N/A
Bidder 8	5	18	20	5	5	5	58	33.6	**91.6**	$178,475.00
Bidder 9	4	11	10	1	5	5	36	27.8	63.8	$219,736.30
Bidder 10	5	13	3	0	1	1	23	N/A	N/A	N/A
Bidder 11	4	19	0	5	5	5	38	40	78.0	$146,919.20
Bidder 12	3	4	0	2	1	1	11	N/A	N/A	N/A
Bidder 13	5	18	20	4	5	3	55	32.8	**87.8**	$177,751.00
Bidder 14	2	11	0	2	1	0	16	N/A	N/A	N/A

4.4 Lessons Learned (LL)

This section compares the lessons (from the owner's perspective) gained from this thesis research to identify the opportunities and challenges in order to respond to the following questions:

Identify the opportunities: What went well?

- Lesson 1: The modular classroom RFP offers a best-value grading system that ensures the quality of the awarded proposals. As it is described in the previous section, the lowest proposed price is not necessarily the top bid. In order to ensure the quality of the project, a minimum of 40 out of 60 points is required. This idea is aligned with the nature of modular construction where better production at a premium cost can reduce the cost of maintenance and installation. This guarantees the quality of the proposals. This is consistent with one of the lessons identified from the literature review.
- Lesson 2: By issuing a purchase order (PO), the owner can specify the specifications of the modules. Each school board and the school has a different type of architecture and specifying the specifications, such as mill workings etc., streamlines the process of connection of the modules at the installation stage.
- Lesson 3: Since the installation locations of the modules could vary, the cost of transportation is affected, especially when the manufacturer site is outside of Alberta. However, some of the bidders might be able to deliver the modules at a lower price as they might be using highly automated techniques. In order to increase the competitiveness of the RFP and encourage bidders from other provinces, such as British Columbia, Ontario, or from other countries, the owner requests the bidders to provide the price of transporting the module to the centre point of Alberta; however, this is only a benchmark rather than a criterion.
- Lesson 4: The specifications of the classrooms stipulate that the modular classrooms each have an independent mechanical system. This increases the level of ventilation in the modules and ensures the indoor air quality at the time of operating the modules.
- Lesson 5: The specifications in the supplying stage exemplify the architectural design of an accepted module. This can reduce the identified challenges in the literature review in the design stage. The specifications only specify and enforce the bidder to deliver the required performance; however, the bidder is free to use innovative design and materials to deliver the same performance.

- Lesson 6: New bidders that do not have experience with modular classrooms can participate in the procurement process; however, they need to produce two modules as a prototype that the owner, and a third-party consultant must approve the modules. This reduces the rework and the risk of damage as the bidder can follow the same instructions as they followed in the prototype stage. This can reduce the challenges identified in the literature review in the production stage.
- Lesson 7: The procurement process enables the owner to select at least four bidders to whom contracts will be awarded for the delivery of the modular classrooms. This reduces the risk of delay and cost overruns as the owner has alternatives based on the location of the school. Moreover, the owner does not have to set up another procurement if a dispute occurs between the parties as the contract stands for five years with at least four selected bidders. This establishes a unique concept for procuring modular classrooms when the owner is in the public sector with jurisdiction over a broad area.
- Lesson 8: The procurement process allows the owner to issue a PO as a standing order to the awarded bidder based on the location of the school. This reduces the risk of increasing the cost of transportation and other challenges identified in the literature review.

Identify the challenges: What could have gone better?

- Lesson 9: Selection criteria (SC): the bidders have difficulty satisfying the SC. More bidders can be encouraged to participate in the procurement process if SC is clear and relevant to modular classrooms.
- Lesson 10: New bidders are restricted from participating in the bidding process as there are some requirements inhibiting them from gaining points.
- Lesson 11: there is some confusion caused by the context and SC used in the RFP, which can cause miscommunication and misunderstandings between the parties at the time of procurement.

Chapter 5: Evaluate the SC used in the RFP of modular classrooms

This research proposes a framework for evaluating selection criteria used in the RFP of modular classrooms as illustrated in Figure 5- 1. The research evaluates the framework by applying it to the RFP issued by Alberta Infrastructure as a case study.

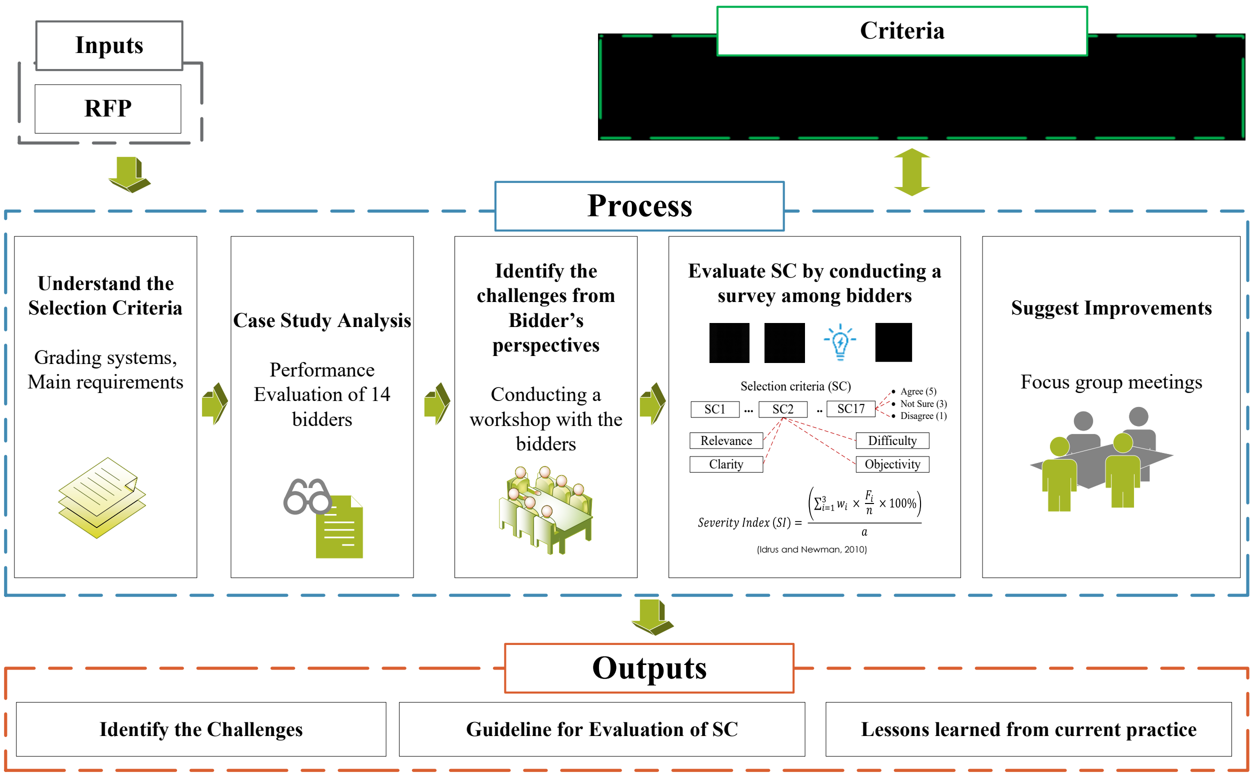


Figure 5- 1. The proposed framework for evaluating selection criteria used in RFP of modular classrooms

5.1 Apply the framework to the case study

5.1.1 Corporate profile (SC1)

Table 5- 1 shows the requirements of SC1. It includes four main requirements which total 5 points. Table 5- 1. Main Requirements of SC1

	Evaluation Criteria (Qualification Requirements)	60
SC1	Corporate Profile	5
SC1.1	History of bidder: type of services and construction provided and areas of expertise (Provided and relevant =2 pts, provided and partially relevant= 1, not provided=0)	2
SC1.2	Key Personnel's experience: (provided= 1, not provided =0)	1
SC1.3	Identify manufacturing facilities: (provided= 1, not provided = 0)	1
SC1.4	An organization chart that explains how the key personnel are organized, by indicating formal reporting lines and informal lines of communication (provided= 1, not provided = 0).	1

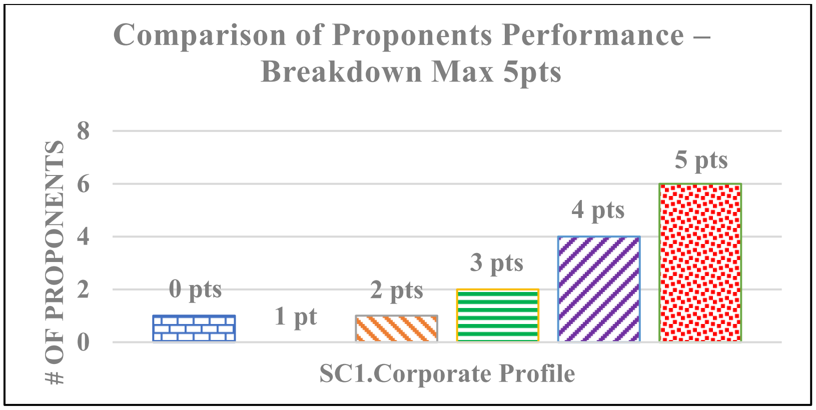


Figure 5- 2. Performance of 14 bidders for SC1

Figure 5- 2 shows that half of the bidders have scored most of the points; however, only one bidder had difficulty satisfying this requirement.

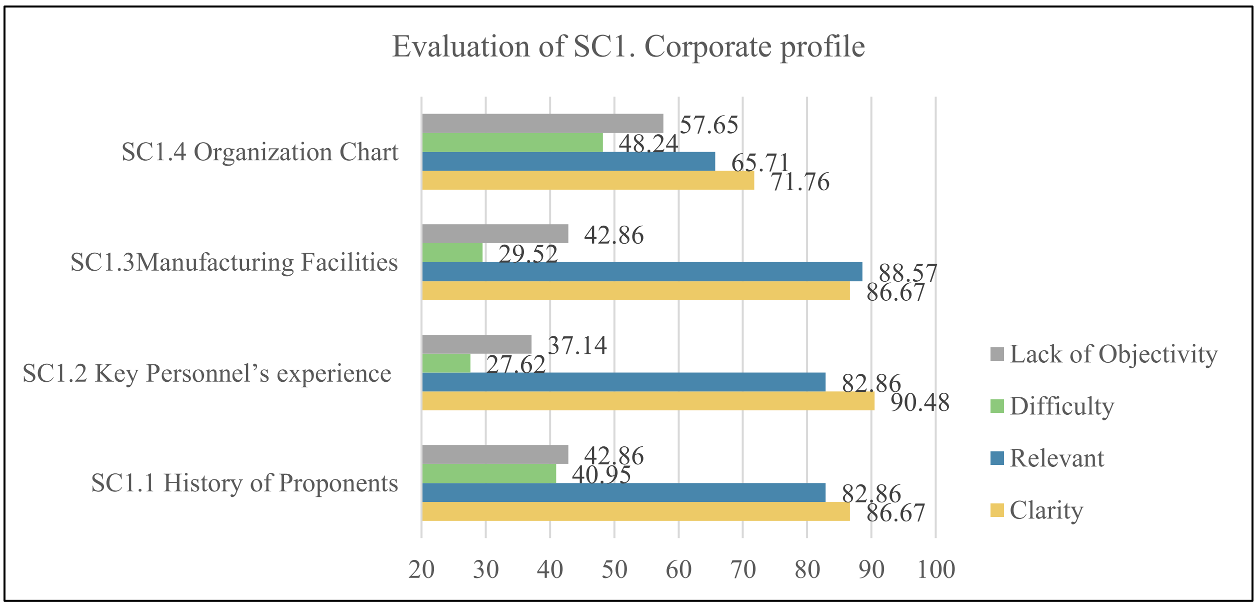


Figure 5- 3. Evaluation of corporate profile (SC1)

- SC1.3 requires that bidders provide detailed information about their manufacturing facilities. One bidder suggested that the owner make a visit to the bidder's facility as part of the evaluation for this criterion, in addition to evaluating the information provided by the bidder.
- As part of the qualification, the RFP requests an organizational chart from each bidder in SC1.4. The results show that this criterion is not relevant (Figure 5- 3), as every bidder has different internal structures and communication tools, which makes each bidder unique and difficult to compare with others. During the focus group meetings with the owner, they reported that this criterion had been used as a main requirement in part RFPs, meaning that, if a proposal does not submit the organizational chart, they would be considered

incompliant and their proposal would be rejected. One possible recommendation arising from the focus group discussion is that this be considered a qualitative criterion rather than quantitative one, as is explored in the literature.

Improvements suggested for Corporate Profile: Bidders should demonstrate experience working with multiple trades and managing the design, construction, and delivery of modular buildings similar to those described in the RFP. Projects qualifying as similar could include offices, residential buildings, military buildings, or workforce housing, rather than be limited to previous modular classrooms projects only. The bidder should highlight projects with attributes including, but not limited to, the following:

- High energy efficiency (up to or exceeding silver LEED standard)
- Relocatability
- Participation of the bidder as either the general supplier, sub-supplier, or project manager.
- High volume (mass production) of modular buildings
- Work on government contracts (optional)

Bidders and new manufacturers should be encouraged to form partnerships in order to meet the required experience, expertise, and manufacturing facility requirements. Key personnel from partnering companies may be presented. However, partnership contracts and documents must be included in the application. The owner may consider making submission of bid bonding documents a requirement for submission, especially for partnerships.

5.1.2 Capacity and Resources (SC2)

Table 5- 2 breakdowns the requirements of SC2. It includes five main requirements which total 20 points.

Table 5- 2. Main Requirements of SC2

	Evaluation Criteria (Qualification Requirements)	60
SC2.	Capacity & Resources	20
SC2.1	Capacity and Resources: Provide information about capacity and resources and how they will be managed (fully provided = 5, partially provided = 3, not provided = 0)	5
SC2.2	Manufacturing Capacity: Describe and provide details of their manufacturing capacity per month and information if capacity could be increased (capacity of 16 units and more= 5, 12 units = 4, 8 units = 3, 4 units = 2, 3 to 1 unit= 1, not provided = 0)	5
SC2.3	Prototype design and Manufacturing schedule: A schedule to meet design and manufacturing that lists steps for the prototypes, Inspection and Approval schedule or written approvals for each	5

	prototype within 6 last months must be provided (0-3 months = 5, 3-6 months = 4, 6-12 months = 2, 12 + months = 0)	
SC2.4	Tracking schedule performance: Describe strategies for ensuring the completion date will be met, including tracking and early indication of schedule performing issues should be provided (fully provided = 3, partially provided = 1, not provided = 0)	3
SC2.5	Pre-Inspection & Delivery Plan: Describe and provide the bidder's plan for pre-inspection and delivery and storage of modular classrooms including size and location of storage premises; plan for proper storage and access to storage site (fully provided=2, partially provided = 1, not provided = 0)	2

- SC2 requires the bidders to state their capacity output at the time of bidding. Some bidders do not agree with this criterion. As one of the bidder states, *"The current RFP is set up for the owner to place a call for "x" units to a given bidder to be built in a certain period. Manufacturers need to establish an assembly line"*. Furthermore, some of the bidders submitted RFIs pertaining to the delivery schedule, as the capacity of the manufacturer may be different based on the total scope of the project awarded and, due to a lack of information about the delivery time at the time of bidding, the capacity output is only an assumption made by the bidder at the time of tendering. The results show that bidders have difficulties satisfying this criterion, as is illustrated in Figure 5- 4. The other issue identified with respect to this section of the RFP is that it does not provide any opportunity for partnering with multiple manufacturers and prevents the potential for dealers to participate, as the results show that this section lacks flexibility in the process of evaluation (Figure 5- 5).

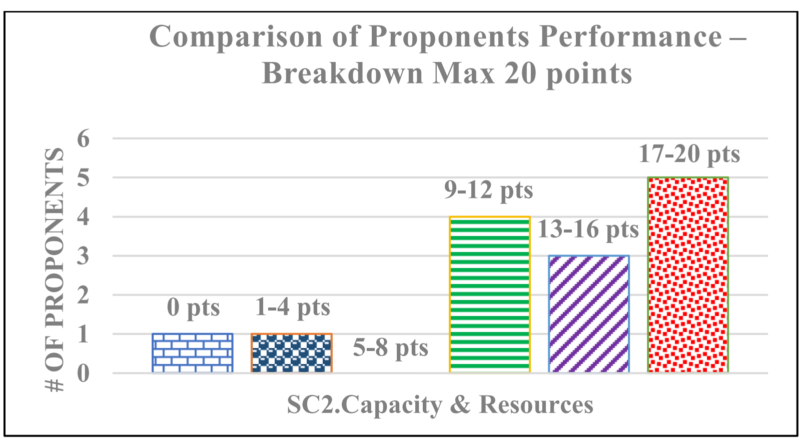


Figure 5- 4. Performance of 14 bidders for SC2

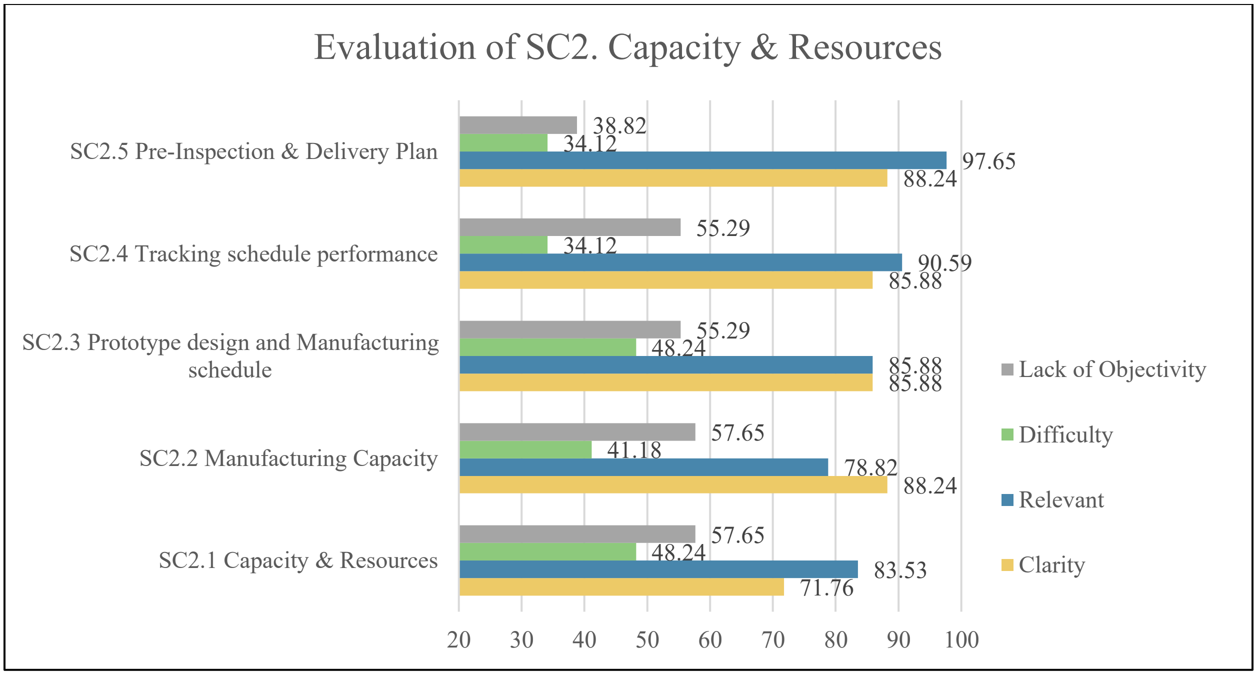


Figure 5- 5. Evaluation of SC2

Improvements suggested for Capacity & Resources: There is a lack of clarity in the requirement for experience and acceptable manufacturing facilities. As mentioned with respect to the corporate profile section above, it is recommended that partnerships be permitted in order for bidders to demonstrate resource and manufacturing capacity. However, partnership contracts and documents (e.g., MOU or proof of partnership) must be included in the application. The contribution of each partner to total manufacturing capacity (facilities, production volume, and manufacturing personnel) from all partners should be summarised. Available storage capacity may be considered as a factor for assessment, as well as a demonstrated ability to increase production capacity.

