JURNAL ILMIAH TEKNIK INDUSTRI
ISSN: 1412-6869 (Print), ISSN: 2460-4038 (Online)
Journal homepage: http://journals.ums.ac.id/index.php/jiti/index
doi: 10.23917/jiti.v24i1.8648

Risk Mitigation on Damage and Maintenance of Industrial Engineering Building Facilities at University XYZ Using The House of Risk (HOR) Method

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Abstract. *This study addresses the frequent damage to facilities in the Industrial Engineering Building at XYZ University, impacting classrooms, laboratories, and faculty rooms. Employing the House of Risk (HOR) method, this research identifies key risk agents and prioritizes mitigation strategies. Phase 1 of HOR focuses on risk identification and the calculation of Aggregate Risk Potential (ARP), while Phase 2 evaluates mitigation strategies using the Effectiveness to Difficulty Ratio (ETD). The findings highlight user negligence, lack of preventive maintenance, and poor procurement quality control as primary risk factors. Proposed mitigations include the implementation of Standard Operating Procedures (SOPs), targeted training, and enhanced maintenance scheduling. The results contribute to a systematic framework for improving the sustainability and reliability of campus facilities.*

Keywords: *Risk Management, House of Risk Method, Campus.*

I. INTRODUCTION

The efficient operation of building amenities is crucial for enhancing the effectiveness of the teaching and learning process in an academic setting. The Industrial Engineering Building at XYZ University, a primary facility for academic pursuits, features essential amenities such as faculty offices, classrooms, and laboratories. In recent years, these facilities have frequently sustained damages, including inoperative laboratory equipment, malfunctioning air conditioning systems, and unusable tables and chairs. This problem not only undermines user comfort but also affects the productivity of instructors, students, and support personnel.

Based on ISO 31000:2009, risk management offers a systematic and structured approach to understanding risks, establishing context, and implementing appropriate mitigation actions (Pujawan, 2009). In this context, risk management plays a crucial role in ensuring operational stability through the management of facility infrastructure complexity. The risk management process, which includes the stages of identification, analysis, evaluation, and risk control (Atmajaya, 2020), enables organizations to identify potential threats, assess their impacts, and establish effective mitigation priorities. This is relevant for addressing facility damage in the industrial engineering building, where the reactive approach that has been applied so far is often inefficient. Furthermore, the implementation of effective risk management can support better decision-making and enhance the organization's competitiveness through the reduction of uncertainty and the protection of critical assets (Smith et al., 2016). In this case, risk management not only aims to avoid losses but also to seize opportunities to improve efficiency, particularly in the facility maintenance process. This approach becomes highly relevant for XYZ University to create a more reliable and sustainable academic environment.

One of the root causes of the damage to this facility lies in the maintenance system, which is poorly structured and not integrated with an adequate risk management approach. For example, facility maintenance tends to be carried out reactively (correctively), that is, only after damage occurs. This approach not only increases repair costs but also causes operational downtime

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Submited: 10-02-2025 Revised: 25-05-2025
Accepted: 18-06-2025

that can affect academic and administrative performance. Moreover, the lack of implementation of preventive and predictive maintenance indicates untapped opportunities to reduce the risk of facility damage.

Preventive maintenance, which is carried out on a scheduled basis to prevent damage through regular maintenance and inspections, has proven capable of reducing the frequency of emergency repairs and minimizing long-term costs (Ahuja, 2015). However, the implementation of this strategy at XYZ University is still suboptimal. Additionally, predictive maintenance, which uses data and analysis to predict component failures before they occur, has not yet been fully implemented. However, the integration of risk management with predictive maintenance can help allocate resources more efficiently and reduce the risk of unexpected facility failures (Pintelon et al., 2019).

Another issue that arises is the low quality of control in the process of receiving goods from procurement. Many new facilities are received without going through adequate quality control procedures, thereby increasing the likelihood of non-specification items entering the system. This contributes to the high initial damage rates, especially for equipment used in laboratories and classrooms.

