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An Integrated Model for Efficient Defect Management and Improved Service Delivery: A Preliminary Study at Malaysian Polytechnics

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ABSTRACT

This study examines the factors that contribute to inefficiency in managing academic building defects and their impact on maintenance costs and the quality of service delivery. Through in-depth interviews with five heads of maintenance units from five ageing polytechnics in Malaysia, this study has identified vital themes such as staff awareness and understanding, allocation and resource constraints, management and implementation of repairs, recurring damage issues, and communication and collaboration. The findings show that the maintenance of gutters, water supply systems, internal sanitation, and various other types of maintenance is the highest scope of work performed. The Integrated Building Defect Management Model (IBDMM) is proposed as a comprehensive framework to address these challenges. This model emphasises the importance of provision support, staff training, and improved communication between all parties involved. This study contributes to facility management area by providing in-depth insight into practical strategies for managing building defects in academic institutions, particularly at polytechnics. By applying this model, the management of building defects can be improved, further providing a better and safer learning environment for the occupants, especially at ageing educational institutions.

1.0 INTRODUCTION

Effective defect management ensures building quality, functionality, and safety. Common defects include water seepage, cracks, and paint issues (Olanrewaju et al., 2021). Key strategies include implementing proactive maintenance procedures (Jesumoroti & Cheen, 2021), improving communication and information sharing (Lambers et al., 2023), and adopting innovative technologies like Building Information Modeling (BIM) for quality inspection and defect management (Lin et al., 2016). Factors influencing defect management include user attitudes, weather conditions, and maintenance practices (Olanrewaju et al., 2021). Effective management requires adequate funding, resource allocation, and adherence to best practices (Jesumoroti & Cheen, 2021). Implementing defect management principles varies across organizations but remains crucial for maintaining building performance (Abdullah et al., 2021).

However, implementing effective building defect management programs faces several challenges. For example, inappropriate selection of systems, contractors, personnel, and inadequate training, hinder the successful implementation of effective building defect management (Hassanain et al., 2017). Moreover, poor workmanship might also cause defects, necessitating improved quality control processes (Sandanayake et al., 2021). Thus, addressing poor workmanship, focusing on control measures, technology use, audits, and knowledge promotion can significantly improve defect management practices (Sandanayake et al., 2021).

Managing building defects is critical in maintaining educational infrastructure, especially in polytechnic institutions. This is because the quality of service delivery in managing building defects plays a vital role in ensuring a conducive and safe learning environment (Zeithaml et al., 1996). As noted by Janjua et al. (2019), building performance is affected by the service life of the building and the replacement of building components through maintenance work. However, building managers in polytechnics often need the necessary competence or skills to assess the types of building defects, exacerbating the problem of defect management (Raouf & Al-Ghamdi, 2020). This results in high maintenance costs borne by polytechnics due to inefficient defect assessment and management processes. The main problem identified in this study is the inefficiency of building managers in assessing and managing building defects. Building managers with insufficient competence or skills tend to make inaccurate assessments of the type and severity of building defects (Milion et al., 2021). This causes the problem of building defects needing to be dealt with effectively, ultimately increasing maintenance costs. In addition, this inefficiency also affects the quality of service delivery, as inefficient maintenance processes cause disruptions in the polytechnic's daily operations and reduce user satisfaction. Based on the identified problems, this study aims to achieve two specific objectives: (i) to identify the factors that contribute to inefficiency in the management of building defects by the building manager at the polytechnic. (ii) to analyse the impact of the inefficiency of building defect management on maintenance costs and the quality of service delivery at the polytechnic.

Building defect management is a complex field that requires extensive knowledge and skills in both technical and managerial aspects. As Atkinson (1999) claimed, the building defect management program under the level 3 soft landing framework can potentially reduce the number of building defects during delivery in Malaysian public universities (Mohd Nor Julia et al., 2019). In academic buildings such as polytechnics, buildings often suffer from defects such as wall cracks, roof leaks, electrical and plumbing system damage, and other structural problems. These defects can affect the safety and comfort of the occupants and disrupt the learning and teaching process (Midhal et al., 2024). Therefore, effective defect management ensures a safe and well-functioning environment. As Zhang and Yang (2020) claimed, effective defect management is essential to provide a safe and well-functioning environment, addressing environmental damage and variation in health conditions.

However, managing defects in polytechnics is often faced with various challenges. Inefficiency in defect management can also cause delays in remedial action; according to Zhang et al. (2020), this delay not only increases maintenance costs but also affects the quality of service delivery building users, including students and staff, may experience disruptions in their daily activities, which may affect their learning and teaching experience. Therefore, the purpose of this study is to identify the factors that contribute to the inefficiency of building defect management and analyse the impact of this inefficiency on maintenance costs and the quality of service delivery. Furthermore, it provides an in-depth understanding of the challenges in managing polytechnic building defects. It can help devise effective strategies to improve management efficiency and reduce maintenance costs. Additionally, by analysing the impact of defect management inefficiencies on the quality of service delivery, this study can provide valuable insights into how to improve the experience of building users, including students and staff.