5.1.3 Technical Submission (SC3)

Table 5- 3 breaks down the requirements of SC3. It includes three main requirements which total 20 points.

Table 5- 3. Main Requirements of SC3

	Evaluation Criteria (Qualification Requirements)	60
SC3.	Technical Submission	20
SC3.1	Technical Submission: Bidder should provide a technical submission that includes product specifications and drawings, (fully inclusive of all elements = 10, includes most elements of the requirements but needs further investigation = 5, technical submission provides minimal or little information to assist the submission = 0)	10
SC3.2	Adherence to Performance Specifications (Fully provided=5, partially provided=3, not provided=0)	5

SC3.3	Ensure LEED Comprehended: The approach and steps the bidder will use to ensure the LEED Silver (49 points to be eligible for Silver certification) should be described. (Fully inclusive of all elements and in compliance with LEED requirements = 5, includes most elements of the requirements but needs further investigation = 3, provides minimal or little information to assess submission = 0).	5

- The technical requirements of the RFP, which are devised to ensure that the bidder meets LEED Silver certification requirements, may introduce unnecessary constraints and challenges for bidders, as the workshop and survey participants report having limited information about them, as it can be seen from Figure 5- 6 that SC3 is the lowest-scoring criterion. Furthermore, the bidders do not see LEED as relevant to modular classrooms since LEED certification is not intended for mobile structures, and thus they are not confident in their capacity to meet the requirements of this criterion (SC3.3). The bidders believe that this criterion lacks objectivity and is difficult to satisfy (Figure 5- 7). Developing frameworks and checklists will assist suppliers to submit an eligible proposal. Some of the respondents stated that SC3.1 systematically discourages the use of innovative material and techniques and that it dictates specifications which require further clarification between owner and bidders before closing the bid. One of the respondents that believe SC3.3 is not relevant to modular classrooms stated that there are other green ratio systems besides LEED, suggesting that requiring LEED rather than allowing the possibility for compliance to other green rating systems makes the RFP too restrictive.

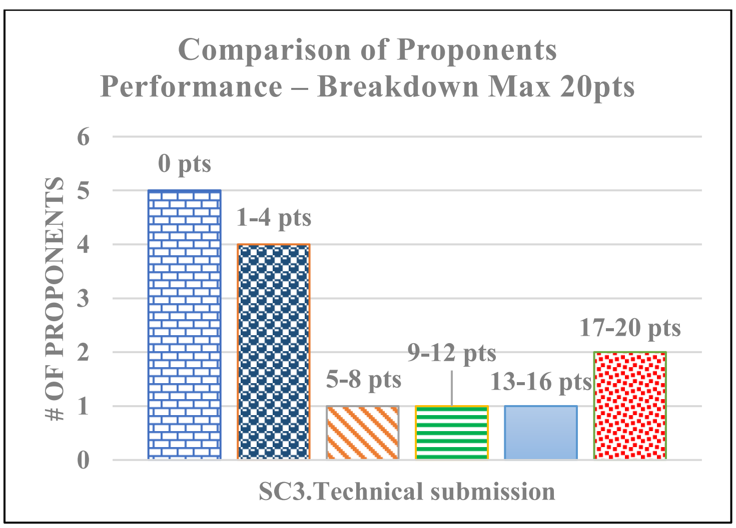


Figure 5- 6. Performance of 14 bidders for SC3

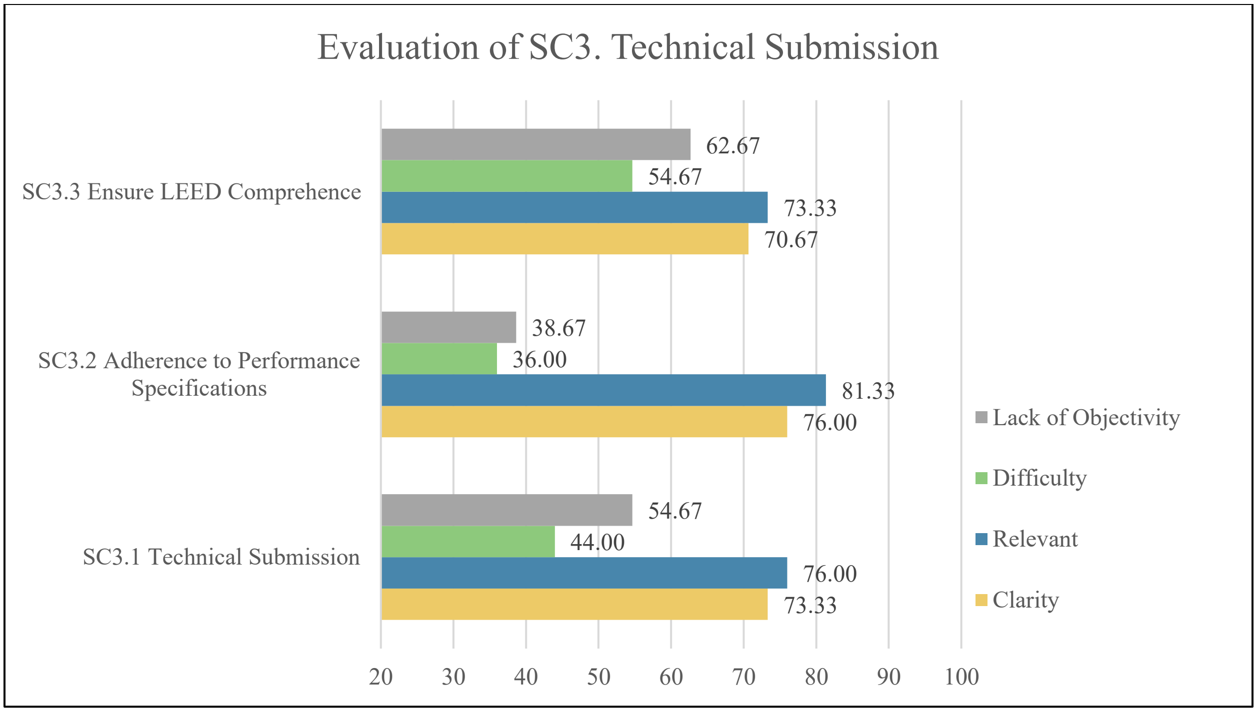


Figure 5- 7. Evaluation of SC3

Improvements suggested for Technical Submission: The issues and challenges to meet this criterion are perhaps the most significant challenges faced by prospective bidders. As can be seen from Figure 5- 6, the most difficult criterion as ranked by respondents is SC3.3. The technical difficulty to satisfy the terms of an RFP can be one of the major factors deterring suppliers from submitting a proposal (Tkáč, Delina, and Sabolová 2016). Therefore, the research suggests rewriting the requirements of this criterion.

5.1.4 RFP Comprehension (SC4)

Table 5- 4 breaks down the requirements of SC4. It includes two main requirements which total 5 points.

Table 5- 4. Main Requirements of SC4

	Evaluation Criteria (Qualification Requirements)	60
SC4.	RFP Comprehension	5
SC4.1	Unique Requirements and Challenges: The bidder should provide a brief analysis of the unique requirements and challenges of this RFP, from the bidder's perspective, based on the information provided in the RFP or which the bidder anticipates. The bidder should present an understanding of the Agreement requirements, identify any special needs or considerations which the Province may	2

	not have identified, and suggest approaches for addressing them (Provided = 2, partially provided = 1, not provided = 0)	
SC4.2	Risk Management: The bidder should describe and identify risks and descriptions of how they might be managed including labour, materials, components, testing, equipment, delivery, warranty and other risks (Fully provided = 3, partially provided = 1, not provided = 0.	3

- According to Figure 5- 8, some of the bidders had difficulty earning adequate points from this criterion. Furthermore, they do not believe that SC4.1 is relevant and clear as a criterion, as is illustrated in Figure 5-9. One respondent stated that presenting challenges can be seen as a weakness of the bidder, and the focus should be more on areas where the bidders could suggest innovative techniques. The results reveal a perception that this criterion lacks objectivity since it is open to subjectivity from both the owner and bidder sides and it is difficult to see how each unique aspect has been brought up and scored in the process of evaluation.

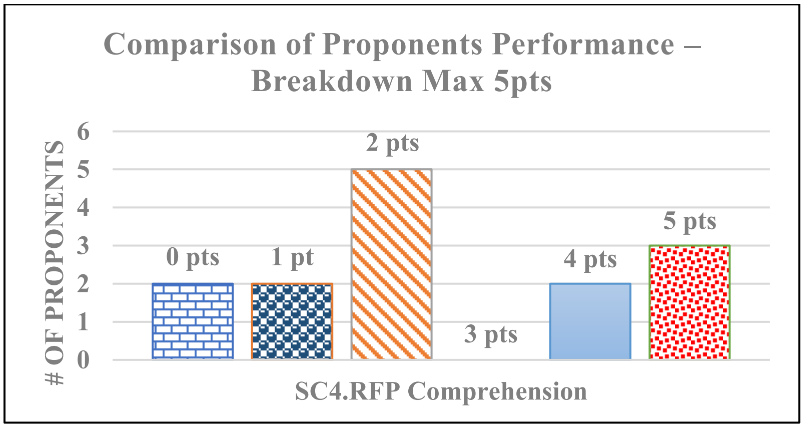


Figure 5- 8. Performance of 14 bidders for SC4

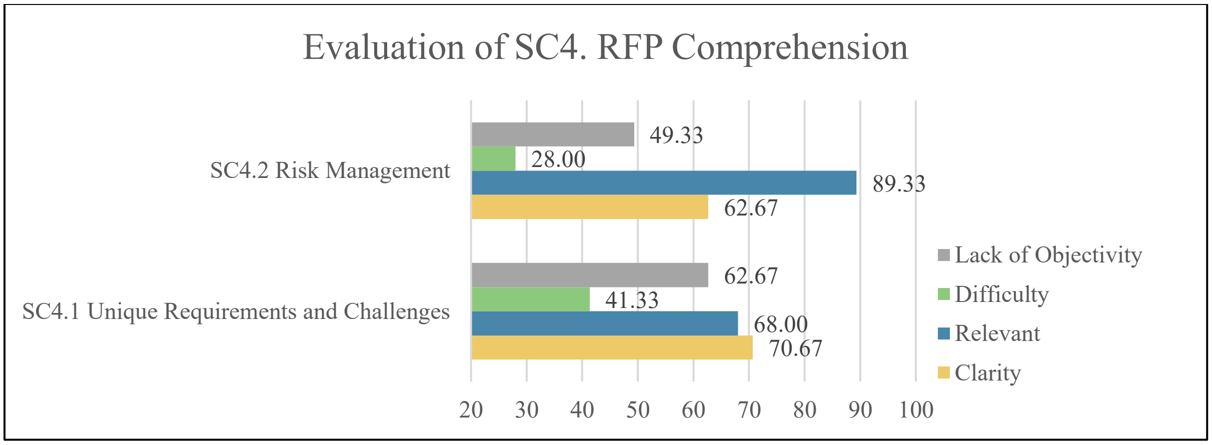


Figure 5- 9. Evaluation of SC4

Improvements suggested for RFP comprehension: In current practice, the structure of this requirement is ambiguous and open for wide interpretation. Also, it does not provide a transparent evaluation system. It should be rewritten to guarantee the clarity and objectivity of the owner's assessment of bidder responses. The bidders could be encouraged to demonstrate innovation and recommend improvements to the RFP document itself or to the classroom design specifications. It is suggested to use qualitative criteria for this evaluation or to consider the points awarded for RFP comprehension as "bonus" points.

5.1.5 Quality Assurance (SC5)

According to the results of the workshop and survey, the bidders did not face any ambiguities with this criterion as shown in Figure 5- 10, Figure 5- 11. Based on the feedback received in the workshop and from the survey conducted for the case study RFP, it should be noted that SC 5 seems to be sufficiently relevant and clear (Table 5-5).

Table 5- 5. Main Requirements of SC5

	Evaluation Criteria (Qualification Requirements)	60
SC5.	Quality Assurance	5
SC5.1	Quality Assurance Plan: Quality assurance plan for the design, testing, production, delivery of Modular Classrooms and associated work processes including roles and responsibilities related to quality assurance. (Fully provided=3, partially provided=2, minimally provided=1, not provided= 0)	3
SC5.2	Management and quality assurance systems: strategies and skills that will be employed to ensure that the Province's expectations around project scope, time, cost, quality and performance will be met (Fully provided = 2, partially provided = 1, not provided = 0).	2

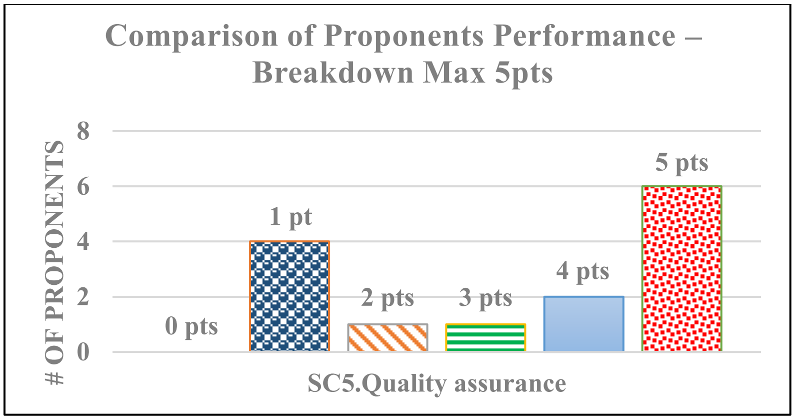


Figure 5- 10. Performance of 14 bidders for SC5

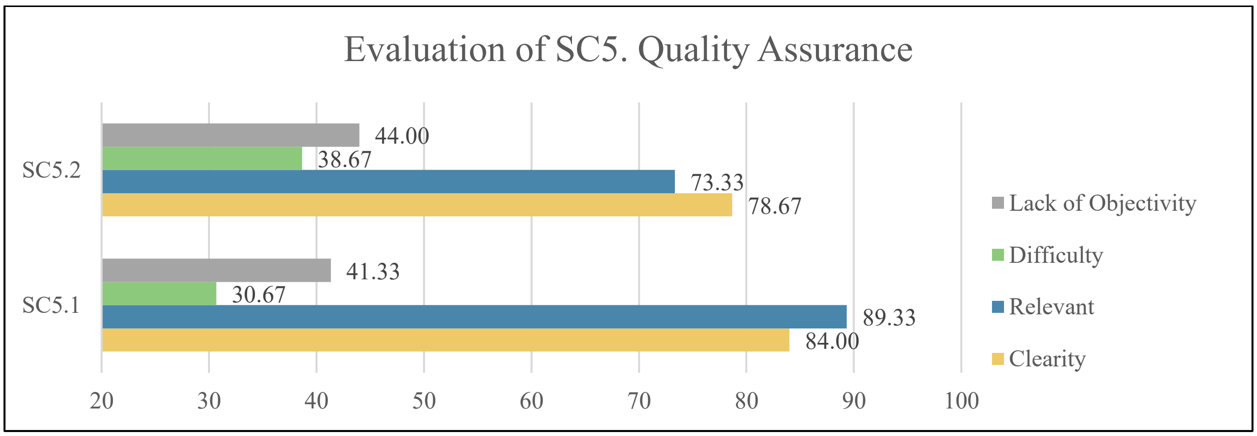


Figure 5- 11. Evaluation of SC5

5.1.6 Experience (SC6)

Table 5- 6 breaks down the requirements of the SC6. It includes one main requirement which represents 5 points.

Table 5- 6. Main Requirements of SC6

	Evaluation Criteria (Qualification Requirements)	60
SC6.	Experience	5
SC6.1	Experience Summaries and References: Bidders should provide summaries and related references for up to three (3) completed projects within the last five years for which the bidder or key personnel have provided buildings and services similar in terms of scope to those in the RFP. (3 projects= 5, 2 projects =3, 1 project = 1, not provided =0)	5

- The results show that one bidder feels challenged to satisfy SC6.1 (Experience) (Figure 5- 12), as the SI for the difficulty of this criterion is found to be above average (Figure 5- 13). One bidder describes that *"The* *specific designs required for modular classrooms are quite unique, and, as a result, unless you have specifically won a tender previously for this product, it's difficult to provide an exact reference to a similar project. With that stated, there are many suppliers that have provided product on large scales to commercial and industrial projects with wood-framed modular that would probably exceed the scope and complexities of size, schedule, and timeline".* The bidders believe this criterion prevents new manufacturers from bidding as they are new to the modular construction. Another bidder stated that the weighting assigned to this section is extremely low and should be improved, as is consistent with the results of the review of 82 RFPs from various jurisdictions that was conducted as part of this study.