Looking at this issue, it is important to identify the main root causes and find the right strategies to improve facility management. The House of Risk (HOR) approach was chosen as a framework that can help in identifying, analyzing, and managing risks associated with facility damage. HOR allows for a systematic analysis of risks by prioritizing the most effective mitigation actions based on the impact and likelihood of risk occurrence.

This research aims to examine the issues occurring in the facility management of the industrial engineering building at XYZ University, particularly in the faculty rooms, classrooms, and laboratories. By utilizing the HOR framework, this research is expected to produce appropriate strategic recommendations to improve the effectiveness of facility maintenance, reduce damage costs, and enhance the quality of procurement control. The results of this research are anticipated to contribute to creating more reliable and sustainable facility management.

II. RESEARCH METHOD

This research was conducted in several stages to achieve the main objective of designing a risk mitigation strategy for the facilities in the Industrial Engineering building at XYZ University. The selection of the research object, the Industrial Engineering campus facilities at XYZ University, includes facilities located in classrooms, faculty rooms, and laboratories that support the smooth conduct of various academic activities by students and faculty. The design stages carried out include identifying issues related to the use of facilities in the Industrial Engineering building at XYZ University by conducting two interviews and distributing two questionnaires. The first interview was conducted to understand the problems with the campus facilities, and the second interview aimed to develop strategies for addressing those issues. The first distribution of the questionnaire aims to assess the level of severity, occurrence, and correlation between the risk agent and the risk event. The second questionnaire aims to assess the correlation between the strategy and the risk agent. The interviews and questionnaire distributions are directed towards the person in charge of the campus facility inventory, lecturers, and laboratory assistants, with the aim of obtaining an overview of the existing problems and relevant assessments. The literature review stage is used to understand and comprehend previous research that has been conducted related to the upcoming research. At the data collection stage related to the risks occurring in the research object through the creation of a questionnaire. The data processing stages use the House of Risk (HOR) method by conducting two phases, namely HOR phase 1 and HOR phase 2, which include risk identification, risk analysis, risk evaluation, and risk planning. In HOR phase 1, the ARP values are sorted, followed by HOR phase 2 to obtain mitigation strategy results.