The selection of the scope of this study is based on several main justifications that are relevant to achieving the objectives of the research and solving the identified problems. Firstly, a Polytechnic was chosen because it is one of the under-researched ageing academic institutions of higher learning that plays a vital role in providing students with technical and vocational education and training (TVET) courses. Polytechnics have also been given a new rating system in order to ensure it serves its role in improving students' learning efficiency and academic achievement well (Khalil et al., 2018). This means the quality of facilities and building maintenance at polytechnics is critical to ensure a conducive learning environment for students. Next, buildings over 20 years old tend to experience more structural defects and require more frequent and intensive maintenance (Pontan et al., 2018). Polytechnics in Malaysia range from seven years old to the oldest being 55 years old. By focusing on ageing academic buildings, this study can identify deeper problems related to old buildings' durability and maintenance efficiency (Pontan et al., 2018). The polytechnic with the highest maintenance cost was chosen for this study because it shows significant issues in managing building defects (Abd Wahab, 2023). Analysis of this polytechnic can provide a clear view of the inefficiency factors and how the cost can be reduced through management improvements. Next, academic block buildings can precisely assess the condition and management of facilities that directly affect the teaching and learning process. This allows the study to provide more accurate and relevant recommendations to improve the quality of educational service delivery. Besides that, buildings with a gross floor area between 10,000m² and 15,000m² were selected to ensure that the study involved facilities large enough and complex enough to represent relevant building defect management challenges. This size allows the survey to evaluate management efficiency on a larger scale and obtain significant data (Ismail, 2022). The selection of this scope ensures that this study is comprehensive and provides practical and applicable findings for improving the management of building defects in polytechnics.

2.0 LITERATURE REVIEW

Building defect management is essential in maintaining educational infrastructure, especially in polytechnic institutions (Ismail, 2018). Building defects must be adequately addressed to ensure the learning environment's safety, comfort, and quality. Faqih et al. (2020) state that deterioration of building conditions, influenced by factors such as structural defects, can reduce the building's ability to function correctly and negatively impact the comfort and health of occupants. Previous literature offers various perspectives and relevant findings to support this study, especially in facility management and building maintenance. Building defect management involves the process of identification, evaluation, and repair actions against structural and functional defects that occur in buildings (Abd Wahab et al., 2015). Gharehbaghi et al. (2021) emphasised that the proposed signal-based building condition monitoring methodology uses a feature selection algorithm based on signal simulation to accurately detect deterioration and damage in building structures. Academic buildings over 20 years old often face various types of defects, such as wall cracks, roof leaks, and damage to the electrical and plumbing systems, requiring urgent maintenance (Olanrewaju,2012). These defects can affect building performance, user comfort and safety (Turner & Richardson, 2004), making regular inspections and maintenance crucial.

Effective defect management requires technical knowledge, management skills, and sound maintenance systems. Pai et al. (2021) claim that integrating the four dimensions of defect management (i.e. software defect analysis, quality, reliability, and development cost or effort) can lead to optimal use of resources in the software development process. Several main factors can cause inefficiency in the management of building defects. Firstly, lack of training and professional development among building managers is often the leading cause. Borg et al. (2020) also said that the lack of further training and incentives to improve project sustainability is a challenge building managers face. Managers with insufficient knowledge and skills tend to make incorrect judgments about the type and severity of defects. Yoon et al. (2021) add that the consequences of inconsistent decision-making and performance in the design, construction, and preservation process will cause building defects. This results in inaccurate or insufficient repair actions, ultimately increasing maintenance costs. In addition, the lack of adequate resources and equipment also contributes to the inefficiency of defect management. Building managers need the appropriate equipment and up-to-date technology to conduct assessments and repairs effectively. Weaknesses in communication and coordination systems between building managers and maintenance also contribute to delays in repair actions, increasing costs and affecting the quality of service delivery. Dzulkifli et al. (2021) discovered that the maintenance practices in Malaysia must be implemented efficiently and comply with maintenance best practices, thus affecting repair actions and the quality of service delivery.

Building defect management has undergone significant changes in recent years, mainly due to technological developments and an increasing emphasis on maintenance quality. In the past, defect management tended to be reactive, where remedial actions were only taken after damage had occurred. This approach often results in increased maintenance costs and disruption to building occupants. However, in the last five years, there has been a shift towards a more proactive and integrated approach. For example, Building Information Modeling (BIM) technology has enabled building managers to plan and detect defects early before they become major problems. In addition, cloud-based maintenance management systems are now widely used, allowing maintenance records to be updated in real-time and accessed from multiple locations. This system also enables more transparent and effective management, with a more complete and organized maintenance history. For example, a case study at a university in Malaysia shows how the implementation of a cloud-based maintenance management system has reduced the response time to defect complaints by 30%, as well as reduced annual maintenance costs by 15% (Ismail, 2022). This shows that the management of building defects can be significantly improved with the right use of technology.