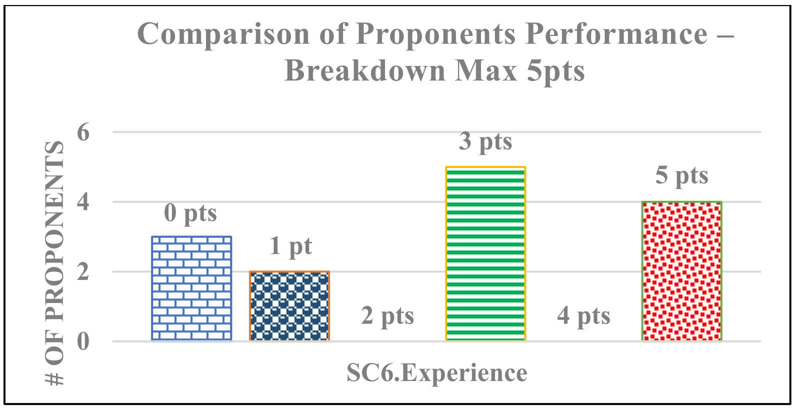


Figure 5- 12. Performance of 14 bidders for SC6

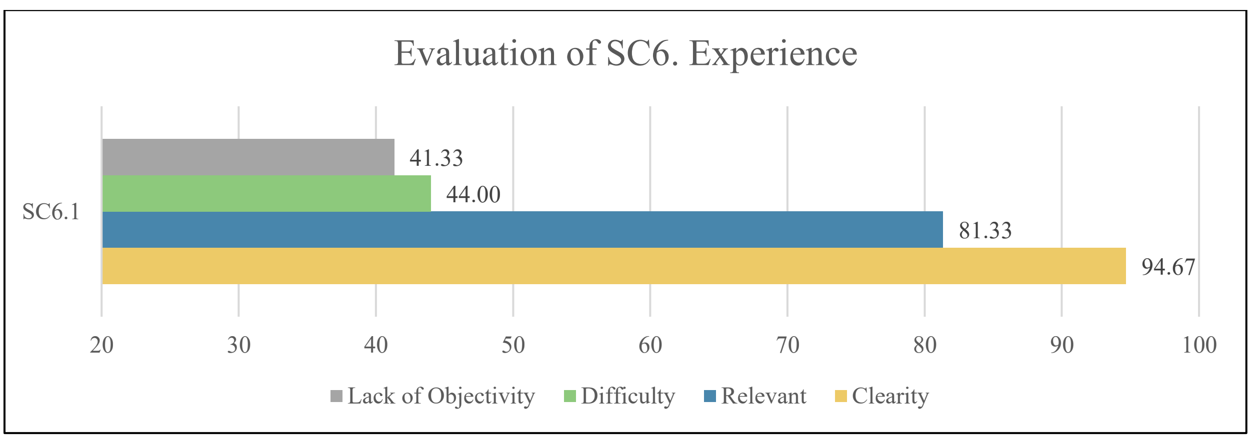


Figure 5- 13. Evaluation of SC6

Improvements suggested for experience: The owner in the case study should consider increasing the weight of the "experience" criterion to better align with other RFPs as reported in the literature review (Xia et al. 2013). Also, the RFP should provide examples of what constitutes “relevant experience” in order to help bidders understand what sort of information is being solicited. Bidders are not sure how to satisfy this requirement.

Table 5- 7 tabulates the results of the survey per each criterion.

Table 5- 7. The rate of SI for each criterion as well as their rank

Criteria	Description	Relevance (SI)	Rank	Clarity (SI)	Rank	Difficulty (SI)	Rank	Lacking Objective (SI)	Rank
SC1.1	History of Bidders	82.86	8	86.67	5	40.95	9	42.86	11
SC1.2	Key Personnel’s experience	82.86	8	90.48	2	27.62	17	37.14	17
SC1.3	Manufacturing Facilities	88.57	5	86.67	5	29.52	15	42.86	11
SC1.4	Organization Chart	65.71	17	71.76	13	48.24	2	57.65	3
SC2.1	Capacity & Resources	83.53	7	71.76	13	48.24	2	57.65	3
SC2.2	Manufacturing Capacity	78.82	12	88.24	4	41.18	8	57.65	3
SC2.3	Prototype design and Manufacturing schedule	85.88	6	85.88	7	48.24	2	55.29	6
SC2.4	Tracking schedule performance	90.59	2	85.88	7	34.12	12	55.29	6
SC2.5	Pre-Inspection & Delivery Plan	97.65	1	88.24	3	34.12	12	38.82	15
SC3.1	Technical Submission	76.00	13	73.33	12	44.00	5	54.67	8
SC3.2	Adherence to Performance Specifications	81.33	10	76.00	11	36.00	11	38.67	16
SC3.3	Ensure LEED Comprehended	73.33	14	70.67	15	54.67	1	62.67	1
SC4.1	Unique Requirements and Challenges	68.00	16	70.67	15	41.33	7	62.67	1
SC4.2	Risk Management	89.33	3	62.67	17	28.00	16	49.33	9
SC5.1	Quality Assurance Plan	89.33	3	84.00	9	30.67	14	41.33	13
SC5.2	Management & Quality Assurance Plan	73.33	14	78.67	10	38.67	10	44.00	10
SC6.1	Experience Summaries and References	81.33	10	94.67	1	44.00	5	41.33	13

Figure 5- 14 illustrates the relationships of the causes of issues and constraints. The results show more clarity and relevance can reduce the difficultness and lack of objectivity of criteria. The results also represent that clarity and relevance are directly related to each other.

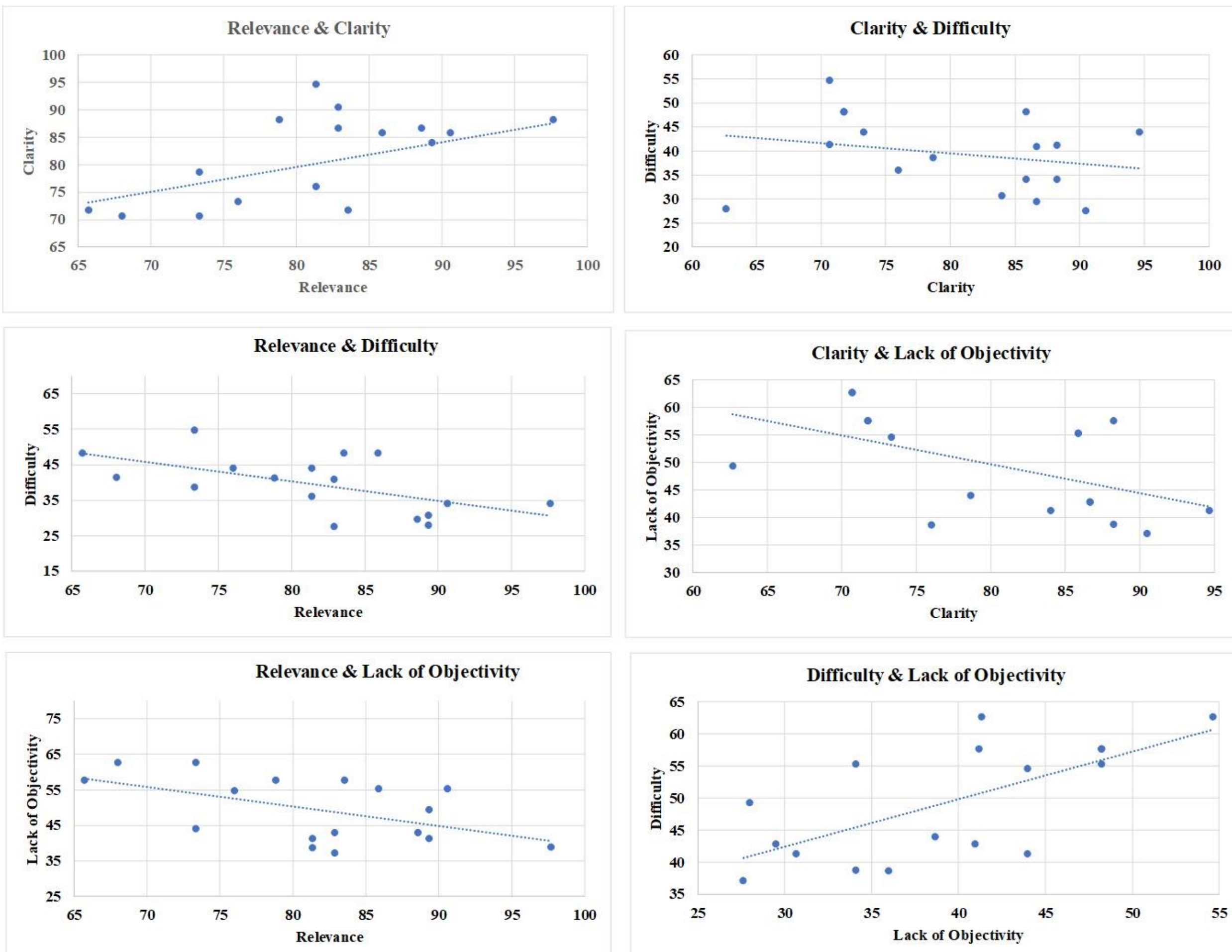


Figure 5- 14. Relationships between different causes of issues and constraints

5.2 Recommendations to the future RFPs

This study proposed the most common SC used in the recent RFPs for modular construction. The evaluation method proposed in the study can be used to evaluate the SC used in the RFP in the supplying stage of modular classrooms. There are four causes of issues identified with the selection criteria used in the RFP of modular classrooms; clarity of the requirements of the SC, the relevance of the SC to modular classrooms, difficulty with satisfying the SC, lack of objectivity in the type of evaluation. The research suggests a method to measure the level of criticality of each issue regarding each SC. The improvements recommended are captured from the focus group meetings with modular construction professionals based on the reviewing of 82 RFPs. The results can be used to evaluate the current selection criteria used to select the contractor in the supplying stage of modular classrooms. The proposed SC also might assist the owner to specify and choose their criteria according to their specific requirements.

To encourage innovation and increase understanding of the terms laid out in the SC of RFP, the following measures are recommended:

- **Clarification meetings**: Further clarification can be provided by holding information sessions once the RFP has been issued. These meetings could include presentations, interviews, or site visits. The owner should take the lead in organizing these sessions, fielding questions and providing further clarity on any items that may be brought up. As suggested by some of the survey respondents, this may be effective in encouraging participation and enhancing prospective bidders' understanding of the criteria.
- **Early involvement of stakeholders:** Useful information which could influence the requirements of the RFP can be sought early—before the RFP is finalized and issued—through early involvement of stakeholders in the form of pre-bid consultation sessions. These sessions should target modular manufacturers, transportation experts, design consultants, modular construction professionals, school district administrators.
- **Developing a BID template:** A bid template should be made available as an attachment to the RFP when it is issued, and bidders should be encouraged to use it. The template would help both the respondents and owners to follow a common structure and would also serve as a guide for respondents. It would also provide ease of evaluation and help to ensure consistency in the evaluation process.

This study focuses on the SC used in RFPs for modular classrooms in Alberta, Canada. One limitation of the study is that the identified issues and challenges might not be the same for other owners, other jurisdictions, or other types of projects. It is recommended for future study that modular classroom projects in different jurisdictions be explored using the proposed evaluation method in order to compare the different SC used in the RFPs. The results of this study can be applied in future projects where modular classrooms are adopted and where the procurement process needs to be improved.

Chapter 6: Conclusion

6.1 Summary

Increasing enrollment, coupled with decreasing school budgets, poses a challenge concerning classroom space at some schools. Modular classrooms provide an enormous advantage to school boards in terms of accommodating changing enrollment. However, even though the adoption of modular classrooms has yielded enormous benefits for schools, the project may result in delays and cost overruns if proper coordination between the stakeholders does not occur. Therefore, the owner must specify the main requirements and criteria upon which the bidders are evaluated. To do that, the owner communicates with the bidders through issuing an RFP. The RFP may inhibit bidders from submitting innovative proposals if it contains ambiguities and confusion. The RFP may also mislead the bidder in the case where the owner misstates the responsibilities and logistics required. Meanwhile, lessons learned from the current RFP of modular classrooms can assist the owner in establishing proper communication with the bidders at the procurement stage. It also develops a better practice for improving the current state by identifying challenges and constraints throughout the project. This thesis develops lessons learned from the current RFP of modular classrooms, focusing on Alberta as one of the leading regions procuring modular classrooms in Canada. A comprehensive literature review provides the lessons learned including those with economic, environmental and social impacts of implementing modular construction over conventional methods throughout the life cycle of the buildings. The challenges develop input for future studies where management of risks in modular construction is the primary concern. Data analysis from 177 recent RFPs provide the typical SCs used in the RFPs of modular classrooms as well as the level of importance and the average weighting associated with each SC. The research presents two main sections.

In the first part of the thesis, the research seeks to develop lessons learned from RFP of modular classrooms by identifying the process of procurement in Alberta using a process mapping technique. Then, the research uses a workshop with bidders to identify the challenges faced by bidders of modular classrooms in the procurement stage. Ambiguities cause challenges due to the RFP, which confuses the communication between the owner and bidder by letting the bidder make assumptions due to a lack of clear statements in the requirements of the RFP. These assumptions influence the effectiveness of the RFP in receiving the best proposals. The research highlights these ambiguities by investigating the RFI and analyzing the performance of fourteen bidders during a real case of evaluation of the proposals. The results of this analysis call for developing a framework to evaluate the SC of the RFP. Lessons learned present the opportunities and challenges, which highlight the potential improvements to the current RFP. The results develop a guideline for future practices to ensure the identified benefits and prevent repeating similar mistakes.

The second part of the thesis (Chapter 5) uses the lessons learned to develop a framework to evaluate the SC stated in the RFP of modular classrooms. The proposed framework is applied to the current RFP of modular classroom issued in Alberta as a case study to exhibit the framework. The framework identifies the four common causes of challenges associated with SC of RFP faced by bidders at the time of bidding. An online survey captures the feedback from the industry regarding the four causes. Finally, focus group meetings determine the improvements to the SC based on the data analysis method captured from the literature review. The results develop a guideline for owners of modular classrooms to evaluate the SC used in the RFP at the supplying stage.

In conclusion, the lessons learned from this research streamlines the process of adopting modular classrooms by developing guidelines and improvements to benefit future practices.

6.2 Research Contributions

The lessons learned can contribute to both academia and industry in that it develops a better practice for the evaluation of RFP of modular classrooms in the supplying stage. The primary contributions from this research are summarized as follows:

- Provide a set of SC for the owners of modular construction. The owners can use the SC identified in the findings of the data analysis to specify the selection criteria in the RFP. The research also proposes the average weighting and the level of importance associated with each SC based on a content analysis of 81 RFPs found in North America.
- Understand the current RFP of modular classrooms by conducting a case study analysis. The research elaborates on the current state by analyzing a case study of modular classrooms, which highlights the process, responsibilities and criteria associated with each stage of modular classrooms. The results provide owners of modular classrooms a guideline to set up the procurement for procuring and delivering of modular classrooms.

- Identify the challenges of procuring modular classrooms in Alberta, which provide some improvements to the current RFP of the modular classrooms. It also pinpoints the lessons learned, which give the owner an insight to manage the time and cost of procuring modular classrooms through the supplying stage.
- Develop a framework to evaluate the SC used in the RFP of modular classrooms in the supplying stage. The framework specifies the potential causes of challenges encountered by bidders in the procurement stage of modular classrooms. The framework assists the owners in evaluating the SC used in the RFP to improve the process of communication with the bidders.

The research proposes a new model for developing an analysis of the RFP processes that can be used in future academic research for evaluating a procurement process. 6.3 Limitations and Future improvements

The results of the research subjects to several limitations. Based on the current research results, some recommendations for future work are proposed in the following section to improve the proposed methodology and prototype system.

- The research elaborates on the most used SC based on the RFPs issued in North America as the leading region in the modular construction practices. Different regions might have different outcomes; however, the proposed method for calculating the average weighting associated with each SC is valid and can be used in future studies.
- The proposed framework uses the industry input as feedback to identify the causes of challenges with the SC in the RFPs. However, different sources of information such as focus group meetings used to evaluate the outcome of the survey; different respondents might impact the identified causes of challenges. Overall, the impact of different inputs does not influence the validity of the framework to evaluate the SC used in the RFP.

The research suggests the following recommendations for future studies:

- One of the most common issues with the selection criteria is the subjectivity of the grading system of the selection criteria. Using new techniques such as fuzzy logic can reduce the subjectivity of the selection criteria and improve the clarity of the bidding process. Developing a framework for the owner to improve the process of inspection of the modules based on the historical cases about the common mistakes and issues with the last modules.

- Conduct a comparative analysis to investigate other models of procuring modular classrooms and their advantages and disadvantages from different stakeholders' perspectives.

References

ADA, Arizona Department of Administration . 2017. "Arizona Procurement Manual", URL: https://spo.az.gov/sites /default/files/Arizona%20State%20Procurement%20Manual%20DC%20009%20r0.pdf

AI (Alberta Infrastructure). 2017. "Public Request For Proposals (RFP) For Supply of Modular Classrooms." https:// vendor.purchasingconnection.ca/Opportunity.aspx?Guid=2CAE0647-4DE0-41B9-9732-FCD44399F68E.

AI, Alberta Infrastructure. 2013. "School Capital Manual", URL: https://education.alberta.ca/media /3795493/school -capital-manual-april-1-2018-addendum-final.pdf

Akmam Syed Zakaria, S. Thayaparan, G. Timothy, R. and G. Brewer. 2018. "Contextual, Structural and Behavioural Factors Influencing the Adoption of Industrialised Building Systems: A Review." *Architectural Engineering and Design Management* 14 (1–2): 3–26.https://doi.org/10.1080/17452007.2017.1 291410.

Al-Ghassani, A, C.Anumba, P. Carrillo, and H. Robinson. 2005. "Tools and Techniques for Knowledge Management." *Knowledge Management in Construction, 6: 83-102*.

Alberta Government. 2017. "Approval Process for Transportation of Modular Construction." URL: http://www. oxfordreference.com/view/10.1093/acref/9780190304737.001.0001/acref-9780190304737-e-3189, Accessed on October, 2019..

Alleman, D, A. Antoine, D. Gransberg, and K R. Molenaar. 2017. "Comparison of Qualifications-Based Selection and Best-Value Procurement for Construction Manager–General Contractor Highway Construction." *Transportation Research Record: Journal of the Transportation Research Board.* 2630 (1): 59–67. https://doi.org/10.3141/2630-08.

Ardichvili, A, V. Page, and T. Wentling. 2003. "Motivation and Barriers to Participation in Virtual Knowledge-Sharing Communities of Practice." *Journal of Knowledge Management.* 7 (1): 64–77.