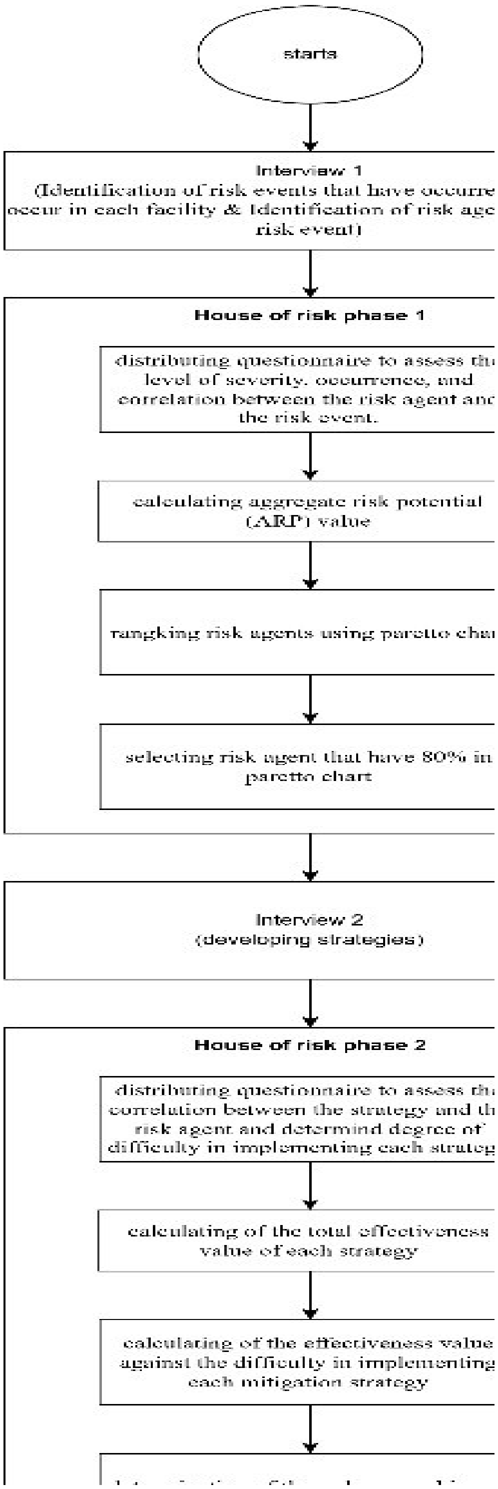

Figure 1. Research Framework

The House of Risk (HOR) process begins with identifying risk events (E_j) and their associated risk agents (A_j). Each risk event is assigned a severity value (S_i), and each risk agent is given an occurrence value (O_j) using a 1-10 scale. The correlation between risk events and agents (R_{ij}) is then determined, rated as 0 (no relationship) or 1, 3, and 9 for low, medium, and high relationships. The Aggregate Risk Potential (ARP) is calculated using $ARP_j = O_j \cdot \sum S_i \cdot R_{ij}$ and risk agents are ranked by their ARP values to prioritize mitigation efforts.

Mitigation strategies (PA_k) are then selected and assessed for correlation with risk agents (E_{jk}). The total effectiveness (TE_k) of each strategy is calculated as $TE_k = \sum ARP_j \cdot E_{jk}$, while the degree of difficulty (D_k) is rated on a scale of 3 (easy) to 5 (difficult). The effectiveness-to-difficulty (ETD) value is derived using $ETD_k = TE_k / D_k$, and mitigation actions are ranked accordingly. The final strategy is confirmed with stakeholders to ensure its alignment with facility needs.

III. RESULT AND DISCUSSION

House of Risk Fase 1

Risk incidents were identified through a breakdown based on dividing the facility into three parts: classrooms, laboratories, and faculty rooms, as a substitute for subprocesses, and then asking questions about what was wrong in the usage of each space. We have asked about potential risk incidents to the respondents before this study was conducted and included many risk incidents that were established in this study. Several other risk events were identified during the study, through interviews and brainstorming sessions with the relevant managers, which then resulted in a total of risk events in each facility respectively, namely 9 in classrooms, 6 in laboratories, and 4 in faculty rooms. Respondents were asked to fill in a number (between 1 and 10) next to each risk event, where a value of 1 indicates almost no impact if the related risk event occurs, while a value of 10 indicates a dangerous impact (Shahin, 2004) for a more detailed scale description. The occurrence value is obtained through a questionnaire distributed to the relevant respondents. Several risk events at each facility are presented in Table 1.

Table 1. Risk event of the classroom

Risk Event of the Classroom	Code	Occurrence
Chair damage	EC1	4
Missing chair	EC2	9
Wobbling or unbalanced whiteboard	EC3	3
Missing electrical socket	EC4	3
AC not cold	EC5	8
AC leaking water	EC6	8
Projector blurry (unclear)	EC7	7
Lights off	EC8	7
Computer screen scratched	EC9	5

Table 2. Risk event of the lecturer room

Risk Event of the Lecturer Room	Code	Occurrence
Trolley is unbalanced	ED1	5
Obstacles or damage during the practicum	ED2	5
Broken electrical socket	ED3	8
Printer damage	ED4	7

Table 3. Risk event of the laboratories

Risk Event of the Laboratories	Code	Occurrence
Trolley is unbalanced	EL1	6
Obstacles or damage during the practicum	EL2	10
Broken electrical socket	EL3	9
Printer damage	EL4	7
Light off	EL5	10
Shoes damage	EL6	7

Many risk agents were noted by the relevant respondents. We provided clarification and suggested several other risk agents that might not be included in the records. We obtained a total of risk agents as presented in Table 4 along with the incidence rates for each facility, namely 15 classrooms, 14 laboratories, and 6 lecturer rooms. The respondents' scores ranged from one to ten, where a score of 1 indicated almost never occurring and a score of 10, the highest range, indicated almost certain occurrence (Shahin, 2004). The next step is to assess the severity level of each risk event, conducted by distributing questionnaires to inventory managers, senior lecturers, and laboratory technicians.