Although there are many studies on the management of building defects, several research gaps need to be filled; firstly, in-depth studies on the factors contributing to academic buildings' defect management inefficiency still need to be completed. Most previous studies focus more on facility management in general without a specific focus on academic buildings such as polytechnics or universities. Next, more studies that detail the impact of defect management inefficiencies on maintenance costs and the quality of service delivery in polytechnics need to be conducted. Most studies only discuss the cost increase without an in-depth analysis of how management improvements can reduce those costs (Kozlovsky et al., 2020). Studies that link the efficiency of defect management with the quality of service delivery in higher education institutions still need to be completed. This study can significantly contribute to understanding how improving management efficiency can lead to a better learning environment and increased building user satisfaction. Several vital elements must be considered to form a conceptual framework for this study. Firstly, the factors contributing to inefficiency in managing building defects must be identified and categorised. These factors can be divided into training and professional development, resources and equipment, and communication and coordination systems.

Moreover, the relationship between the inefficiency of defect management with maintenance costs and the quality of service delivery needs to be analysed (Akni et al., 2020). This can be done by identifying indicators that reflect maintenance costs and service delivery quality and how inefficiency factors affect these indicators (Akni et al., 2020). In addition, strategies to improve the efficiency of defect management need to be formulated based on the study's findings (Lin et al., 2020). These strategies can also include recommendations for increased training and professional development, the use of the latest technology, and improvements in communication and coordination systems (İzmirli & Çalışkan, 2020). Ismail (2019) has shown that inefficiencies in managing building defects often stem from a lack of training and professional development. Building managers needing more knowledge and skills find it difficult to conduct assessments and repairs effectively. In addition, the lack of adequate resources and equipment also contributes to management inefficiency. Building managers need the proper equipment to perform their duties. However, there needs to be more clarity regarding how training and professional development can improve defect management efficiency. Matejić & Ćurčić (2023) have found that although training and professional development are essential, it is not enough if they are not supported by adequate resources and equipment and a sound communication system. These studies emphasise that a more holistic approach is needed to improve the efficiency of defect management. Studies also show that inefficiency in defect management has a significant impact on maintenance costs. Inaccurate or insufficient repair actions can significantly increase maintenance costs (Liu et al., 2019). Additionally, delays in remedial action can also increase costs. Yasin et al. (2023) explained that delays in building maintenance can be caused by increased maintenance costs as the building ages, inaccurate time for work, and unsystematic planning and budgeting. This study emphasises that improving the efficiency of defect management can help reduce maintenance costs significantly. Studies show that defect management inefficiency can substantially affect service quality in the context of service delivery quality (Yacob et al., 2019). Building users, including students and staff, may experience disruptions in their daily activities due to poorly addressed building defects (Yacob et al., 2019). This can affect their learning and teaching experience (Yacob et al., 2019).

According to Parasuraman et al. (1991), several critical service quality dimensions can be related to this study, including reliability, responsiveness, assurance, empathy, and tangible. Reliability refers to the ability of the service provider to perform the promised service consistently and accurately (Perez et al., 2019).

Responsiveness involves the willingness and ability of service providers to help users and provide services quickly (Zeithaml et al., 1996). Guarantees include the knowledge, decency, and trust the service provider holds towards the user (Zeithaml et al., 1996). Empathy emphasises individual attention and understanding of the user's needs and problems (Zeithaml et al., 1996). Tangible includes physical facilities, equipment, and staff appearance (Zeithaml et al., 1996). In building defect management, these dimensions help reduce user dissatisfaction and improve the institution's image. Bazzan et al. (2020) show that good communication and an online complaint system can improve effectiveness in dealing with building defects. Besides this, ongoing technical training for staff also ensures efficiency in defect management (Al-Fraihat et al., 2020). Therefore, high-quality service is essential to manage defects and satisfy users effectively.

3.0 METHODOLOGY

3.1. Research Design

This study adopts a qualitative research methodology, precisely an essential qualitative inquiry, to investigate the management of ageing academic buildings, such as polytechnic building defects by conducting semi structured interviews with the head of maintenance unit at these polytechnics. Qualitative methods were selected for their ability to deeply explore participants' experiences, perspectives, and knowledge regarding this issue. According to Sharan and Tisdell (2016), qualitative research, including interviews, focus groups, and observations, is well-suited for examining and understanding complex, dynamic factors through participants' experiences. This approach aligns with the study's aim to identify the factors contributing to inefficiency in managing building defects and their impact on maintenance costs and service quality. See **Figure 1.**