Art Chaovalitwongse, W., W. Wang, T P. Williams, and P. Chaovalitwongse. 2012. "Data Mining Framework to Optimize the Bid Selection Policy for Competitively Bid Highway Construction Projects." *Journal of Construction Engineering and Management.* 138 (2): 277–86. https://doi.org/10.1061/(ASCE)CO .1943-7862.0000386.

Asad, S, M.M.A Khalfan, and P. McDermott. 2003. "Managing Knowledge across the Construction Supply Chain." In *Proceedings of 2nd SCRI Symposium*, Salford, 12 (13) 2-25.

Asmar, M , W. Lotfallah, G. Whited, and A S. Hanna. 2010. "Quantitative Methods for Design-Build Team Selection."

Journal of Construction Engineering and Management 136 (8): 904–912. https://doi.org/10.1061/(ASCE)CO.1943-7862.0000194.

Azhar, S, M Y. Lukkad, and I. Ahmad. 2013. "An Investigation of Critical Factors and Constraints for Selecting Modular Construction over Conventional Stick-Built Technique." *International Journal of Construction Education and Research* 9 (3): 203–25. https://doi.org/10.1080/15578771.2012.723115.

Bertram, N, S. Fuchs, J. Mischke, R. Palter, G. Strube, and J. Woetzel. 2019. "Modular Construction : From Projects to Products." *McKinsey & Company: Capital Projects & Infrastructure*, no. June: 1–34. https://www.mckinsey.com/~/media/mckinsey/industries/capital projects and infrastructure/our insights/modular construction from projects to products new/modular-construction-from-projects-to-products-full-report-new.ashx.

Blismas, N G., M. Pendlebury, A. Gibb, and C. Pasquire. 2011. "Constraints to the Use of Off-Site Production on Construction Projects." *Architectural Engineering and Design Management* 1 (3): 153–62. https://doi.org/10.1080/17452007.2005.9684590.

Blismas, N, and R Wakefield. 2009. "Drivers, Constraints and the Future of Offsite Manufacturing in Australia." *Construction Innovation* 9 (1): 72–83, https://doi.org/10.1108/14714170910931552.

Bresnen, M, L. Edelman, J. Swan, S. Laurent, H. Scarbrough, and S. Newell. 2002. "Cross-Sector Research on Knowledge Management Practices for Project-Based Learning." Innovation Research in Management European Academy of Management 2nd Annual Conference, Stokholm, Sweden.

Brinko, R, S B. Nielsen, and J. Meel. 2015. "Access over Ownership - A Typology of Shared Use of Facilities." *Facilities*. 33 (11/12): 736-751. https://doi.org/10.1108/F-11-2014-0094.

Brinkoe, R, and S B. Nielsen. 2017. "The Characteristics to Consider in Municipal Shared Spaces." *Journal of Facilities Management* 15 (4): 335–51. https://doi.org/10.1108/JFM-11-2016-0051.

Carrillo, P, H Robinson, A. Al-Ghassani, and C. Anumba. 2004. "Knowledge Management in UK Construction: Strategies, Resources and Barriers." *Project Management Journal* 35 (1): 46–56.

Cartwright, J T. 2011. "Zoning and Designing for Affordability Using Modular Housing." Master Thesis, Iowa State University, Iowa, https://doi.org/10.31274/etd-180810-2133.

Cheung, S, and K H. Yan Pang. 2013. "Anatomy of Construction Disputes." *Journal of Construction Engineering and Management* 139 (1): 15–23. https://doi.org/10.1061/(ASCE)CO.1943-7862.0000532.

Chimay, J.A, E Charles, and C Patricia. 2005. *Knowledge Management in Construction*. Blackwell Publishing. URL: https://epdf.pub/knowledge-management-in-constructionaf7790d128acb8f63e5734f9bf146a2757718.html

Chiu, S T-L. 2012. "An Analysis on : The Potential of Prefabricated Construction Industry." https://open.library.ubc.ca/collections/52966/items/1.0103132.

Choi, J O, X B Chen, and T W Kim. 2019. "Opportunities and Challenges of Modular Methods in Dense Urban Environment." *International Journal of Construction Management* 19 (2): 93–105. https://doi.org/10.1080/15623599.2017.1382093.

CHPS (The Collaborative for high-performance schools). 2006. "Best Practices Manual Relocatable Classrooms." Vol. V1, URL: https://epdf.pub/best-practices-manual-volvi-high-performance-relocatable-classrooms.html

Ciotti, R. 2018. *Contract Drafting for Modular Construction: A Modern Approach to a Traditional Craft*. Modular Building Institute, http://www.modular.org/HtmlPage.aspx?name=MA-feature-contract-drafting.

Concordia University, and MBI (Modular Building Institute). 2015. "Challenges and Opportunities for Modular Construction in Canada Workshop Summary Report," Department of Building, Civil and Environmental Engineering, Concordia University, 1–22, URL: http://modular.org/documents/document_publication/Modular_Industry_Characteristics_and_Barrier_to_its_Increased_Market_Share.pdf.

Durdyev, S, and S. Ismail. 2019. "Offsite Manufacturing in the Construction Industry for Productivity Improvement." *EMJ - Engineering Management Journal* 31 (1): 35–46. URL:https://doi.org/10.1080/10429247. 2018.1522566.

Eastman, C M., and R. Sacks. 2008. "Relative Productivity in the AEC Industries in the United States for On-Site and Off-Site Activities." *Journal of Construction Engineering and Management* 134 (7): 517–26. https://doi.org/10.1061/(asce)0733-9364(2008)134:7(517).

Edelman, H, J Vihola, M Laak, and P Annila. 2016. "Resiliency of Prefabricated Daycares and Schools: Finnish Perspective To Relocatable Education Facilities." *International Journal of Strategic Property Management* 20 (3): 316–27. https://doi.org/10.3846/1648715x.2016.1190793.

Egbu, C, P Quintas, C Anumba, E Kurul, V Hutchinson, A.M Al-Ghassani, and K. Ruikar. 2003. "Techniques & Technologies for Knowledge Management Work Package 3- Interim Report." Knowledge Management for Sustainable Construction Competitiveness , URL: https://pdfs.semanticscholar.org/3801/0da88aaa193587502 3f02b9795a90a7ffd72.pdf?_ga=2.258511626.1651769245.1580773915-1790037153.1580773915

Ferdous, W, Y Bai, T D Ngo, A Manalo, and P Mendis. 2019. "New Advancements, Challenges and Opportunities of

Multi-Storey Modular Buildings – A State-of-the-Art Review.” *Engineering Structures* 183 (October 2018): 883–93. https://doi.org/10.1016/j.engstruct.2019.01.061.

Fernández-sánchez, G, and F Rodríguez-lópez. 2010. “A Methodology to Identify Sustainability Indicators in Construction Project Management — Application to Infrastructure Projects in Spain”, Ecological Indicators, 10 (6): 1193–1201. https://doi.org/10.1016/j.ecolind.2010.04.009.

Gibson, G, C Caldas, A Yohe, and R Weerasooriya. 2007. "*An Analysis of Lessens Learned Programs in the Construction Industry",*, The University of Texas at Austin, URL: https://repositories.lib.utexas.edu /handle/2152/38793

Government of Alberta. 2018. “Technical Design Requirements for Alberta Infrastructure Facilities.,” no. February: 1–452. http://www.infrastructure.alberta.ca/Content/docType486/Production/TechDesignRequirements.pdf.

Government of Alberta, Government of British Columbia, and Government of Saskatchewan. 2010. “New West Partnership Trade Agreement.”http://www.newwestpartnershiptrade.ca/pdf/NewWestPartnershipTrade Agreement.pdf.

Gransberg, D D., and R F. Barton. 2007. “Analysis of Federal Design-Build Request for Proposal Evaluation Criteria.” *Journal of Management in Engineering* 23 (2): 105–11. https://doi.org/10.1061/(asce)0742-597x(2007)23:2(105).

Haas, C T., and W R. Fagerlund. 2002. “Preliminary Research on Prefabrication, Pre-Assembly, Modularization and off-Site Fabrication in Construction.” *A Report to the Construction Industry Institute, the University of Texas at Austin*. https://smartech.gatech.edu/handle/1853/10883.

Haas, C T, J T O’Connor, RT Tucker, JA Eickmann, and WR Fagerlund. 2000. “Prefabrication and Preassembly Trends and Effects on the Construction Workforce.” *A Report to the Center for Construction Industry Studies, University of Texas at Austin,* 14, https://books.google.ca/books/about/Prefabrication_and_Preassembly_Trends_an.html?id=TvTbpwAACAAJ&redir_esc=y.

Hamie, J, and M A Abdul-Malak. 2018. “Rules-Based Approach for Construction Contract Documents Interpretation.” *Proceeding of Construction Research Congress 2018*, no. Vdc: 429–38. https://doi.org/10.1213/01.ANE.0000149897.87025.A8.

Hammad, A WA, A Akbarnezhad, P Wu, X Wang, and A Haddad. 2019. “Building Information Modelling-Based Framework to Contrast Conventional and Modular Construction Methods through Selected Sustainability

Factors.” *Journal of Cleaner Production,* 228: 1264–81. https://doi.org/10.1016/j.jclepro.2019. 04. 150.

Hardiman, T. 2011. “Sustainable Modular Classrooms.” School Planning and Management., https://spaces4learning.com/articles/2011/04/01/sustainable-modular-classrooms.aspx

Hartmann, A, and A Doree. 2015. “Learning between Projects: More than Sending Messages in Bottles.” *International Journal of Project Management* 33 (2): 341–51, https://doi.org/10.1016/j.ijproman.2014.07.006

Hasnain, M, and M J Thaheem. 2016. “Best Value Procurement in Construction and Its Evolution in the 21 St Century : A Systematic Review,”, *Journal for the Advancement of Performance Information and Value*, 8 (1): 1–21, https://cibw117.org/wp-content/uploads/2018/03/3-Systematic-Review.pdf.

Idrus, A B, and J B Newman. 2010. “Construction Related Factors Influencing the Choice of Concrete Floor Systems Construction Related Factors in Uencing the Choice of Concrete Floor Systems”, *Construction Management and Economics, 20 (1): 13-19.* . https://doi.org/10.1080/01446190110101218.

Ioannou, P G., and R E. Awwad. 2010. “Below-Average Bidding Method.” *Journal of Construction Engineering and Management* 136 (9): 936–46. https://doi.org/10.1061/(ASCE)CO.1943-7862.0000202.

Jackson, N M. 2015. “A Case for Increased Regulation of Relocatable Buildings in the Province of Ontario.” A thesis presented to the University of Waterloo in fulfillment of the thesis requirement for the degree of Master of Architecture in Engineering, http://hdl.handle.net/10012/9498.

Jaillon, L.C. 2009. “The Evolution of the Use of Prefabrication Techniques in Hong Kong Construction Industry”. *The Hong Kong Polytechnic University*. https://doi.org/10.1007/s13398-014-0173-7.2.

Johnson, R A, and G K Bhattacharyya. 2014. *Statistics: Principles and Methods*. Wiley Global Education, Volume 7th

Kamali, M. 2019. *Integrated Life Cycle Sustainability Performance Assessment Framework for Residential Modular Buildings*. Doctor of Philsophy Thesis in University of British Columbia, https://open.library.ubc.ca/cIRcle/collections/ubctheses/24/items/1.0379317 .

Kamali, M, and K Hewage. 2016. “Life Cycle Performance of Modular Buildings: A Critical Review.” *Renewable and Sustainable Energy Reviews* 62: 1171–83. https://doi.org/10.1016/j.rser.2016.05.031.

Kamara, J.M, G Augenbroe, C.J Anumba, and P.M Carrillo. 2002. “Knowledge Management in the Architecture, Engineering and Construction Industry.” *Construction Innovation* 2 (1): 53–67, https://doi.org/10.1108/14714170210814685.

Kasvi, J.J.J, M Vartiainen, and M Hailikari. 2003. “Managing Knowledge and Knowledge Competences in Projects and Project Organisations." *Internation Journal of Project Management* 21 (8): 571–82.

Kyrö, R, T Jylhä, and A Peltokorpi. 2019. "Embodying Circularity through Usable Relocatable Modular Buildings." *Facilities* 37 (1–2): 75–90. https://doi.org/10.1108/F-12-2017-0129.

Laryea, S, and W Hughes. 2010. "Risk and Price in the Bidding Process of Contractors." *Journal of Construction Engineering and Management* 137 (4): 248–58. https://doi.org/10.1061/(ASCE)CO.

Lawson, R. M, R G. Ogden, and R Bergin. 2011. "Application of Modular Construction in High-Rise Buildings." *Journal of Architectural Engineering* 18 (2): 148–54. https://doi.org/10.1061/(asce)ae.1943-5568.0000057.

Li, X, Y Geng, Z Song, Q Ma, and X Tian. 2017. "Job Stress and Job Satisfaction of Workers in Traditional Cast-in-Situ Projects and Industrialized Projects," In ICCREM 2017 : 89–96. https://doi.org/10.1061/9780784481059.009.

Liu, S, W Cui, and L Zhang. 2018. "Research on Enterprise Bidding Mode Selection and Control Strategy." *Cluster Computing* 22, 14269-14267. https://doi.org/10.1007/s10586-018-2285-x.

Love, P E D, , F Ackermann, B Carey, J Morrison, M Ward, and A Park. 2016. "Praxis of Rework Mitigation in Construction" 32 (5): 1–10. https://doi.org/10.1061/(ASCE)ME.1943-5479.0000442.

Luu, D T, S. Thomas Ng, and S Chen. 2005. "Formulating Procurement Selection Criteria through Case-Based Reasoning Approach." *Journal of Computing in Civil Engineering* 19 (3): 269–76. https://doi.org/10.1061/(asce)0887-3801(2005)19:3(269).

Mao, C, Q Shen, W Pan, and K Ye. 2013. "Major Barriers to Off-Site Construction: The Developer's Perspective in China." *Journal of Management in Engineering* 31 (3): 04014043. https://doi.org/10.1061/(asce)me.1943-5479.0000246.

Mason, D, and D.J Pauleen. 2003. "Perceptions of Knowledge Management: A Qualitative Analysis." *Journal of Knowledge Management* 7 (4): 38–48, https://doi.org/10.1108/13673270310492930.

MBI (Modular Building Institute). 2011. "Relocatable Buildings 2011- Annual Report.", http://www.modular.org/documents/document_publication/2011relocatable.pdf

———. 2018. *Modular Advantage; Making Sense of the Affordable Housing Crisis,* http://www.modular.org/HtmlPage.aspx?name=MA-feature-making-sense, Accessed on October 2019.

MBI, Modular Building Institute. 2010. "Improving Construction Efficiency & Productivity with Modular Construction.", https://www.modular.org/marketing/documents/Whitepaper_ImprovingConstruction

Efficiency.pdf

———. 2012. “The Economic& Financial Performance of Relocatable Buildings in the U.S. Modular Building Industry.” *Prepared by Sage Policy Group*, 1–36, http://www.modular.org/documents/relocatablebuildingswhitepaper/SAGE_Report_final.pdf.

McGraw Hill Construction. 2011. *Prefabrication Modularization in the Construction Industry SMR 2011R*. https://www.nist.gov/sites/default/files/documents/el/economics/Prefabrication-Modularization-in-the-Construction-Industry-SMR-2011R.pdf.

Miller, G, C W Furneaux, Davi, P Love, and A O’Donnell. 2009. “Built Environment Procurement Practice: Impediments to Innovation and Opportunities for Changes,” no. May: 1–184, https://eprints.qut.edu.au/27114/1/Furneaux_-_BEIIC_Procurement_Report.pdf.

Mohamad, M I, M Zawawi, and M.A.Nekooie. 2009. “Implementating Industriaised Building System (IBS) In Malaysia: Acceptance and Awareness Level, Problems and Strategies.” *Malaysian Journal of Civil Engineering* 21 (December): 435–40. https://doi.org/10.13140/RG.2.1.3921.2884.

Molenaar, K, and J Vanegas. 2000. “Appropriate Risk Allocation in Design-Build RFPs.” In *Construction Congress VI: Building Together for a Better Tomorrow in an Increasingly Complex World*, 1083–92.

Morgan, D, and R Krueger. 1998. *The Focus Group Kit*. Thousand Oaks, CA: SAGE.

Na, L. 2007. “Investigation of the Desginers and General Contractors' Perceptions of Offsite Construction Techniques In the United States Construction Industry,” Clemson University. http://etd.lib.clemson.edu/documents/1181668809/umi-clemson-1259.pdf.

OECM (Ontario Education Collaborative Marketplace) . 2017. “Portable Classrooms- Supply and Installation, Request for Proposal.” https://oecm.ca/sites/default/files/RFP/PCU-299-RFP.pdf.

O’Connor, J T., W J. O’Brien, and J O Choi. 2015. “Standardization Strategy for Modular Industrial Plants.” *Journal of Construction Engineering and Management* 141 (9): 040150261-0401502610. https://doi.org/10.1061/(asce)co.1943-7862.0001001.

Office of Legislative. 2014. “Change Orders in County Construction Projects.”, https://www.montgomerycountymd.gov/OLO/Resources/Files/2014_reports/FinalChangeOrderReport.pdf

Office of Procurement Ombudsman. 2018. “Procurement Practice Reviews.’ Follow up on 2008-2009 Procurement Practice Reviews.” , http://opo-boa.gc.ca/documents/praapp-prorev/2008-2009/chptr-1-eng.pdf.

Palliser. 2019. “Modulars Arrive at Jennie Emery Elementary.” Retrieved on November 20th 2019. https://www.pallisersd.ab.ca/about-us/news/post/modulars-arrive-at-jennie-emery-elementary.

Paranagamage, P, P Carrillo, K Ruikar, and P Fuller. 2012. “Lessons Learned Practices in the UK Construction Sector: Current Practice and Proposed Improvements.” *Engineering Project Organization Journal* 2 (4): 216–30. https://doi.org/10.1080/21573727.2012.681643.

Partnerships,. 2010. "Modular Classroom Project Statement of Requirements", British Columbia, http://www.partnershipsbc.ca/files-4/documents/AppendixBStatementofRequirementsnosevering.pdf.

PMI. 2004. *A Guide to the Project Management Body of Knowledge (PMBOK®guide)*. Third Edit. Project Management Institute.

Polyaninova, T. 2011. “Knowledge Management in a Project Environment: Organisational CT and Project Influences.” *Vine* 41 (3), http://doi:10.21427/D7NK7M.