The relationship between risk agents and risk events is identified using values of 0, 1, 3, or 9 assigned in each combination. The relationship between each risk agent and each risk event is shown in HOR 1, which includes the calculation of the aggregate potential risk of each risk agent at each facility.

Based on Table 7, the ARP calculation was conducted from the assessments made by two experts for the classroom facilities. Using the ARP calculation formula, it was found that the highest ARP value is on the risk agent AC2, which is user negligence. The carelessness of users here refers to students and lecturers who use classroom facilities for teaching activities. Where in the classroom, the negligence of users refers to the use of chairs. The number of chairs in each classroom is around 40-50 chairs, which also causes the frequency of chair damage to occur

Table 4. Risk agent of the classroom

Risk Agent of the Classroom	Code	Severity
User overload (laptop or bag is too heavy placed on the table)	AC1	7
User carelessness	AC2	9
Lack of coordination in leading	AC3	10
Unstable whiteboard	AC4	8
Worn hinges/hooks	AC5	6
Negligence in the placement of electrical socket	AC6	4
Excessive use (AC not turned off when the room is not in use)	AC7	7
The AC is old	AC8	9
Delay in AC service (maintenance of air filters and AC freon)	AC9	9
The distance between LCD and projector is not appropriate	AC10	6
Dirty projector lens	AC11	6
The lamp is old	AC12	8
Prediction of lamp usage time is not accurate	AC13	4
No computer screen protector	AC14	7
User carelessness (hit by sharp/rough object) on the computer screen	AC15	8

Table 5. Risk agent of the lecturer room

Risk Agent of the Lecturer room	Code	Severity
Lack of coordination in leading	AD1	2
Less precise in choosing curtains	AD2	7
Incorrect installation	AD3	6
Poor product quality	AD4	5
Non-ideal installation of the electrical socket (in hanging condition)	AD5	3
Open-plan concept space with partitions (every room is open)	AD6	4

Table 6. Risk agent of the laboratories

Risk Agent of the Laboratories	Code	Severity
Overload goods	AL1	6
User carelessness (rough shifting and impact)	AL2	3
Not clean enough in cleaning the tools	AL3	4
Lack of care in setting up tools	AL4	1
Lack of user concentration	AL5	3
User forget to turn off or often press the on-off button	AL6	6
Incorrect installation	AL7	1
Product quality is not good	AL8	7
User carelessness	AL9	1
Excessive use	AL10	3
Uncertainty of the goods submitted being accepted for procurement	AL11	7
Old age of use	AL12	7
The predicted usage time is not accurate	AL13	3
Not in accordance with procurement specifications	AL14	7

more often compared to other facilities. Therefore, further analysis is needed to mitigate the risk of damage to the chairs in the classroom.

The ARP calculation from the evaluation carried out by an expert, specifically a senior lecturer who has been using the lecturer's room for more than

Table 7. HOR 1 Classroom facilities

	AC1	AC2	AC3	AC4	AC5	AC6	AC7	AC8	AC9	AC 10	AC 11	AC 12	AC13	AC14	AC15	Severity of risk
EC1	9	9	1													6
EC2		3	9													8.5
EC3		1		9	9											4
EC4		3	9			9										3
EC5		3					9	9	9							8.5
EC6							3	3	3							7.5
EC7										9	9					7
EC8		1										9	1			5.5
EC9		9												9	3	4.5
Occof Agent	7.5	7.5	9	8.5	6	3.5	6	9.5	9	5.5	6.5	7.5	4.5	6	8	
ARP	405	1230	985.5	306	216	94.5	594	940.5	891	346.5	409.5	371.25	24.75	243	108	7165.5

Table 8. HOR 1 Lecturer facilities

	AD1	AD2	AD3	AD4	AD5	AD6	Severity of risk
ED1	9						5
ED2		9					5
ED3			1	1	9		8
ED4						9	7
Occ of agent	2	7	6	5	3	4	
ARP	90	315	48	40	216	252	961

20 years, is displayed in Table 8. According to the computation results, the risk agent AD2, which is the improper curtain selection, has the highest ARP value. According to the lecturer's room situation, the concept involves dividing spaces between lecturer's rooms, therefore only the rooms with windows have curtain facilities. The observation team discovered that the current curtains do not completely cover the sides of the windows, allowing light from outside to dazzle and discomfort the lecturers while they are doing activities in their rooms. This observation was made during the first round of risk event and risk agent identification. This might be uncomfortable and interfere with focus and concentration. Therefore, more research is required to mitigate the risk of choosing a curtain model that meets the lecturer's needs.