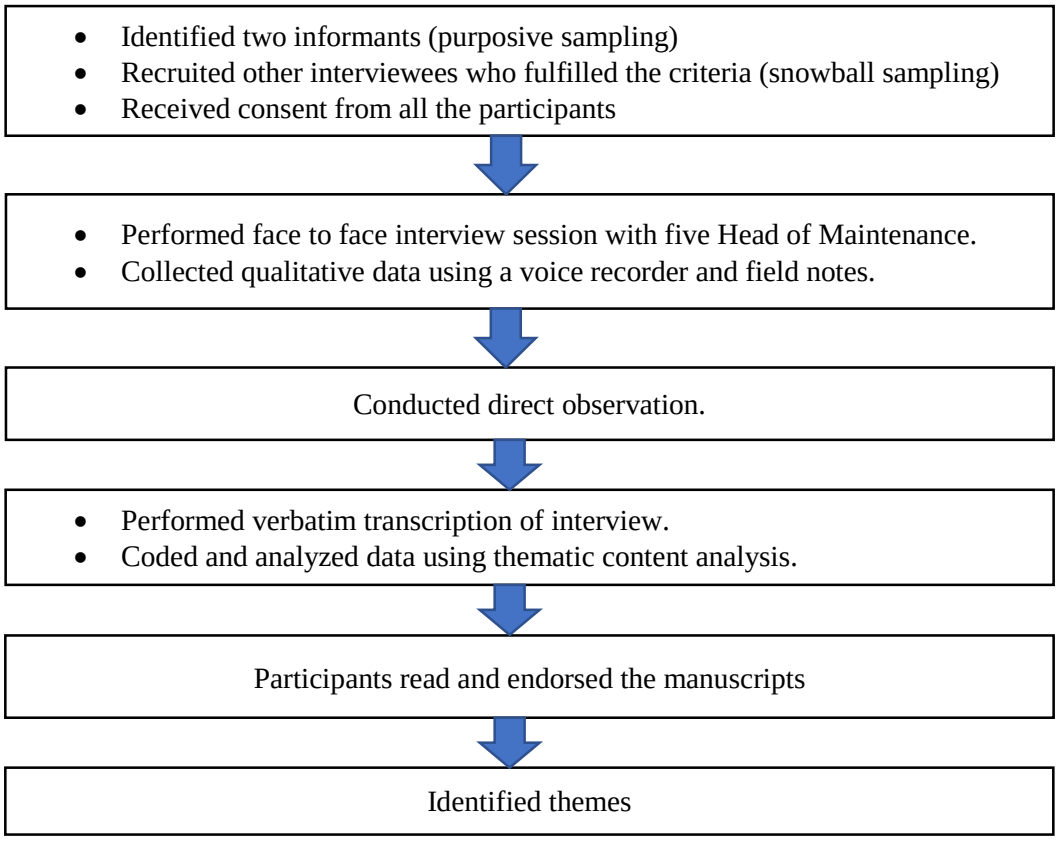

Figure 1. Flowchart of the study

3.2. Data Collection Methods

This study's primary data collection methods were in-depth interviews and observations. Interviews were conducted with five heads of maintenance units from five polytechnics. In this study, the average age of the Polytechnic chosen is around 28 years old, with the youngest polytechnic being 26 years old and the oldest polytechnic being 39 years old, located in different regions in the country. Next, participants were selected based on their extensive experience, with a minimum of 10 years in managing building defects, ensuring they

provided relevant and expert insights. The five selected maintenance heads as study participants are adequate because the main goal was to gain an in-depth understanding of the issue being studied through their experiences and perspectives. Moreover, the selected participants had adequate information power to contribute to new knowledge, thus justifying the lower number of samples needed in this study (Malterud et al., 2016). Therefore, the five maintenance heads with extensive experience managing building defects can provide rich and meaningful data. The interview guide consisted of semi-structured questions to draw out detailed and significant information. Additionally, observations were conducted to directly witness the building defect management processes, offering insights into issues that might not have been mentioned in the interviews. This combination of interviews and observations facilitated the gathering of rich, comprehensive data on the participants' experiences and views. Purposive sampling was employed to select participants, focusing on five heads of maintenance units in polytechnics with a minimum of 10 years of experience. This sampling method was chosen to ensure that participants had substantial experience and expertise in managing building defects, providing meaningful and pertinent data to the research questions (Barbour, 2022).