Quale, J, M J. Eckelman, K W. Williams, G Sloditskie, and J B. Zimmerman. 2012. “Construction Matters: Comparing Environmental Impacts of Building Modular and Conventional Homes in the United States.” *Journal of Industrial Ecology* 16 (2): 243–53. https://doi.org/10.1111/j.1530-9290.2011.00424.x.

Rahman, M. M. 2013. “Barriers of Implementing Modern Methods of Construction.” *Journal of Management in Engineering* 30 (1): 69–77. https://doi.org/10.1061/(asce)me.1943-5479.0000173.

Ramsey, D, M El Asmar, and G. E Gibson. 2016. “Quantitative Performance Assessment of Single-Step versus Two-Step Design-Build Procurement.” *Journal of Construction Engineering and Management* 142 (9): 04016033. https://doi.org/10.1061/(asce)co.1943-7862.0001145.

Randolphlaw. 2019. “Avoiding Ambiguities in the RFP Peocess.” 2019. http://www.randolphlaw.com/avoiding-ambiguities-rfp-process/.

Rice, T, and R E. Smith. 2017. “Offsite Construction Industry Meta-Analysis; Industry Survey Results.” *Offsite Architecture: Constructing the Future* 1.

Roshnavand, A A, M Nik-bakht, and S H Han. 2019. “Towards Automated Analysis of Ambiguity in Modular Construction Contract Documents (A Qualitative & Quantitative Study).” In *Advances in Informatics and Computing in Civil and Construction Engineering*, 343–50. Springer International Publishing. https://doi.org/10.1007/978-3-030-00220-6.

Ruparathna, R, and K Hewage. 2013. “Review of Contemporary Construction Procurement Practices.” *Journal of*

Management in Engineering 31 (3): 04014038. https://doi.org/10.1061/(asce)me.1943-5479.0000279.

Schmold, S. 2010. "Resolving Alberta's School Infrastructure Deficit: School Boards' Input toward Solutions.", Alberta School boards Accosiation, https://www.asba.ab.ca/wp-content/uploads/ 2018/10/school _infrastructure _report.pdf.

Shane, J S., D D. Gransberg, K R. Molenaar, and J R. Gladke. 2006. "Legal Challenge to a Best-Value Procurement System." *Leadership and Management in Engineering* 6 (1): 20–25. https://doi.org/10.1061/(ASCE)1532-6748(2006)6:1(20).

Sharafi, P, M Rashidi, B Samali, H Ronagh, and M Mortazavi. 2018. "Identification of Factors and Decision Analysis of the Level of Modularization in Building Construction." *Journal of Architectural Engineering* 24 (2): 04018010. https://doi.org/10.1061/(asce)ae.1943-5568.0000313.

Shokri-Ghasabeh, M, and N Chileshe. 2014. "Knowledge Management: Barriers to Capturing Lessons Learned from Australian Construction Contractors Perspective." *Construction Innovation* 14 (1): 108–34. https://doi.org/10.1108/CI-06-2013-0026.

Smith, R E. 2010. "Prefab Architecture: A Guide to Modular Design and Construction." *John Wiley & Sons*.

Smith, R E., and J D. Quale. 2017. *Offsite Architecture: Constructing the Future*. *Offsite Architecture: Constructing the Future*. https://doi.org/10.4324/9781315743332.

Smith, R E., and T Rice. 2017. "Permanent Modular Construction- Construction Performance." In *Offsite Architecture: Constructing the Future*, Chapter 7.

Song, L, Y Mohamed, and S AbouRizk. 2009. "Early Contractor Involvement in Design and Its Impact on Construction Schedule Performance." *Journal of Management in Engineering* 4 (October): 166–76. https://doi.org/10.1061/(ASCE)0742-597X(2009)25.

Southern, J. 2016. "Smart Construction," KPMG, https://assets.kpmg/content/dam/kpmg/pdf/2016/04/smart-construction-report-2016.pdf.

SPOSA, School Plant Office Society of Alberta. 2005. "Modular Classrooms A New Generation of Relocatable Classrooms."

Tan, H.C, C.J Anumba, P.M Carrillo, D Bouchlaghem, J Kamara, and C Udeaja. 2010. *Capture and Reuse of Project Knowledge in Construction*. John Wiley&Sons, West Sussex. https:// DOI:10.1002/9781444315448

Tanja, B. 2016. "Collecting Lessons Learned: How Project-Based Organizations in the Oil and Gas Industry Learn from Their Projects.” Delft University of Technology. https://doi.org/10.4233/uuid.

Thomas, H R, G R Smith, and R E Mellott. 1994. “Interpretation of Construction Contracts.” *Journal of Construction Engineering and Management* 120 (2): 321–36.

Thomas, W H. 2011. *The Basics of Project Evaluation and Lessons Learned*. Portland, United States: Productivity Press, 2nd edition.

Tkáč, M, R Delina, and M Sabolová. 2016. “Analysis of Request for Proposals in Construction Industry.” *Quality Innovation Prosperity* 20 (1): 104–17. https://doi.org/10.12776/QIP.V20I1.686.

Urquhart, S, and A Whyte. 2018. “Rethinking the Tendering Frameworks of Construction Contractors in the Context of a Soft Systems Methodology Approach.” *Frontiers of Engineering Management* . https://doi.org/10.15302/j-fem-2018019.

Velamati, S. 2012. “Feasibility, Benefits and Challenges of Modular Construction in High rise Development in the United States: A Developer's Perspective.” *Massachusetts Institute of Technology,* http://hdl.handle.net/1721.1/77129.

Williams, T. 2007. “Post-Project Reviews to Gain Effective Lessons Learned.” . Project Management Institute.

Wuni, I Y., G Q.P. Shen, and A T Mahmud. 2019. “Critical Risk Factors in the Application of Modular Integrated Construction: A Systematic Review.” *International Journal of Construction Management* 0 (0): 1–15. https://doi.org/10.1080/15623599.2019.1613212.

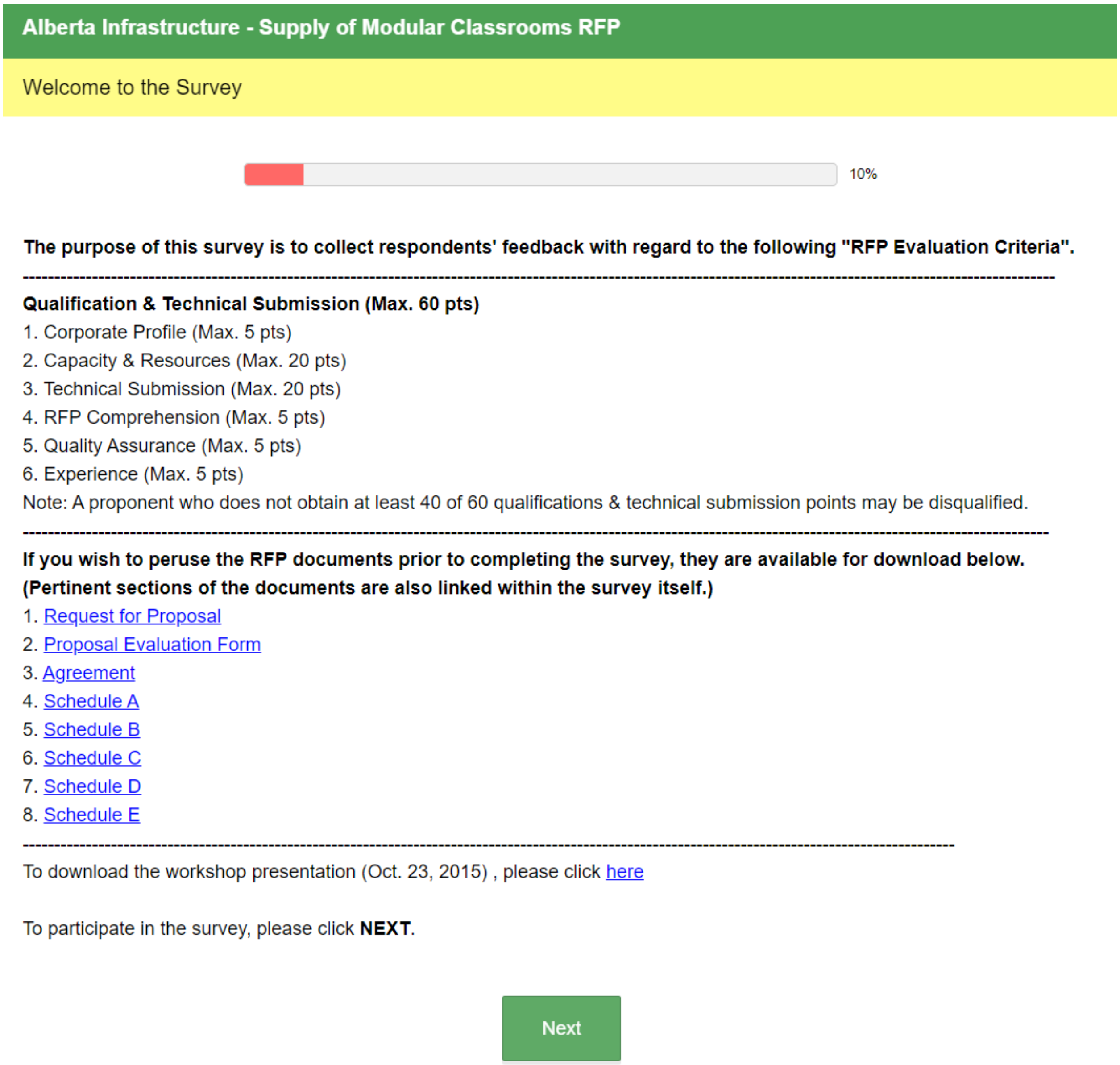
Xia, B, A Chan, J Zuo, and K Molenaar. 2013. “Analysis of Selection Criteria for Design-Builders through the Analysis of Requests for Proposal.” *Journal of Management in Engineering* 29 (1): 19–24. https://doi.org/10.1061/(asce)me.1943-5479.0000119.

Xia, B, M Skitmore, and J Zuo. 2011. “Evaluation of Design-Builder Qualifications through the Analysis of Requests for Qualifications.” *Journal of Management in Engineering* 28 (3): 348–51. https://doi.org/10.1061/(asce)me.1943-5479.0000095.

Yap, J B H, and A Lock. 2017. “Analysing the Benefits, Techniques, Tools and Challenges of Knowledge Management Practices in the Malaysian Construction SMEs.” *Journal of Engineering, Design and Technology* 15 (6): 803–25. https://doi.org/10.1108/JEDT-07-2017-0067.

Zivov, A, D Bailey, and Herron D. 2012. “U.S. Army Corps of Engineers Air Leakage Test Protocol for Building Envelopes.” https://www.wbdg.org/FFC/ARMYCOE/usace_airleakagetestprotocol.pdf.

Appendix 1



Alberta Infrastructure - Supply of Modular Classrooms RFP
Welcome to the Survey
10%
The purpose of this survey is to collect respondents' feedback with regard to the following "RFP Evaluation Criteria".
Qualification & Technical Submission (Max. 60 pts)
1. Corporate Profile (Max. 5 pts)
2. Capacity & Resources (Max. 20 pts)
3. Technical Submission (Max. 20 pts)
4. RFP Comprehension (Max. 5 pts)
5. Quality Assurance (Max. 5 pts)
6. Experience (Max. 5 pts)
Note: A proponent who does not obtain at least 40 of 60 qualifications & technical submission points may be disqualified.
If you wish to peruse the RFP documents prior to completing the survey, they are available for download below. (Pertinent sections of the documents are also linked within the survey itself.)
1. Request for Proposal
2. Proposal Evaluation Form
3. Agreement
4. Schedule A
5. Schedule B
6. Schedule C
7. Schedule D
8. Schedule E
To download the workshop presentation (Oct. 23, 2015) , please click here
To participate in the survey, please click **NEXT**.
Next

Alberta Infrastructure - Supply of Modular Classrooms RFP

1. CORPORATE PROFILE (Max. 5 pts)

20%

1(i) History of the Proponent, types of services/ construction provided, and areas of expertise. *(provided and relevant = 2 pts, provided and partially relevant = 1 pt, not provided = 0 pts)* **(Refer to Article 4 Section 00 22 16)**

* **In your opinion is this requirement a relevant criterion?**

- Yes
- No
- Not Sure

* **Is the system for scoring this requirement clear?**

- Yes
- No
- Not Sure

* **Do you anticipate that your company might have difficulty satisfying this requirement?**

- Yes
- No
- Not Sure

* **Is this requirement missing any of the information that would ensure an objective, quantitative evaluation?**

- Yes
- No
- Not Sure

Comments

1(ii) Key Personnel's experience and contact information is provided. *(provided = 1 pt, not provided = 0 pts)* **(Refer to Article 4 Section 00 22 16)**

* **In your opinion is this requirement a relevant criterion?**

- Yes
- No
- Not Sure

* **Is the system for scoring this requirement clear?**

- Yes
- No
- Not Sure

1(iii) Identify manufacturing facilities and any other relevant manufacturing information. *(provided = 1 pt, not provided = 0 pts)* **(Refer to Article 4 Section 00 22 16)**

*** In your opinion is this requirement a relevant criterion?**

- Yes
- No
- Not Sure

*** Is the system for scoring this requirement clear?**

- Yes
- No
- Not Sure

*** Do you anticipate that your company might have difficulty satisfying this requirement?**

- Yes
- No
- Not Sure

*** Is this requirement missing any of the information that would ensure an objective, quantitative evaluation?**

- Yes
- No
- Not Sure

Comments

1(iv) An organizational chart noting how the key personnel are organized, by indicating formal reporting lines and informal lines of communication. *(provided = 1 pt, not provided = 0 pts)* **(Refer to Article 4 Section 00 22 16)**

*** In your opinion is this requirement a relevant criterion?**

- Yes
- No
- Not Sure

*** Is the system for scoring this requirement clear?**

- Yes
- No
- Not Sure

*** Do you anticipate that your company might have difficulty satisfying this requirement?**

- Yes
- No
- Not Sure

*** Is this requirement missing any of the information that would ensure an objective, quantitative evaluation?**

- Yes
- No
- Not Sure

Comments

Prev Next

Alberta Infrastructure - Supply of Modular Classrooms RFP

2. CAPACITY & RESOURCES (Max. 20 pts)

30%

2(i) Provide information about capacity and resources that discusses how they will be managed and provide the Modular Classrooms and services. *(fully provided = 5 pts, partially provided = 3 pts, not provided = 0 pts)* **(Refer to Article 5 Section 00 22 16)**

*** In your opinion is this requirement a relevant criterion?**

- ◯ Yes
- ◯ No
- ◯ Not Sure

*** Is the system for scoring this requirement clear?**

- ◯ Yes
- ◯ No
- ◯ Not Sure

*** Do you anticipate that your company might have difficulty satisfying this requirement?**

- ◯ Yes
- ◯ No
- ◯ Not Sure

*** Is this requirement missing any of the information that would ensure an objective, quantitative evaluation?**

- ◯ Yes
- ◯ No
- ◯ Not Sure

Comments

2(ii) Proponents should describe and provide details of their manufacturing capacity per month and information if capacity could be increased. *(current capacity 16+ units = 5 pts, 12 units = 4 pts, 8 units = 3 pts, 4 units = 2 pts, 3 to 1 units = 1 pt, not provided = 0 pts)* **(Refer to Article 5 Section 00 22 16)**

*** In your opinion is this requirement a relevant criterion?**

- ◯ Yes
- ◯ No
- ◯ Not Sure

*** Is the system for scoring this requirement clear?**

- ◯ Yes
- ◯ No
- ◯ Not Sure

*** Do you anticipate that your company might have difficulty satisfying this requirement?**

- ◯ Yes
- ◯ No
- ◯ Not Sure

*** Is this requirement missing any of the information that would ensure an objective, quantitative evaluation?**

- ◯ Yes
- ◯ No
- ◯ Not Sure

Comments

2(iii) A schedule to meet design and manufacturing that lists steps for the first prototype of unit A and unit B, as outlined in the Agreement, Article 8, should be provided. *(0-3 months = 5 pts, 3-6 months = 4 pts, 6-12 months = 2 pts, 12+months = 0 pts)* **(Refer to Article 5 Section 00 22 16 & Article 8 of Agreement)**

*** In your opinion is this requirement a relevant criterion?**

- ◯ Yes
- ◯ No
- ◯ Not Sure

*** Is the system for scoring this requirement clear?**

- ◯ Yes
- ◯ No
- ◯ Not Sure

*** Do you anticipate that your company might have difficulty satisfying this requirement?**

- ◯ Yes
- ◯ No
- ◯ Not Sure

*** Is this requirement missing any of the information that would ensure an objective, quantitative evaluation?**

- ◯ Yes
- ◯ No
- ◯ Not Sure

Comments

2(iv) Describe strategies for ensuring the Completion Date will be met, including tracking and early indicators of schedule performance issues should be provided. *(fully provided = 3 pts, partially provided = 1 pt, not provided = 0 pts)* **(Refer to Article 5 Section 00 22 16)**

* **In your opinion is this requirement a relevant criterion?**

- Yes
- No
- Not Sure

* **Is the system for scoring this requirement clear?**

- Yes
- No
- Not Sure

* **Do you anticipate that your company might have difficulty satisfying this requirement?**

- Yes
- No
- Not Sure

* **Is this requirement missing any of the information that would ensure an objective, quantitative evaluation?**

- Yes
- No
- Not Sure

Comments

2(v) Describe and provide the Proponent's plan for pre-inspection and delivery of modular classrooms, as described in Articles 9 and 11 of the Agreement should be provided. *(fully provided = 2 pts, partially provided = 1 pt, not provided = 0 pts)* **(Refer to Article 5 of Section 00 22 16 & Article 9, Article 11 of Agreement)**

*** In your opinion is this requirement a relevant criterion?**

- ◯ Yes
- ◯ No
- ◯ Not Sure

*** Is the system for scoring this requirement clear?**

- ◯ Yes
- ◯ No
- ◯ Not Sure

*** Do you anticipate that your company might have difficulty satisfying this requirement?**

- ◯ Yes
- ◯ No
- ◯ Not Sure

*** Is this requirement missing any of the information that would ensure an objective, quantitative evaluation?**

- ◯ Yes
- ◯ No
- ◯ Not Sure

Comments

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3. TECHNICAL SUBMISSION (Max. 20 pts)