The ARP calculation from the evaluation carried out by two experts, specifically the laboratory managers, is displayed in Table 9. The industrial engineering laboratories number six, but only the risky laboratories are subjected to the risk mitigation study. According to the computation results, risk agents AL3 and AL12 have the highest ARP values, both of them have a score of 380. Inadequate hygiene in cleaning equipment is a characteristic of AL3. Numerous production tools, including lathes, drilling, CNC, welding, carbide, and others, are in the lab. The equipment required routine cleaning and maintenance. Each intern completes the machine cleaning procedure following the running activity. Practitioners occasionally neglect to thoroughly clean the equipment throughout the cleaning procedure. As a result, risk mitigation measures must be put into place in line with the Pareto diagram's findings, which will be examined further.

The next step in determining the risk agents to be further analyzed using the Pareto diagram approach is based on the fact that 80% of the risk agents contribute to the overall ARP value in each facility. Below is the Pareto diagram of the three facilities shown in the following image.

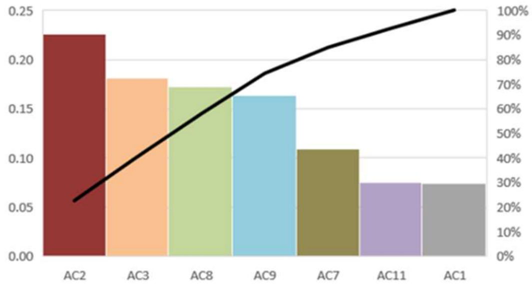

Figure 1. Classroom pareto diagram

Based on Figure 1, the Pareto diagram analysis for classroom facilities identifies seven priority risk agents for risk mitigation, ranked from the highest to the lowest: user negligence, lack of coordination in equipment borrowing, old age of air conditioning (AC) units, delays in AC servicing, excessive AC usage, dirty projector lenses, and overcapacity usage. From the analysis, user negligence has the highest ARP value, making it the primary focus for mitigation due to its potential for causing the most significant damage to classroom facilities. Furthermore, the old age of AC units and lack of coordination in borrowing equipment also rank high in priority due to their significant ARP values, indicating the need for regular maintenance and better management of borrowing systems. Mitigation for other risk agents, such as delays in AC servicing, excessive AC usage, dirty projector lenses, and overcapacity usage, is still necessary as part of future improvements in maintaining classroom facilities.

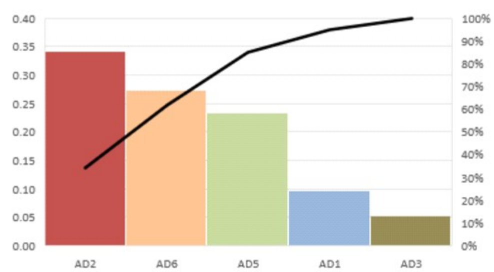

Figure 2. Lecturer room pareto diagram

Based on Figure 2, the Pareto diagram analysis for lecturer room facilities identifies five priority risk agents for mitigation, ranked from highest to lowest: improper curtain selection, open-plan room concept with partitions (each room is open), non-ideal installation of electrical sockets, lack of coordination in chair borrowing, and installation errors. These five risk agents require further risk mitigation as they directly affect the comfort, efficiency, and productivity of activities in the lecturer rooms. Improper curtain selection can reduce privacy and disrupt natural lighting, potentially affecting concentration and working comfort. The open-plan room concept with open partitions presents challenges related to noise and a lack of privacy, which can hinder focus and effective communication among lecturers. Non-ideal electrical socket installations pose a risk to the usability of electronic devices, especially in the digital era where access to electricity is essential for tasks such as charging laptops or using presentation tools. A lack of coordination in chair borrowing also becomes a barrier that may affect the availability of basic facilities for meetings or collaborative activities. Lastly, installation errors indicate potential structural or technical issues that could compromise safety and reduce the durability of the facilities. Therefore, mitigating risks associated with these five risk agents is crucial to ensure that lecturer rooms can optimally support work productivity, comfort, and user safety.