3.3. Data Analysis

The five interviews yielded approximately 85 pages, a sizable amount of data. Several researchers have shown how Microsoft Office programs can be used for qualitative data analyses, which can be used for coding and retrieval of interview data based on basic functions in Word instead of using complex, powerful and sophisticated software. Thematic analysis, as described by Braun and Clarke (2006), was used to analyse the data. The coding process was conducted manually using Microsoft Word and involved identifying critical themes from the interviews and observations. Aiming to gain an in-depth understanding of participants' experiences and perspectives (Boyatzis, 1998). The thematic analysis involved a systematic and comprehensive data review to identify and consider all significant themes (Lochmiller, 2021). Using Microsoft Word, the researchers were able to quickly highlight, copy, and paste text, as well as add notes or comments to relevant sections. In addition, Microsoft Word provided great flexibility for organizing and managing text data. Researchers also used the 'Find' function to quickly identify specific words or phrases and use various text formats such as colours, fonts, and styles to distinguish different themes or categories during coding. The structure in Word (Heading 1, Heading 2, and Heading 3) was used to structure the text into main categories, topics, and subtopics.

3.4. Ethical Consideration

This study addressed several ethical considerations. Participants were informed about the purpose of the study, and consent was obtained before the interviews were conducted. Confidentiality and anonymity were maintained, and the data was used exclusively for research. The study also received ethical approval from the institutional review board.

3.5. Ensuring Validity and Reliability

Multiple strategies were employed to ensure data validity and reliability. Triangulation was used by combining data from interviews and observations, providing a more comprehensive view of the issue. Participants reviewed interview transcripts to confirm the accuracy of the information. The data analysis process also included peer review to minimise bias and ensure accurate interpretation. These rigorous methodological steps were followed to provide a thorough and reliable understanding of the factors contributing to inefficiency in managing building defects in polytechnics.

4.0 RESULT AND DISCUSSION

This study has identified key findings from interviews with five participants overseeing maintenance units. The following are the primary results from the data analysis. See **Table 1**.

Table 1. Demography of participants

Participant	Gender	Experience (years)	Polytechnic	Age of Polytechnic (years)
1	Male	35	Polytechnic A	39
2	Male	22	Polytechnic B	34
3	Male	19	Polytechnic C	26
4	Female	28	Polytechnic D	22
5	Female	24	Polytechnic E	21

4.1. Awareness and Understanding of Maintenance Roles

In the initial interview, participants were questioned about their level of awareness and comprehension of the roles and responsibilities of managing building defects within maintenance units and service providers. The responses revealed varied levels of awareness, with the majority indicating a high or moderately high level of understanding of their respective roles. However, it was noted that there was some uncertainty surrounding specific procedures that necessitate improvement, such as the need for procedural understanding. For example, Participant 1 stated, "I rate their awareness and understanding moderately high. They understand their responsibilities, but sometimes there is confusion about certain procedures". This shows that despite good awareness, there is still room for improvement in procedural understanding.

4.2. Challenges in Managing Building Defects

The second question examined the primary challenges in managing defects in polytechnic buildings, and consistent themes emerged. Most participants highlighted the need for more resources as the primary challenge. A significant obstacle was the need for more skilled personnel and adequate equipment. Time-consuming allocation applications and competition for allocations further added to these challenges. Participant 4, for example, said, "The main challenge is the allocation constraint. In managing defects in the Polytechnic building, many skilled assistants (craftsmen) are required for repair actions." This shows that it is only possible to implement the necessary repairs effectively with adequate provision.

4.3. Strategies and Recurring Issues in Dealing with Building Defects

The third interview question focused on participants' experiences dealing with building defect issues. They described various strategies, including applications for one-off allocations to the Department of Polytechnic Education and Community College (DPCCE), the headquarters that governs the administration of Malaysian Polytechnics and Community Colleges, periodic maintenance contracts, and minor repairs conducted by assistant engineers. Participant 1 highlighted this, "Prepare paperwork and cost estimates for major damage, perform minor repairs by department/unit, and get technical advice for major damage". The importance of cooperation and effective communication among staff to address these issues was emphasised as highlighted by Participant 4. "Rating communication and collaboration as very high with good working relationships and regular discussions to find the best solution". The third question highlighted several recurring problems, such as rainwater gutter damage, water pipeline leaks, and internal infrastructure damage, including toilet hardware and mouldy walls. Inadequate maintenance of older buildings was also a significant concern, as voiced by Participant 1, "The maintenance of the water supply system and internal sanitation as the highest scope of work". Thus, participants highlighted various strategies for managing building damage, including using one-off allocations for periodic maintenance works and minor repairs. In addition, effective communication and collaboration among staff is essential to ensure recurring issues. This strategy emphasises the need for better maintenance, especially in old buildings.

4.4. Communication and Cooperation

The fourth question (a) evaluated the communication and cooperation between maintenance units and service provider staff. Most participants rated this aspect as high or very high, indicating effective communication and practical cooperation in managing building defects. However, some responses suggested that communication and collaboration were low or moderately low in certain areas, indicating a need for improvement. For example, Participant 3 stated, "Communication and collaboration are deficient. Users rarely give timely feedback, and this causes delays in remedial action." In response to the fourth question (b), several suggestions were provided to enhance cooperation, including bringing critical issues to management meetings, implementing an online complaint system, improving communication among all parties, and providing maintenance management platforms such as e-breakdowns. Additionally, recommendations were made for technical training for staff and creating a database for classifying data related to damages.