40%

3(i) Proponents should provide a technical submission that includes product specifications and drawings, for all of Standard and Heavy Duty unit A, unit B and Vestibule, demonstrating adherence with the requirements in Schedule B, Performance Specifications, Article 3. *(fully inclusive of all elements outlined in Appendix A, Section 3 = 10 pts, includes most elements of the requirements but needs further investigation = 5 pts, Technical submission provides minimal or little information to access submission = 0 pts.)* **(Refer to Article 3 Schedule B)**

*** In your opinion is this requirement a relevant criterion?**

- Yes
- No
- Not Sure

*** Is the system for scoring this requirement clear?**

- Yes
- No
- Not Sure

*** Do you anticipate that your company might have difficulty satisfying this requirement?**

- Yes
- No
- Not Sure

*** Is this requirement missing any of the information that would ensure an objective, quantitative evaluation?**

- Yes
- No
- Not Sure

Comments

3(ii) Proponents should describe the processes used to ensure adherence to the Performance Specifications, Guidelines, and design concepts identified in Schedule B, Schedule C, and Schedule D.*(fully provided = 5 pts, partially provided = 3 pts, not provided = 0 pts)* **(Refer to Schedule B, Schedule C, Schedule D)**

*** In your opinion is this requirement a relevant criterion?**

- Yes
- No
- Not Sure

*** Is the system for scoring this requirement clear?**

- Yes
- No
- Not Sure

*** Do you anticipate that your company might have difficulty satisfying this requirement?**

- Yes
- No
- Not Sure

*** Is this requirement missing any of the information that would ensure an objective, quantitative evaluation?**

- Yes
- No
- Not Sure

Comments

3(iii) The approach and steps the Proponent will use to ensure the LEED requirements identified in Schedule B, Article 4 should be described. *(fully inclusive of all elements and in compliance with LEED requirements as outlined in Appendix A, Article 4 = 5 pts, includes most elements of the requirements but needs further investigation = 3 pts, provided minimal or little information to access submission = 0 pts.)* **(Refer to Article 4 Schedule B)**

*** In your opinion is this requirement a relevant criterion?**

- Yes
- No
- Not Sure

*** Is the system for scoring this requirement clear?**

- Yes
- No
- Not Sure

*** Do you anticipate that your company might have difficulty satisfying this requirement?**

- Yes
- No
- Not Sure

*** Is this requirement missing any of the information that would ensure an objective, quantitative evaluation?**

- Yes
- No
- Not Sure

Comments

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4. RFP COMPREHENSION (Max. 5 pts)

50%

4(i) The Proponent should provide a brief analysis of the unique requirements and challenges of this RFP, from the Proponent's perspective, based on the information provided in this RFP or which the Proponent anticipates. The proponent should demonstrate an understanding of the Agreement requirements, identify any special needs or considerations which the Province may not have identified, and suggest approaches for addressing them. *(provided = 2 pts, partially provided = 1 pt, not provided = 0 pts)* **(Refer to Article 7 Section 00 22 16)**

*** In your opinion is this requirement a relevant criterion?**

- Yes
- No
- Not Sure

*** Is the system for scoring this requirement clear?**

- Yes
- No
- Not Sure

*** Do you anticipate that your company might have difficulty satisfying this requirement?**

- Yes
- No
- Not Sure

*** Is this requirement missing any of the information that would ensure an objective, quantitative evaluation?**

- Yes
- No
- Not Sure

Comments

4(ii) The Proponent should describe and identify risks and descriptions of how they might be managed including labor, materials, components, testing, equipment, delivery, warranty, and other risks. *(fully provided = 3 pts, partially provided = 1 pt, not provided = 0 pts)* **(Refer to Article 7 Section 00 22 16)**

* **In your opinion is this requirement a relevant criterion?**

- Yes
- No
- Not Sure

* **Is the system for scoring this requirement clear?**

- Yes
- No
- Not Sure

* **Do you anticipate that your company might have difficulty satisfying this requirement?**

- Yes
- No
- Not Sure

* **Is this requirement missing any of the information that would ensure an objective, quantitative evaluation?**

- Yes
- No
- Not Sure

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5. QUALITY ASSURANCE (Max. 5 pts)

60%

5(i) The Proponent should describe the quality assurance plan for the design, testing, production, and possible delivery of Modular Classrooms, and associated work processes including roles and responsibilities related to quality assurance. *(fully provided = 3 pts, partially provided = 2 pts, minimally provided = 1 pt, not provided = 0 pts)* **(Refer to Article 8 Section 00 22 16)**

*** In your opinion is this requirement a relevant criterion?**

- Yes
- No
- Not Sure

*** Is the system for scoring this requirement clear?**

- Yes
- No
- Not Sure

*** Do you anticipate that your company might have difficulty satisfying this requirement?**

- Yes
- No
- Not Sure

*** Is this requirement missing any of the information that would ensure an objective, quantitative evaluation?**

- Yes
- No
- Not Sure

Comments

5(ii) Describe the management and qualify assurance systems, strategies and skills that will be employed to ensure that the Province's expectations around project scope, time, cost, quality and performance will be met. *(fully provided = 2 pts, partially provided = 1 pt, not provided = 0 pts)* **(Refer to Article 8 Section 00 22 16)**

*** In your opinion is this requirement a relevant criterion?**

- Yes
- No
- Not Sure

*** Is the system for scoring this requirement clear?**

- Yes
- No
- Not Sure

*** Do you anticipate that your company might have difficulty satisfying this requirement?**

- Yes
- No
- Not Sure

*** Is this requirement missing any of the information that would ensure an objective, quantitative evaluation?**

- Yes
- No
- Not Sure

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Alberta Infrastructure - Supply of Modular Classrooms RFP

6. EXPERIENCE (Max. 5 pts)

70%

6(i) Proponents should provide summaries and related references for up to three (3) projects completed within the last five (5) years, for which the Proponent or key personnel have provided buildings and services similar in nature in terms of scope to those in the RFP. These referenced projects should specifically identify and/ or demonstrate as outlined in Section 00 22 16, Article 9. *(3 projects = 5 pts, 2 projects = 3 pts, 1 project = 1 pt, not provided = 0 pts)* **(Refer to Article 9 Section 00 22 16)**

*** In your opinion is this requirement a relevant criterion?**

- Yes
- No
- Not Sure

*** Is the system for scoring this requirement clear?**

- Yes
- No
- Not Sure

*** Do you anticipate that your company might have difficulty satisfying this requirement?**

- Yes
- No
- Not Sure

*** Is this requirement missing any of the information that would ensure an objective, quantitative evaluation?**

- Yes
- No
- Not Sure

Comments

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Appendix 2

The lessons learned from the construction of modular classrooms will be provided as the following stages:

1. Understand the current process of modular classrooms

The current process of modular classrooms will be identified by conducting focus group meetings and site visits. Also, a cost analysis of the current practice has been conducted to identify the cost of modular classrooms per each stage. The cost of projects built over 3 years (2017-2019) has been received from the Edmonton Public School Board to conduct a cost cycle analysis. The results of this section will establish knowledge of modular classrooms from the owner's perspective.

2. Identify the Challenges associated with the construction process of modular classrooms: these challenges are identified using site visits and focus group meetings as well as a survey conducted among the operators of modular classrooms in Alberta. The survey was conducted to evaluate the identified mitigation strategies found in the focus group meetings. The respondents to this survey were facility managers operating modular classrooms in Alberta. A total of 36 survey responses have been received to date. The structure of this survey has been illustrated in Appendix 3. The main focus of this survey is on the configuration of the mechanical systems of the units, including start-up, commissioning, and controls.
3. Collecting lessons learned: Focus group meetings with facility managers of modular classrooms and a survey are used to validate lessons learned from current practice. The result of the survey suggests some improvements to the process of modular classrooms. These results are further investigated by conducting a focus group meeting. Then, the lessons learned are compared and analyzed with the benefits and challenges identified in the literature review.

A2.1 Understand the current process of modular classrooms

Design stage

Following the issuance of a PO by the owner, the manufacturer starts supplying the modules by submitting the specifications to the owner to get the pre-approval to the production of the modules. Upon receiving the written approval of the owner and if the manufacturer is new to building modular classrooms, the manufacturer needs to produce two prototypes . If the manufacturer has experience with modular classrooms, the manufacturer is not required to produce prototypes and can start producing the modules after obtaining written pre-approval for production.

Prototype stage

In this stage, the manufacturer is required to get written approval of interior inspection, air leakage test, acoustic performance test, and lighting test. If the tests get rejected the first time, the manufacturer is responsible for the cost of subsequent inspections. All the inspections should be conducted by a third-party consultant hired by the contractor. When the prototypes are approved, they can be used as part of the units requested in PO and the manufacturer can commence producing the rest of the modules.

Production stage

Once the modules are produced, the pre-delivery inspection is required to be conducted by the owner. The time of inspection can occur either every 4 calendar weeks or upon completion of the project. Following approval of the pre-delivery inspection, the contractor is responsible for storing the module in the storage yard specified in the proposal in the procurement stage until the pick-up date occurs.

Transportation stage

Depending on the type of payment, fixed fee including delivery or a fixed fee per unit agreed at the PO stage, the contractor might be responsible for the transportation of the module to the school site. The total distance of transportation from the manufacturing yard to the school site should be calculated from Google Maps. After the transportation of the modules, the contractor sends an invoice to the owner and if no dispute exists, the owner pays the amount within 30 days. The contractor may send the invoice after picking up the unit if the type of payment is agreed to be ‘fixed fee per unit’.

Transporting a module to the school site is a critical factor that must be considered before ordering modular classrooms from manufacturers or relocating them from other school sites. In fact, the dimensions of most modular classrooms are determined by transportation limits along specific routes. To reduce the risk of any damage to the module, the route of transportation should be carefully checked before transportation. In order to transport a module, the contractor must obtain approval in accordance with the Traffic Safety Act (TSA) and Commercial Vehicle

Dimension and Weight (CVDW) regulations (Alberta Government 2017). The contractor needs to submit detailed information regarding the project, location of the project, schedule, total number of loads, configuration and weights for each load and proposed transportation route from manufacturing location to the school site.

Installation stage

Site preparation should be completed prior to the delivering of modules to the school site. Site preparation is usually conducted at the same time as producing and transporting the module to the school site, which reduces the cost of the project due to the shortening of the time of the project. The module can be installed on a parking lot, playground area, or an empty area. The activities required for site preparation may be different depending on the ground condition and the type of the foundation required.

Figure A- 1. Installation of foundation piles

Figure A- 2. The positioning of modular classrooms using cranes (Palliser 2019)

The installation of the module includes placement of the module and connecting the module to other modules. Generally, the process of installation of the module and connecting the modules to other buildings should be performed by the general contractor hired by the owner or school board.

A critical issue is the location of modular classrooms relative to other modules and to the school core building. Modular classrooms should be located near school facilities such as the library, gym, etc., whereas modules that are isolated from the school core building can cause long walks for students in order to access services such as washrooms. This problem can be more challenging during extreme weather. The covered walkways between the modular classrooms and the school building can alleviate the problem; however, they add an extra cost to the project. Also, the positioning of the module should be compatible with fire codes as the fire codes specify some specific locations when the building is not equipped with the sprinklers from inside of the building.

After positioning the module to its assigned place, the module should be connected to other modules and the school building. The connection of the module consists of two main activities, including 1) connection of the module to other buildings, and 2) connection of the module to the ground. The connection of the module to the surrounding buildings includes the connection of utilities such as electrical, mechanical, etc. During this process, the cost of the connection of the module could be more expensive if the installed module has different heights or different weights. Control systems also should be installed to ensure proper communication of the module to the school's core building.

Figure A- 3. Connection of the module to other buildings

To connect the module to the ground, different types of conditions between the level of ground and floor of the school might affect the specific type of work that should be performed. According to Figure A- 4, if the level of the floor of the school is higher than the ground, the modules can be directly installed on the metal piles installed on the ground while excavation is required if the ground and floor have the same level of height. Depending on which of these two cases is applicable, stairs should be installed to ensure the classroom is accessible to students. Furthermore, the space between the ground and floor should be filled, which is called 'skirting' the module. Below the module, there should be some ventilation ducts placed to prevent moisture and mould below the building.

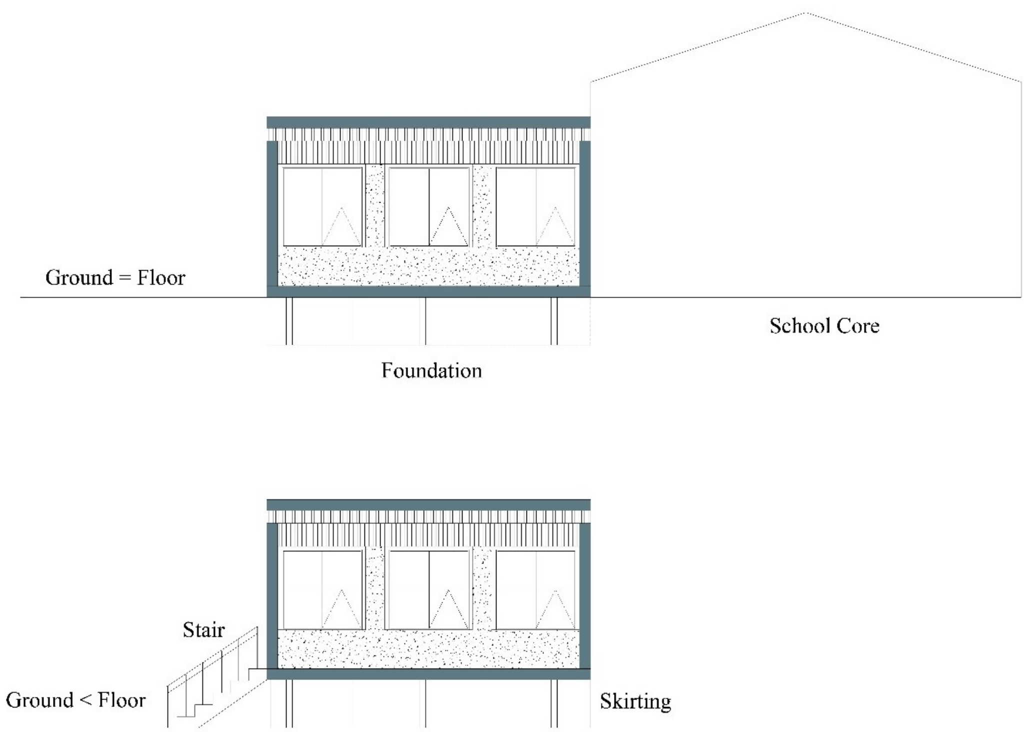

Figure A- 4. Different levels between ground and floor

Figure A- 5. Ventilation ducts below the units

After the connection of the module, the modules should be tested to see if the mechanical and electrical systems are working correctly. This process is called the "commissioning" of the module, which ensures that all the systems are correctly installed and communicating with the other buildings.

Replacement stage

This stage only occurs if the module is required to be moved to another location. In this case, the donor school board submits their request indicating that they do have an extra module that is no longer required. Then, the cost of disassembling the module, transporting it, and assembling it in the new place can be paid by the owner. Disassembling the module includes disconnecting the utilities and separating the module from other buildings while assembling requires similar activities required at the installation stage. A design consultation service is required to design the site layout of the new school based on the current buildings.

Cost analysis

When looking at the cost of any project it is essential to focus on the full life cycle cost, not just the construction costs. The increased precision of construction that happens in a factory environment can have a significant impact on the performance of the building. One owner has lowered energy bills in its buildings by 25 percent after the transition to modular construction (Bertram et al. 2019). Reviewing the past studies, it can be seen that each study focused on a particular aspect of life cycle cost analysis (LCCA) and no comprehensive study is available to be able to identify the costs associated per each stage over the life cycle of the building relying on actual costs derived from the current practice. Kamali and Hewage (2016) compared and reviewed all the life cycle assessments of modular buildings. They conclude that most of the literature stated the positive and negative aspects of modular construction qualitatively, not quantitatively. For example, there is no clear and sound cost analysis, such as life cycle cost analysis (LCCA), supporting that modular buildings are preferable when compared with identical traditional buildings (from an economic point of view).

An LCCA will determine different costs per each module type and per each stage. There are 12 types of modular classrooms for two types of weather conditions, which will be 24 types, and performing an LCCA would determine the most cost-effective type of classroom, and also determine the risks associated with the cost and time of each step based on the variations. The cost items are examined from the owner's perspective. It reveals the cost and time benefits of modular classrooms compared with conventional methods. Table A- 1 tabulates the cost items based on the stages associated with it. These items have been identified using the case study analysis of modular classrooms in Alberta. The cost of each stage could be defined as shown in Table A- 1.

Table A- 1. The cost items available for cost analyzing of relocatable modular buildings

Stage	Cost items
Supplying	- Cost of producing the module (stated in RFP by contractor) - Cost of Transportation (stated in the RFP; may vary based on the total distance of transportation)
Installation	- Foundation cost - Landscaping - Skirting - Stairs - Utility hook up costs (Mechanical, electrical etc.,) - Crane costs
Replacement	- Utility disconnection (mechanical, electrical etc.,) - Site reclamation costs (removal of foundations/ piles, removal of stairs, removal of skirting) - Consultant costs (Consultant fees, permits, etc.,) - Foundation cost - Landscaping - Skirting - Stairs - Utility hook-up costs (Mechanical, electrical etc,.)

	- Crane costs

Cost of Supplying stage: The cost of supplying modular classrooms will be determined based on the cost proposed by bidders at the time of bidding. The bidder is also requested to provide the cost of transportation in case the bidder is required to transport the module from the factory to the school site.

Cost of Installation: For installing the module, depending on the site conditions, a foundation is required. Skirting of the modules is required to fill the space between the ground and the floor of the module, which prevents moisture from getting to the building by facilitating the installation of ventilation ducts below the floor. The cost of landscaping may be applied to the project in the case where there is a difference between the level of the module and the school core building. Where the modules are above the ground level, the installation of stairs will be necessary to provide adequate access from the module to the ground. To connect the module to other buildings, the hookup utilities should get connected. The utilities include electricity, mechanical (sprinkler, etc.,.) and fire alarm if required. The total cost of the connection may vary based on the total area of connection.

Cost of Relocation: To relocate a module, the cost will be the sum of removal of the module, transportation, installation to the new school site. A consultation cost will be applied varied based on the site condition. Furthermore, an additional cost will be incurred to obtain relevant permits and approvals before transporting the module.