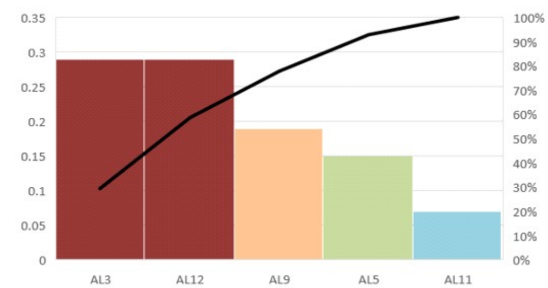

Figure 3. Laboratories pareto diagram

Based on Figure 3, the Pareto diagram analysis for laboratory facilities identifies five priority risk agents for mitigation, ranked from highest to lowest: inadequate cleaning of equipment, old age of lighting fixtures, user negligence in machine operation, lack of user focus, and uncertainty regarding the approval of proposed procurement items. These five risk agents require further mitigation as they significantly impact the efficiency, safety, and operational sustainability of laboratory facilities. Inadequate cleaning of equipment can lead to contamination, which not only reduces the accuracy of experimental results but also risks damaging the equipment, increasing repair costs. The old age of lighting fixtures poses a risk of inadequate illumination, hindering detailed observations during experiments and increasing the potential for errors. User negligence in operating machines is a major cause of equipment damage, which not only disrupts laboratory activities but also adds to the financial burden of replacement or repair. Additionally, a lack of user focus can result in operational errors, potentially leading to accidents or other losses, particularly in a work environment involving sensitive equipment. Lastly, uncertainty about whether proposed items are approved for procurement is a significant obstacle to ensuring smooth operations, as delays or unavailability of necessary tools can disrupt research and learning processes. Therefore, mitigating risks associated with these five risk agents is essential to ensure that laboratory facilities function optimally, remain safe, and meet user needs effectively.

House of Risk Fase 2

In HOR 2, the risk agent used in the final pareto result, this aims to ensure that the risk agents used describe 80% of the problems that occur. The relationship between risk agents and mitigation strategies is identified using values of 0, 1, 3, or 9 assigned in each combination. the degree of difficulty in implementing each risk mitigation, marked by Dk, using a scale of 3, 4, and 5, which respectively indicate strategies that are easy to implement, somewhat difficult to implement, and difficult to implement. The relationship between risk agents and mitigation strategies is shown in Table 10.

The experts gave the classroom facilities a Dk value of 3, citing the ease of implementation and low cost of the suggested techniques. The computations showed that PA1 was the best option. Furthermore, the current SOP for managing damage and maintaining classroom infrastructure still leaves certain important details, according to the experts' views.

The Dk value for each proactive action (PA) varies, according on Table 11's findings from expert interviews and questionnaire results. PA2 is

Table 10. HOR 2 Lecturer facilities

Agent	Code	Providing SOP (PA1)	Poster inviting people to maintain facilities (PA2)	Checklist maintenanc e (PA3)	ARP
User carelessness	AC2	9	9		1230
Lack of coordination in leading	AC3	9	3		985.5
The AC is old	AC8			3	940.5
Delay in AC service (maintenance of air filters and AC freon)	AC9	3		9	891
Excessive use (AC not turned off when the room is not in use)	AC7	3	9	1	594
Dirty projector lens	AC11	3		9	409.5
User overload (laptop or bag is too heavy placed on the table)	AC1		9		405
TEk		25623	23017.5	15120	
Dk		3	3	3	
ETDk		8541	7672.5	5040	
Rank		1	2	3	