4.5. Recommendations for Improving Defect Management

The fifth question (a) focused on participants' hopes and suggestions for improving defect management. Recommendations included regular maintenance with adequate provision, enhancement of defect management processes, upgrading the grade of engineers, and increasing the number of technical staff. Participants also suggested providing more technical training to staff and adjusting allocations more objectively. For example, Participant 4 highlighted that "Provide staff and skilled assistants (artisans) for each discipline (civil, electrical, mechanical) and also sufficient allocations to carry out maintenance, especially periodic maintenance that must

be carried out every year to ensure buildings and infrastructure facilities function well continuously and safely used."

Next, the fifth question (b) proposed strategies to overcome challenges in defect management, such as DPCCE support in channelling allocations, detailed reporting supported by regulatory agencies, consumer awareness, and regular preventive maintenance. Improving staff technical skills and developing scoring and rubrics for building damage were also suggested, as mentioned by Participant 3, "I hope to increase the number of technical staff as much as possible who have skills and expertise in implementing and making Building Condition Assessment (BCA)."

4.6. Frequency of Maintenance Work Scope

The sixth question investigated the most common type of work carried out to address building defects. Maintenance work on the water supply system, internal sanitation, and building structure maintenance were found to be the most frequently performed tasks, as shared by participants. This highlights the importance of ongoing maintenance in crucial building systems to avoid additional damage.

Table 2: Themes derived from thematic analysis

Codes	Theme
High, Medium High, Very High	High Level of Awareness and Understanding
Procedural Confusion, Need Additional Instructions.	Confusion in Procedure
Lack of Allocation, Lack of Skilled Staff, Lack of Equipment and Expertise, Slow Application Process, Competition for Allocation	Key Challenges in Management
One-off allocation Requests, Periodic Contract Maintenance, Minor Repairs by Assistant Engineers, Good Cooperation and Communication	Strategies for Dealing with Defect Issues
Gutter Damage, Leaky Water Pipes, Toilet Hardware, Moldy Walls, Aged Buildings Not Maintained	Recurring Issues
High, Very High, Very Low, Medium Low, Inconsistent Communication	Conditions of Communication and Cooperation
Management Meetings, Online Complaint System, Improved Communication, Maintenance Management Platform, Technical Training, Damage Database	Steps to Increase Cooperation
Periodic Maintenance, Adequate Allocation, Distribution of Allocation According to Building Type, More Important Defect Management, Higher Engineer Grade, Increasing Technical Staff, Building Condition Assessment Skills and Expertise	Hopes and Suggestions
Support from (DPCCE), Detailed Reporting, Regulatory Agency Support, Consumer Awareness, Regular Preventive Maintenance, Technical Skills, Scoring and Damage Rubric	Strategies to Overcome Challenges
Gutter Maintenance, Water Supply and Indoor Sanitary System Maintenance, Other Maintenance, Building Structure Maintenance	Scope of Work

Thus, the study's findings indicate that inefficiencies in managing polytechnic building defects are rooted in several primary factors, such as a lack of allocation, insufficient skilled staff, and weaknesses in the maintenance system. These challenges can be mitigated through increased technical training, enhanced communication and collaboration between users and staff, and improved support from management and regulatory agencies. This research offers practical insights to optimise the efficiency of building defect management in polytechnics, aiming to foster a safer and more conducive environment for all users. **Table 2** summarises the primary results and observations from a meticulous thematic analysis, encapsulating the main thematic elements and coding.

These findings indicate that academic buildings like polytechnics face challenges managing building defects. Among the highest scope of work are gutter maintenance, water supply system, internal sanitation,

and other maintenance work. This reflects the physical condition of the building, which requires special attention to maintain its safety and function. As stated by the participants, the importance of periodic maintenance and effectiveness in defect management can be seen through the need for immediate action in dealing with recurring issues. Cavalcante et al. (2021) found that a fixed periodic maintenance schedule with a fixed time for preventive replacement and an adequate frequency of visits can significantly increase the reliability and availability of the system. The researcher opined that the appropriate model to solve the problem is the Integrated Building Defect Management Model (IBDMM). The proposed model using a convolutional neural network (CNN) can accurately detect and localise building defects, potentially reducing disruptions and safety risks (Perez et al., 2019).