Figure A- 6 presents a summary of a cost analysis of 10 recent relocation projects including 26 modular classrooms built since 2015. The cost breakdowns of 10 projects over 3 years ago are tabulated in Table A- 1. ‘Miscellaneous cost’ represents the cost required for permits, the security of the construction site, etc. that school boards are responsible for paying if the modules are getting relocated. Each project might entail the replacement of multiple units.

The results show that the supply stage forms about 85% (production + transportation) of the total cost of the project stage over the life cycle of the modular classrooms as illustrated in Figure A- 6.

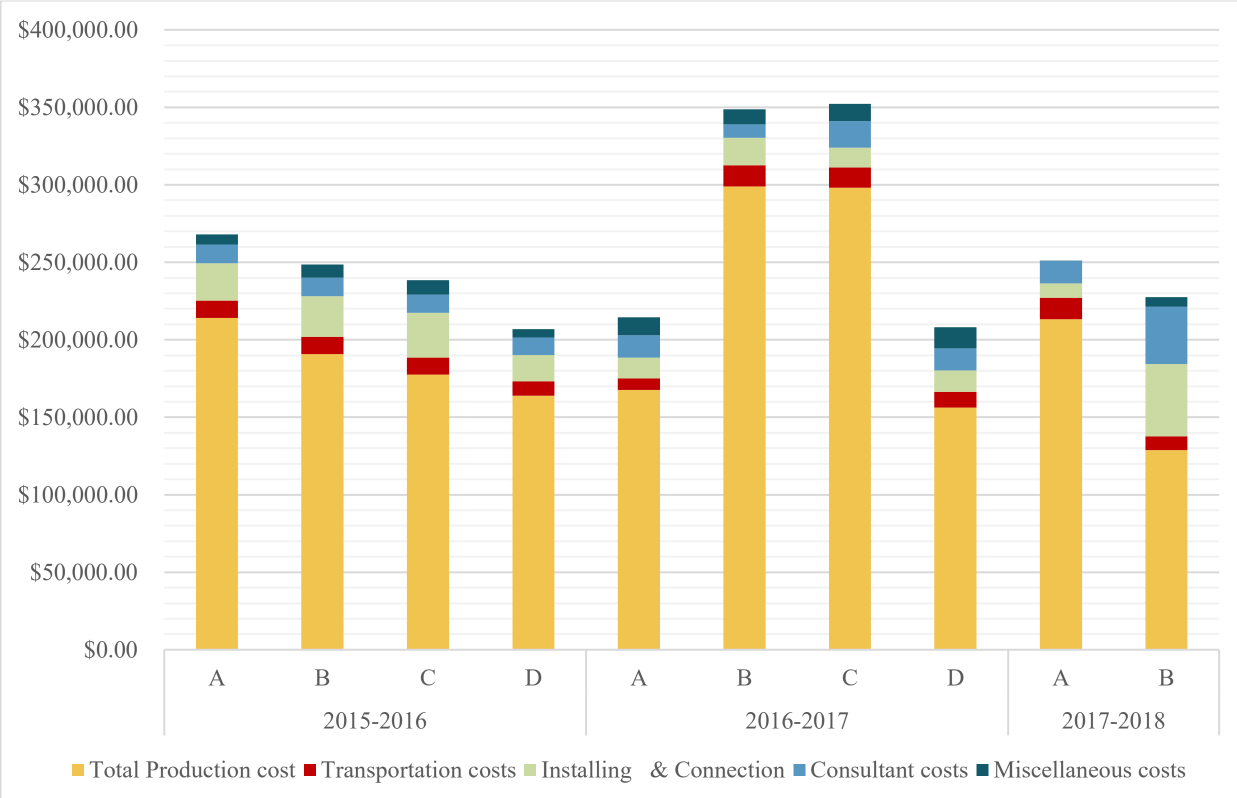

Figure A- 6. The relocation cost breakdown of the 10 projects based on their stages

Due to the confidentiality of information, there is no detail about the condition of each site. However, the results show that the total cost of installation and connection of units can vary depending on the site layout. In order to understand the variation of the costs and the causes of expenses and costs per each stage, the total cost of each stage per each project is divided into the number of units (Figure A-6). As can be seen, the variation in the costs in the supply stage could be more than $170,000 per module. The cost variation in the supply is due to the fact that some of the modules have been procured in different years. The costs do not include the value of money at the time since there is no information available about the time of supplying of these modules.

Table A- 2. Cost breakdown of the modules relocated since 2015

Year	Project Name	No.	Total supply cost	Transportation costs	Installing & Connection	Consultant costs	Miscellaneous costs	Total
2015 - 2016	A	3	$642,150.00	$33,850.00	$71,974.29	$36,089.68	$20,059.18	$1,018,173.15
	B	2	$381,656.72	$22,000.00	$52,691.73	$23,794.34	$16,844.67	$687,815.82
	C	2	$354,949.64	$22,000.00	$57,780.40	$23,419.45	$18,943.05	$654,567.36
	D	2	$327,825.44	$18,650.00	$33,618.58	$22,919.13	$10,898.00	$577,823.87
2016 - 2017	A	2	$335,216.56	$15,000.00	$26,878.41	$28,783.06	$22,931.59	$596,417.90
	B	4	$1,196,219.60	$54,000.00	$70,876.36	$35,195.26	$38,713.11	$1,694,059.23
	C	4	$1,192,919.40	$52,000.00	$50,907.85	$68,769.00	$44,388.50	$1,707,214.60
	D	2	$312,660.22	$20,000.00	$27,999.89	$28,255.56	$27,161.36	$572,407.14
2017 - 2018	A	4	$853,316.08	$55,000.00	$37,140.15	$57,764.53	$948.00	$1,217,497.78
	B	1	$128,790.69	$9,000.00	$46,580.53	$37,034.58	$6,048.80	$356,245.29
Total		26	$5,725,704.35	$301,500.00	$476,448.19	$362,024.5	$206,936.26	$9,082,222.14

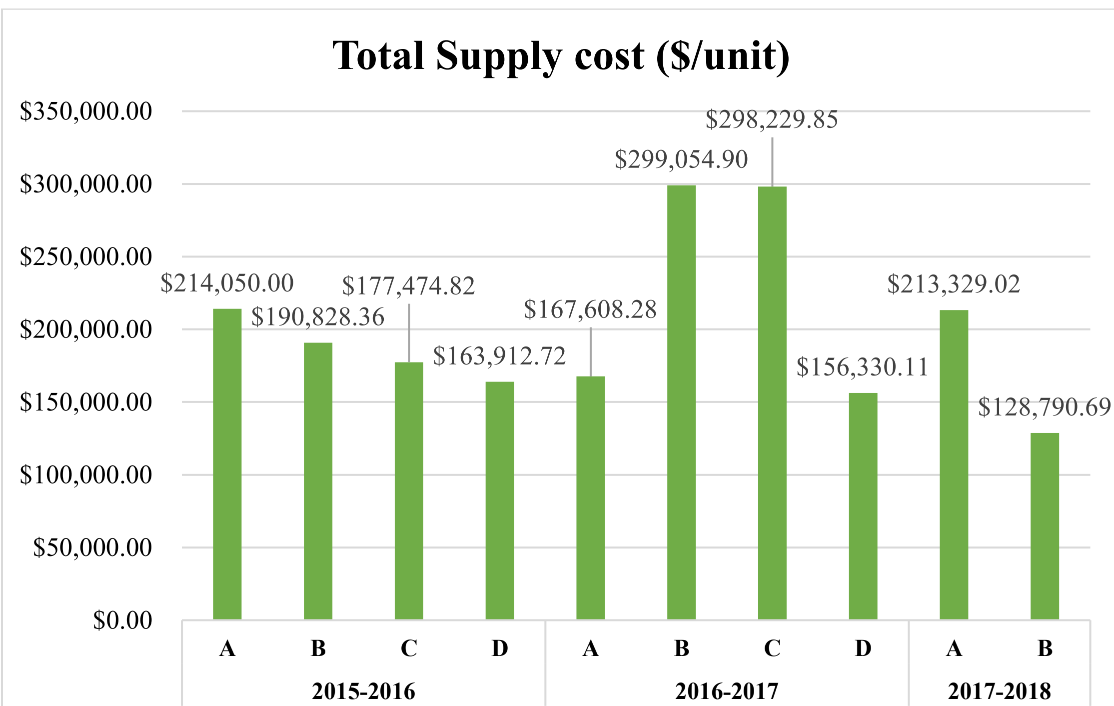

Figure A- 7. The cost of Supply per each unit

While the cost of transportation might vary according to the distances between the manufacturer's site and school site, this variation is not significant and can be justified as the distance of the factory to the school might be different (Figure A-8).

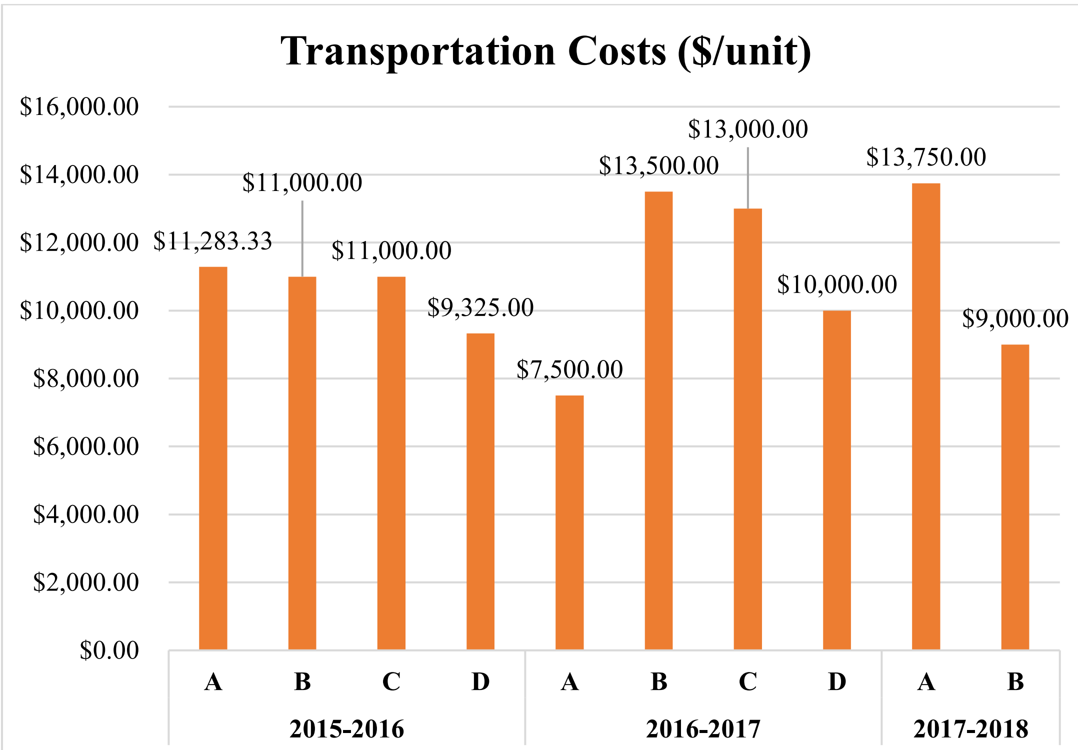

Figure A- 8. The total cost of transportation per unit of module

The costs of consultation, installation, and connection vary considerably as the older modules need more configuration and consideration at these two stages. As illustrated in Figure A-9, A-10 the cost spent on project B 2017-2018 shows a significant difference compared with other projects. This discrepancy might be due to the fact that the modules have fewer costs associated with production, perhaps due to the modules being older than other modules. The miscellaneous costs represent the various costs associated with different site conditions and locations to which the modules are relocated (Figure A-10).

This thesis shows the total impact of site conditions on the cost; however, due to the limitation of the research, it does not have any information about site specifications and any restrictions applied to that specific area. Further investigations are encouraged to explore the different impacts of site conditions on the costs.

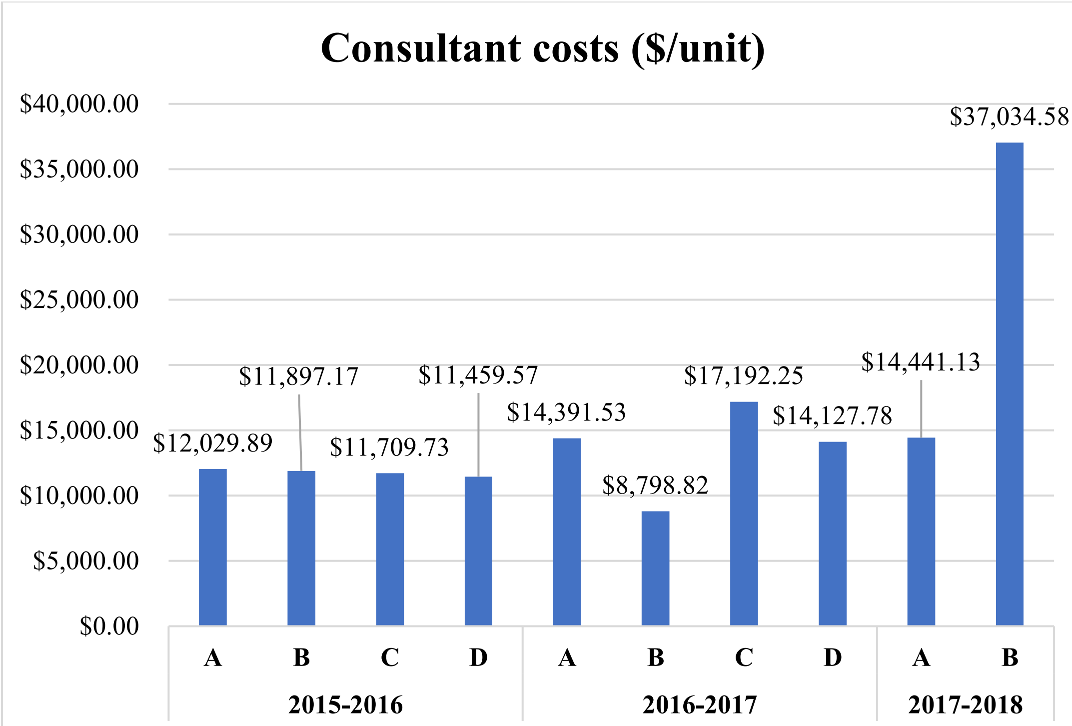

Figure A- 9. The total cost of consultation per module

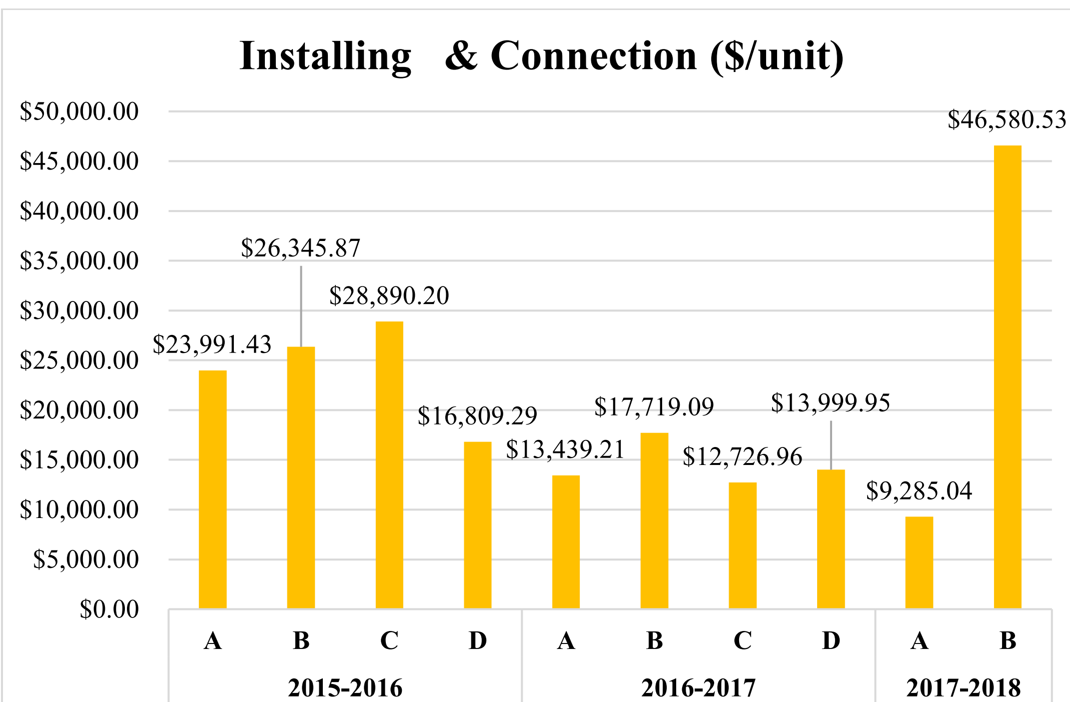

Figure A- 10. The total cost of installation and connection per module

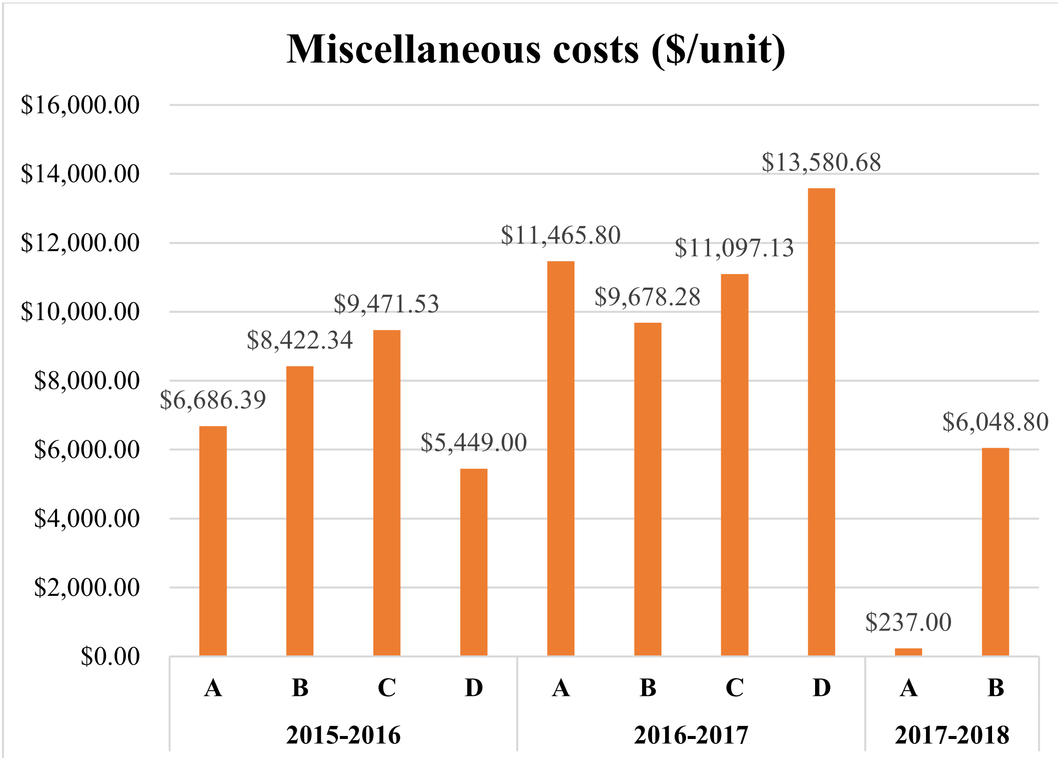

Figure A- 11. Miscellaneous cost per module

A2.2 Challenges associated with the construction process of modular classrooms

The issues and challenges in this phase are indicative of difficulties which might cause dissatisfaction. In this section, the issues and constraints identified from the literature review will be further explored using site visits, interviews, and workshop with facility managers and contractors involved in the process of modular classrooms to see which issues and constraints have been experienced more often than others and what are the causes of those issues. Focus group meetings have been conducted to propose some alternative solutions based on which the survey will be designed.