Table 11. HOR 2 Lecturer facilities

Agent	Code	Provide spare seats in each aisle (PA1)	Selection of a wider curtain model (PA2)	Longer roll changes and improved placement (PA3)	Building an audio room (PA4)	ARP
Less precise in choosing curtains	AD2		3			315
Open-plan concept space with partitions (every room is open)	AD6				9	252
Non-ideal installation of the electrical socket (in hanging condition)	AD5			3		216
Lack of coordination in leading	AD1	9				90
Incorrect installation	AD3			3		48
TEk		810	945	792	2268	
Dk		3	4	3	5	
ETDk		270	236.25	264	453.6	
Rank		3	2	4	1	

Table 12. HOR 2 Laboratorium facilities

Agent	Code	SOP for labor assistant (PA1)	Provide break time between practicals (PA 2)	Checklist for submission and receipt of goods (PA3)	Checklist maintenance (PA4)	ARP
Not clean enough in cleaning the tools	AL3	9			9	380
Old age of use	AL12				3	380
User carelessness	AL9	3	1			248
Lack of user concentration	AL5	3	9			195
Uncertainty of the goods submitted being accepted for procurement	AL11			9		96.75
TEk		4749	2003	870.75	4560	
Dk		3	5	3	3	
ETDk		1583	400.6	290.25	1520	
Rank		1	3	4	2	

rated as fairly tough, PA4 as challenging, and PA1 and PA3 as straightforward to implement. PA4, which entails establishing a dedicated audio room to handle noise issues in the open-plan concept space, is the highest priority action according to the risk mitigation priorities based on the Effectiveness to Difficulty ratio (ETDk). This mitigation is intended to maximise instructors' comfort, effectiveness, and productivity using a practical and efficient method.

According to Table 12, the expert interviews and questionnaire results showed that the proactive acts fall into four groups. While PA2 is thought to be challenging to implement, the Dk values for PA1, PA3, and PA4 are thought to be simple. Nonetheless, PA1, which entails developing a SOP for laboratory assistants, has the greatest priority for immediate mitigation based on the ETDk values. The significance of a SOP in the entire laboratory workflow, its influence on other risk variables, and its ability to avert unintended incidents—all of which need to be taken into account—were underlined by experts.

IV. CONCLUSION

This study effectively detects and ranks the risks affecting XYZ University's Industrial Engineering Building through the use of the House of Risk (HOR) technique. In HOR Phase 1, ARP analysis was used to identify key risk agents, including user carelessness, antiquated equipment, and inadequate maintenance. Phase 2 then offered practical mitigation techniques, giving priority to those with the best efficacy-to-difficulty ratios.

Seven priority risk agents for risk mitigation were identified by Pareto diagram analysis for classroom facilities. These agents were ranked from highest to lowest and included: user negligence, old air conditioning (AC) units, lack of coordination in equipment lending, excessive use of the AC, dirty projector lenses, and excessive capacity utilisation. The primary focus was on routine maintenance in the form of checklists and improved management of the lending system by creating SOPs. Analysis of Pareto diagrams for lecture hall amenities classified the following five risk elements in order of importance for mitigation: improper curtain selection, open space concept with partitions (any open space), and the primary necessity for mitigation in the construction of the building's audio room. Five priority risk agents for mitigation were identified by Pareto diagram analysis for laboratory facilities. These agents were ranked from highest to lowest: ageing light fixtures, inadequate equipment cleaning, user carelessness when operating machines, lack of user focus, and uncertainty regarding approval of proposed procurement items. The mitigation strategy focused on developing SOPs for laboratory assistants to monitor the cleanliness and completeness of the equipment.

Establishing thorough SOPs for facility maintenance and user behaviour is the top-ranked tactic since it directly addresses reoccurring problems and lowers the possibility of future damages. Preventive maintenance plans and quality inspections during the purchase process are two further suggestions. When taken as a whole, these actions improve facility dependability and guarantee a favourable atmosphere for learning. This strategy provides a model that can be used in different educational settings to solve comparable problems.

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