Figure 2 is a model formed based on the main themes identified in this study. It provides a comprehensive framework to address issues related to managing polytechnic building defects, ensuring that all aspects, from financial allocation to staff training, are considered. With the implementation of this model, it is hoped that the polytechnic can improve the efficiency of building defect management and further provide a better and safer learning environment. The main themes are (i) Level of Awareness and Understanding: Increasing the level of awareness and understanding of staff regarding their responsibilities in defect management is critical for management efficiency, (ii) Allocation and Resource Constraints: Overcoming the lack of allocation and ensuring fair and efficient distribution is essential to ensure the smoothness of defect management, (iii) Repair Management and Implementation: Implement a systematic strategy in the management and implementation of repairs including periodic maintenance and the use of modern technology, (iv) Recurring and Critical Damage Issues: Address frequently recurring damage issues immediately to avoid more significant losses, (v) Conditions of Communication and Cooperation: Improving communication and cooperation between users and maintenance unit and service provider staff is essential to ensure that defect issues are dealt with quickly and efficiently, (vi) Measures to Improve Cooperation: Measures such as management meetings, the use of an online complaint system, and a maintenance management platform are essential to increase cooperation, (vii) Hopes and Recommendations for Improvement: Providing adequate provision, technical training, and addition of skilled personnel are among the main recommendations to improve defect management strategies to Overcome Challenges: Develop a comprehensive strategy based on DPCCE support, detailed reporting, and regulatory agency support. By using this model, the building manager at the polytechnic can identify and deal with factors that contribute to inefficiency in managing building defects, thereby improving the quality of service delivery and reducing maintenance costs. See **Figure 2**.

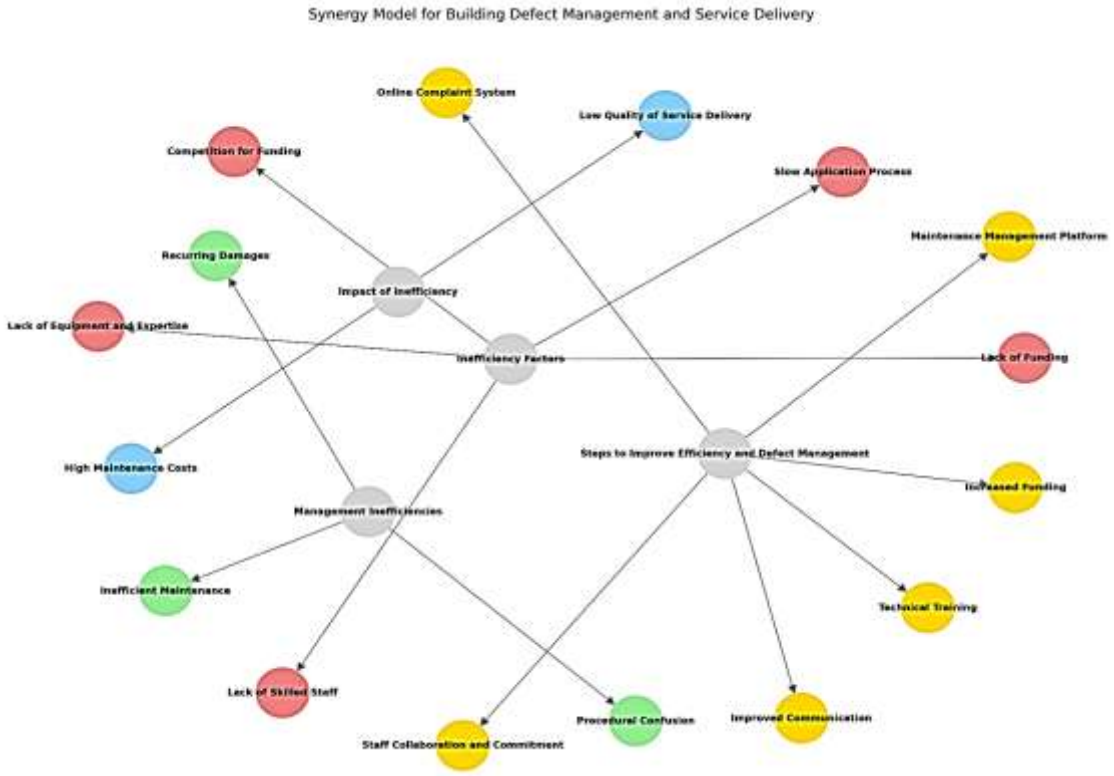

Figure 2: IBDM Model.

This study reveals vital results and noteworthy observations that can be formulated from the data analysis; some coding and themes have been identified. These themes cover the awareness and understanding of maintenance unit staff and service providers regarding their roles and responsibilities in managing building defects. The interviews showed that the level of awareness and knowledge was very high, with some participants emphasising the need for more clarity and training to reduce procedural confusion. Allocation and resource constraints were the main themes that the participants often repeated. Lack of allocations, the slow application process, and the unfair distribution of allocations cause problems in managing building defects. This finding is also supported by Vytlačil (2019). Consistent with Ranjithapriya and Arulselvan (2020), this study also found that the lack of skilled staff and equipment adds to the burden of maintaining the building efficiently. Another theme includes strategies and experiences in implementing building repairs. The results align with the findings of Perez et al. (2019), who noted that several approaches can be used for building repairs, such as one-off allocation application, periodic contract maintenance, and minor repairs by assistant engineers. Besides this, hands-on solutions and specialist services or external companies are also mentioned as strategies to overcome defect issues. Identification of the types of damage is also often repeated and requires particular emphasis. Rainwater gutter damage, water pipe leaks, toilet damage, and air conditioning problems are among the issues that are frequently encountered. These damages require immediate action to prevent more significant losses, as highlighted by Bhagat et al. (2019).