Through the site visits, interviews, workshops, and the online survey, issues and challenges are discovered from the perspectives of contractors and of school boards, as the representatives of end users of the modular classrooms.

Identified issues from school boards' perspective:

- **Problem with system control:** Programmable thermostats, which are typically found in units, can be easily defeated and the programs lost (as well as issues with compatibility with the existing core building automation system, and that it is difficult to adjust and set controls): 37 % of respondents stated that they replace the system control at the installation stage with their own system control;
- **Problem connecting modules from different manufacturers**: The most common issues are:
  - due to different height and floor affecting connections of utilities (Figure A-12); and
  - different exterior dimensions are affecting foundation layout, varying unit weights (Figure A-12).

Figure A- 12. Problems and challenges regarding connecting the modules

- **HVAC**:
    - Insufficient start-up instruction, support and training provided on startup/commissioning
    - Component failure including: freezing of sprinkler lines, condensate freeze-up causing furnace failure, whistling sound, gas valves and mechanical controls not working, condensate pump causing floods into the corridors, venting problems with the furnace
    - Controller failures, programming issues (various issues including dead battery, complicated program, wide temperature fluctuations and comfort level from set range, incomplete/incompatible software, required reprogramming)
    - Parts and service for furnaces (no local service)
- **Structural Stability**
    - **Leakage**: 43 % of respondents believed that they had received a unit with a leak. The most common location of leakage was reported at the roof penetrations and at the roof seams. This is assumed to be due to the fact that there is a time gap between the pre-delivery inspection and the time of operation during which the modules are exposed to extreme weather. The module is stored at the manufacturer's yard for almost 6 months, then it will be transported to the school site. The module is placed somewhere near the school before installation. The total time of installation of a module from picking up date until commissioning and start operating the module may take up to 4 months, which is 10 months after the pre-delivery inspection. During this time, the ownership of the modules is transferred from the contractor to the owner, which makes the owner responsible for this issue. Developing better coordination and better communication methods between contractor, manufacturer, and owner might reduce the time gap and improve the quality of the modules at the time of operation.
    - Poor floor seams/welds

Poor quality of modules:

- Missing flooring, missing pull stations, poor quality of paint and taping workmanship, missing door hardware

- **Transportation-related issues**: High transportation cost and installation cost when units are transported from remote suppliers and required for longer route due to access restrictions resulting from unit dimensions

- issues with folded doors (also, doors and frames being twisted during transportation)
- broken windows (see Figure A-13)

Figure A- 13. A broken window at the transportation stage

- **Disconnections of modules:** Crude disconnections of electrical and mechanical systems on used modular units is one of the challenges discussed by facility managers. This is consistent with lessons identified in the literature review where a higher level of skills are required on site for installation and connection of modules.
- Slow service/warranty work: The modules are not installed by manufacturers. This enables them to ignore the issues that might occur during the installation and connection of modules to each other.
- Design of the modules:
    - Less than optimal instructional space is available due to the mechanical room layout. The mechanical room is necessary for each module to be able to manage the indoor air quality of the classroom. Transportation regulations restrict the total dimensions of modules and the design of the modules is according to those specified rules and regulations. This can be seen as a constraint for modular classrooms as it is investigated in the literature review.
    - Different height dimensions in the modules: the dimensions provided in the RFP do not restrict the internal space between the floor and ceiling. This is emphasized to increase the creativity of proposals. The RFP specifies the external dimension in order to facilitate the connection of multiple modules. Consequently, there can be seen two modules with two different heights next to each other and occupants are complaining about this difference (Figure A-14).

Figure A- 14. Different internal dimensions between two different modules

    - Insufficient space for lockers and boot racks especially for joined modular

- Cost of Design: When some existing schools need a new classroom, they need a consultant service to design and find the best location of the modules based on the availability and accessibility to other places in the school. It is seen as a challenge for school boards when they need to connect the module to other buildings. This causes the project more cost and more time if it is not addressed.
- Tight schedule: The owner approves and notifies the school boards every year in the middle of March whether they will receive new classrooms and after that they are responsible for preparing the site and hiring a contractor to install the module. Classrooms can only be built when students are away in the summer, so they only have 4 months to apply for the permits, approvals, and to set up the foundation and design a place where the module should be placed. This increases the risk of the project going over budget because otherwise the project will not be finished within the 4-month timeframe and schools would have to prepare an alternative place to be used as a classroom for students.

Identified issues from contractor's point of view:

- Flooding can postpone the completion of the project: The units are left for a long time before the installation of the module and connecting them to other modules. Besides, in the process of installing the module, if excavation is required, as is illustrated in Figure A-15, Figure A-16, the modules should be first positioned and then the levelling occurs. During this time, if it rains then flooding might occur and the completion of the project will be delayed. In this case, the contractor needs to dry below the unit and then continue the project.

Figure A- 15.Flooding at the time of installation

- At the time of procurement, the bidders are asked to provide a cost per kilometre (km) for transporting modules. This cost is fixed and does not consider the road conditions and specific rules controlling that road. The bidders and contractors feel challenged since they might spend more money if the location of the project is different and requires them to get other approvals and permits.

Figure A- 16.Flooding should be dried before starting the work

- Higher risk of an incident due to large modular units: As the modules are large, the process of installation and transportation of modules will be riskier and requires the contractor to pay more attention. Figure A-17 shows a recent incident that occurred in the process of installation of modular classrooms in Alberta.

Figure A- 17. An incident during the installation of a module

- Change of design specifications at the time of the PO: Specifying design requirements at the time of issuing purchase order by owner might set different requirements from what has been specified in the RFP. This requires contractors to spend more time to modify the design and proceed to the production stage.

The summary of the issues and challenges are tabulated in Table A-3.

Table A- 3. Summary of challenges discussed with stakeholders

Challenge	Cause
HVAC System	- Freezing of sprinkler lines - Condensate freeze-up causing furnace failure - Whistling sound - Gas valves and mechanical controls not working - Condensate pump causing floods into the corridors - Venting problems with the furnace - Lack of local service to the furnace
Poor quality of modules	- Poor quality of painting and taping workmanship - Missing floors - Crude disconnections of electrical and mechanical systems at the time of disassembling - Cracks and leakage at the roof and external side of the module - Broken windows due to poor transportation - Long exposure to extreme weather before starting of operation
Transportation-related issues	- Large distances affect the cost - Regulations might apply to certain routes - Poor transportation damages the modules (windows, doors)

	- Different road conditions may damage the module
Higher risk of the incident at the installation stage	- the large volume of modular units - Site layout
Commissioning HVAC system	- Insufficient start-up instruction - Complicated coding system - A compatible system with the school building
User's opinions issues	- Less space than optimal instructional space due to - Mechanical layout room - Dimensions' restrictions due to transportation regulations - Insufficient space for lockers and boot racks especially for joined modular - Lack of access to the school building due to site layout
A dispute between contractor and owner	- Slow service of warranty after installation - Damaged units at the time of delivery
Schedule related challenges	- Flooding - Lack of coordination between school boards and contractor - Lack of framework to obtain approvals and permits - Access restrictions to some specific routes
Cost related challenges	- Tight schedule at the time of installation - Site layout affect the consultation cost - Lack of coordination between school boards and contractor - Higher transportation costs due to restricted access for longer routes - Incompatible control system - Change of design specifications at the standing order stage - Connecting modules with different dimensions and weights - The higher cost of installation due to building surroundings - Different road conditions may affect the cost of transportation

A2.3 Lessons learned from practicing of modular classrooms

Opportunities:

- Lesson 1 (Owner's view): In order to streamline the process of connection of the modules to each other in different locations, different types of modules have been used (Section 3.2.1). To ensure the structural stability of the modules, two types, standard and heavy, have been introduced and used as described in Section 3.2.7.
- Lesson 2 (Owner's view): To improve the effectiveness of the process of installation, the bidders at the supplying stage are only responsible for producing and delivering the module to the school site or a place nearby. The responsibility for obtaining the permits and local approvals and installing the units is mainly transferred to the local contractors hired by school boards. The contractors are awarded contracts via another procurement issued by school boards and they are more familiar with the local regulations and logistics

required for the process of installation. This arrangement ensures the completion of the project on time and on budget. Furthermore, this increases the coordination between school boards and contractors as they have a direct contract.

- Lesson 3 (Owner's view): The concept of ownership is a challenge in modular construction as described in the literature review. The ownership of the modules has been clearly defined and transferred through the life cycle of the modules. The manufacturer was not the owner of the modules when they delivered the modules at the site. At the time of installation, the owner of the modules is transferred to the school boards and they are responsible for the connection of the module to the building. In case of replacement of the module, this ownership is transferred from the donor school board to the receiver school board.

Challenges:

- Lesson 4 (School boards' view): Communication of control systems**:** Each school board uses its own mechanical systems to maintain the modules. When a module is relocated to a new school, the new school board will replace the mechanical system, which results in more expenses for the project. In other words, this issue occurs due to the fact that modular units are relocatable and should be relocated from one place to another. Moreover, each school board uses different control systems depending on their budget, availability of local service to the system etc.; therefore, it is not possible to use a system that would be compatible with all the schools. A simple improvement would be to remove the control system at the time of production and then deliver the module. Each school board can pay and feed their own system into the module. The results of the survey (Appendix 3) completed by 35 facility managers across Alberta show that 71 % of respondents would like to receive their units without an installed control system.
- Lesson 5 (School boards' view): The commissioning of the HVAC System: 87% of respondents suggested that an initial start-up HVAC commissioning program should be offered by the manufacturer of the modular classrooms. This can improve the coordination between user and manufacturer and increase the satisfaction of the users of the modular classrooms.
- Lesson 6 (School boards' view): Connecting modules from different manufacturers: the modules have been produced off-site and if there is any variation with respect to the height or weight of the module, it is difficult to perform any modifications. The connection of modules could be more challenging if the dimensions and

weight of the modules are not equal. This can be more challenging if the modules are produced by different manufacturers. According to the survey results, 24 % of respondents stated that they had an issue connecting units from different manufacturers. The best way to eliminate these challenges is to standardize the geometrical dimensions introduced in the RFP. Key geometrical considerations presented in the RFP that may not be changed include overall classroom size (including length, width and height), wall and floor thicknesses, and door and window dimensions. These dimensions should be clearly stated in the RFP and should be monitored at the time of inspections; pre-production approval and indoor inspection are two places where these issues should be checked. Therefore, at the time of installation and disassembling the units, an expert in modular classrooms aware of these issues and challenges should be used or proper instructions should be given to the labours. Developing some framework and checklists for future research is recommended.

- Lesson 7 (School boards' view): Installation of modules in existing schools: modular classrooms are sometimes installed far from the school core building on a playground or parking area (CHPS 2006), which causes a problem with respect to maintaining the building. A proper framework should be developed to provide some guidelines to school boards to establish a better knowledge of risks and challenges associated with units at the time of operation.
- Lesson 8 (School boards' view): Utility connection in the existing schools: Another challenge with existing schools is that finding a proper place for units can be challenging as the utility hookups should be linked to the modular classroom. According to fire regulations, there should be at least 20 feet clearance between the unit and the school core building (Government of Alberta 2018; CHPS 2006). This causes a problem when students and parents complain about having a class outside of the school core without direct access to the school facilities, meaning they have to go outside if they want to go to the washroom, which is uncomfortable when the weather is extreme during the cold or hot seasons. This challenge needs to be taken as the main problem in future research to evaluate alternative solutions such as using multi-storey modular units etc.
- Lesson 9 (School boards' view): Poor structural stability at the time of receiving the unit: The units have been sitting at the manufacturer yard for almost 6 months before the picking-up date occurs. Furthermore, the total duration required for transportation and installation is generally between 4 and 6 months. This means modules might start operating at least 1 year after the units are produced. During this time, they are exposed

to extreme weather and no protection is provided to prevent damage to the unit such as roof cracks. This problem should be addressed by developing a better coordination platform between manufacturer and owner at the time of delivery. Developing a guideline can also be useful for facility managers to be aware of the risks and challenges that may occur during this stage.

- Lesson 10 (Owner's view): Transporting the modules from the manufacturer's yard to the school site should be undertaken with more caution as road conditions might damage the units. Using certain protections can be suggested; however, it might not be the best way as it increases the cost of transportation. Further investigation in this area is recommended.
- Lesson 11 (User's view): Lack of sufficient space for lockers: To increase the space available for lockers of the modules, it is recommended to change the layout of the units as illustrated in Figure 3-36.

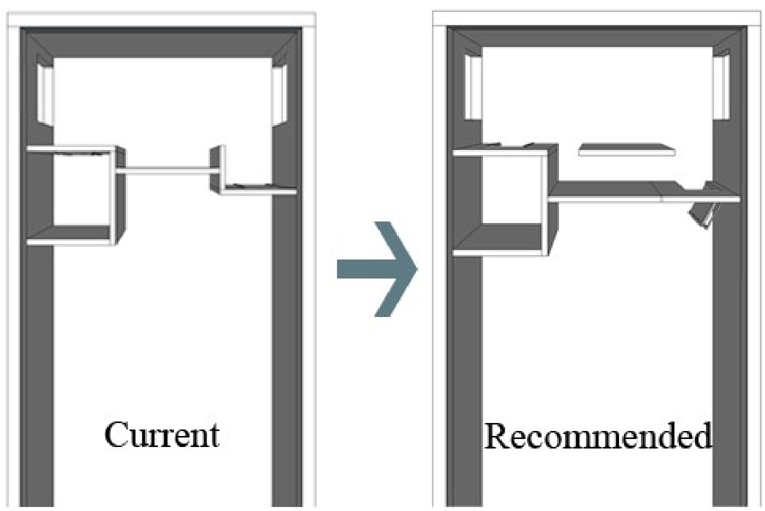

Figure A- 18. Suggested layout to be used for modular units

Appendix 3

Modular Classrooms - Performance Survey

Alberta Infrastructure is soliciting input from all Facility Managers in relation to the modular classrooms provided to jurisdictions within the last 2 to 3 years. This information will help us to determine if the needs are being met with the modular classrooms, specifically in relation to controls and HVAC requirements. We are looking for tangible information from the users of the modular classrooms in order to provide a better product in the future. Our main focus is currently on configuration of the mechanical systems of the units, including start-up, commissioning and controls.

* **1. Which modular classroom manufacturer(s) do you have experience with?** (Please check all that apply).

- ☐ BCT Structures
- ☐ Enzo
- ☐ Green smart
- ☐ Modus
- ☐ Tru-Co Structures
- ☐ WREM

* **2. Do you retain the controls which accompany the modular classroom or do you replace them with a different control system?**

- ◯ Original Controls Retained
- ◯ Original Controls Replaced

If replaced, what is the issue with the supplied controller? Which controller is used to replace the original?

* **3. Would your jurisdiction like to have the option of ordering a modular classroom without an installed control system?** (Wiring would be pulled to the controller location with no control box installed).

- ◯ Yes
- ◯ No

* **4. Have you experienced any problems connecting two modulars from different suppliers together?**

- ◯ Yes
- ◯ No

If so, please specify.

* **5. Have you experienced any ongoing issues with the initial HVAC start-up and commissioning of the units?** Please specify.

* **6. Would your jurisdiction be open to taking advantage of an initial start-up - HVAC Commissioning Program that would be offered by the manufacturer of the modular classroom?**

- Yes
- No

* **7. Have you received any complaints on the light levels being:**

- Too high?
- Too low?
- No complaints.

* **8. How often do you experience issues with occupancy sensors triggering start-up of the furnace?**

- Never
- Rarely
- Often
- Frequently

* **9. Has there been any leakage within the modular units you've received?**

- Yes
- No

If yes, where did it occur?

* **10. Have you had any concerns or challenges with the transportation and/or placement of the modulars you have received?** Please specify.

* **11. Please outline below any additional concerns you have experienced with the modular classrooms you have received?** Please specify.

* **12. Please rate your satisfaction on the following items on a scale of 1 (poor) to 10 (excellent).**

	1	2	3	4	5	6	7	8	9	10
Overall modular classroom product	○	○	○	○	○	○	○	○	○	○
Ease of HVAC Commissioning	○	○	○	○	○	○	○	○	○	○
Ease of HVAC and mechanical issue resolution with the manufacturer	○	○	○	○	○	○	○	○	○	○

Next

Modular Classrooms - Performance Survey

* **School Region** (check all applicable options)

- [ ] Edmonton
- [ ] Calgary
- [ ] Alberta North
- [ ] Alberta Rockies
- [ ] Alberta Central
- [ ] Alberta South
- [ ] Other (please specify)

* **Jurisdiction represented by respondent** (please select a jurisdiction from the list)

Add another Jurisdiction represented by respondent (please select a jurisdiction from the list) (optional)

Add another Jurisdiction represented by respondent (please select a jurisdiction from the list) (optional)

Add another Jurisdiction represented by respondent (please select a jurisdiction from the list) (optional)

Add another Jurisdiction represented by respondent (please select a jurisdiction from the list) (optional)

Person who filled the survey:

First and Last name (optional)

Job Title (optional)

We appreciate your feedback and your input will be considered as we work to improve the modular classroom product for all users.

Prev Done