Next, the state of communication and cooperation between users and maintenance unit staff or service providers is essential in managing building defects (Bernardini et al., 2020). Moreover, the findings indicate that communication and collaboration are high to very high, except for a few cases of lack of feedback and inconsistent communication. This issue has also been highlighted by past studies that studied improving the inspection repair process with building information modelling and image classification (Zhan et al., 2019); (Pour Rahimian et al., 2020). This theme includes proposed measures to improve cooperation in managing building defects. The proposed measures include management meetings, an online complaint system, improved communication, and technical training. These findings are aligned with the conclusions found by (Bazzan et al., 2020b) (Ismail, 2018).

Next, providing a maintenance management platform and damage database is also an essential step. This theme includes the hopes and suggestions of participants to improve the management of building defects. Recommendations include periodic maintenance with adequate allocations, increasing engineers' grades, technical staff, and skills in Building Condition Assessment (BCA). This finding is also supported byCrespo Marquez et al. (2020) in their study related to digital technology and data analytics. Intelligent Asset Management Platforms (IAMP) as a platform can assist in monitoring the condition of assets, predicting maintenance needs and optimising maintenance strategies. This is in line with the recommendation of periodic maintenance with adequate provision and improvement of the skills of technical staff in Building Condition Assessment (BCA) to manage building defects effectively. IAMP data models and functions can support these maintenance practices and improve asset management efficiency and effectiveness. The objective coordination of allocations and support from DPECC is also mentioned to improve building defect management at polytechnics.

The participants also shared how to overcome the challenges of managing building defects. Among the suggested methods are increasing funding support from DPCCE, effective polytechnic management, staff cooperation and commitment, detailed reporting, and regulatory agency support such as support from service providers. This finding is also supported by Zhang & Yang (2020), who found that detecting defects in the manufacturing process using advanced technology is a strategy to manage defects well and safely. Both disciplines strongly emphasise the necessity of effectively managing flaws to guarantee building occupants' functionality and general well-being. Increasing awareness and regular preventive maintenance were also cited as essential strategies. Mourtzis et al. (2020) offer a significant improvement in maintenance operations, with the potential for broader applications by further integrating more advanced AI algorithms to improve defect management systems' predictive accuracy and efficiency.

5.0 CONCLUSION

This study has revealed significant findings regarding managing building defects in ageing academic buildings such as polytechnics. The study's findings will also impact the literature on facility management and building maintenance as the study found that five critical facility services significantly correlate with cost variance, and maintenance priority affects maintenance costs. Key findings indicate that inefficiency factors

and management inefficiency need to be considered which has resulted in high maintenance costs and low-quality service delivery. In addition, this study identifies practical steps that can be taken to improve building defect management efficiency. In building maintenance and management, this study offers a valuable addition to the need for specific skills and competencies among building managers. The study also shows the importance of improving maintenance procedures and systems to improve efficiency and service quality.

The study provides a basis for further research in this field, especially in identifying more factors contributing to inefficiency and strategies to overcome them. Future studies are recommended to focus on quantitative research involving a larger sample size to expand the generalization of the findings. In addition, studies on the long-term impact of building defect management and the effectiveness of periodic technical training are also important to ensure continuous improvement in the quality of maintenance and service delivery. This study contributes significantly to several vital aspects, including government, community, industry, and science. For example, the findings can help the government formulate better policies and guidelines for managing building defects in educational institutions, especially polytechnics. Moreover, the findings suggest that the government can direct resources and efforts towards improving the efficiency of building managers through more focused training and professional development programs. Significant players in Malaysia need to gain an understanding and awareness of proactive maintenance management, contributing to the inefficiency of building defect management (Khalid et al., 2019). This can directly reduce the cost of building maintenance borne by the government, increase the effectiveness of public spending, and ensure that educational buildings are in good condition for the long term. In addition, the academic community and students at the polytechnic will benefit from this study as it aims to improve the quality of service delivery through more efficient management of building defects which may result in better learning experience and a safer environment (Dzulkifli et al., (2021a). Moreover, the local community will also see a reduction in nuisance and safety risks due to building defects that are not adequately addressed.

Next, the industry can use the results of this study to improve training and professional development for their employees, thereby improving defect management standards, thus improving their practices and reducing costs associated with defect maintenance. Finally, this work adds to the body of knowledge regarding the management of architectural faults in educational institutions from an academic perspective. It provides viewpoints and information that other researchers can utilize.

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