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Extensive or Exclusive? : The Utilisation Of Project Management Toolsets In The Manufacturing And Services Sector Of The Aviation Industry

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Abstract: This study assesses the level of project management tools and techniques utilisation in Malaysia's aviation industry manufacturing and services sector. The methodology in this study is divided into two parts: the first part focuses on secondary research to understand the types of project management tools and techniques used. The second part focuses on the primary research on gathering responses from the personnel at various levels evaluated using the Fuzzy Delphi Method (FDM) to gather expert consensus feedback. This study provides valuable insights into the project management toolsets commonly used in the aviation industry that would assist companies in selecting and implementing project management tools or techniques. A preliminary study analysis discovered positive trends and patterns in the extensive use of project management toolsets among personnel in the industry.

Keywords: *Tools and Techniques, Manufacturing Services, Expert Review, Items Ranking, Integrated Project, Aviation Management*

1. Introduction

The Malaysian Aerospace Industry Blueprint 2030 anticipates that there will be potential growth in the aviation industry manufacturing and services, which outlines four substantial sub-sectors: the maintenance, repair and overhaul (MRO), aero-manufacturing, system integration and education and training (Zainal et al., 2015). In the blueprint, the future growth of the sectors targeted based on the individual sub-sector, which are five per cent of the global market share (in the MRO sub-sector), 3.5% for the global market share of engineering and design, 70% self-reliant to the local content for the systems integration and to be the first in South-East Asia in the sourcing of parts and components for the manufacturing sub-sector. In the context of the MRO sector, the roles of the manufacturing and services industry are essential. For example, the aircraft comprises millions of parts and components; hence, maintenance, repair, modification and overhaul are needed through in-sourcing or outsourcing (Meijer, 2021). Therefore, MRO companies have a greater responsibility to provide effective and efficient services to ensure optimal services are provided while performing the MRO activities of the aircraft.

An effective project management (PM) approach to utilising the right tools and techniques is essential in managing a complex business, operations and management such as MRO companies. Project management minimises maintenance costs and aircraft grounding time but could improve revenues and enhance aircraft availability and operations (Yadav et al., 2022). The organisation's project management is an essential and critical success factor in implementing effective company strategy (Fuertes et al., 2020; Hyväri, 2016). Thus, adopting PM skills is essential for entrepreneurs to manage their organisations (Sarvari et al., 2021). Project management is *"the application of knowledge, skills, tools, and techniques to project activities to meet the project requirements", as* defined in the Project Management Book of Knowledge (6th Edition), allowing

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organisations to manage their projects effectively and efficiently. As part of the essential pillars of PM, the tools and techniques used in its implementation can be regarded as one of the most important disciplines that need to be empowered and utilised. Moreover, various studies have shown that PM tools and techniques positively impact project success (Patanakul et al., 2010). However, using PM tools and techniques was not given proper empirical attention (C. Chen & Nakayama, 2016). Investigating its utilisation among building sector companies shows an imbalanced use of PM tools and techniques (Ismael & Raúl, 2019).

Results from the same study indicate that some of the project tools and techniques are either getting positive results (such as the use of cost and time estimation techniques, management reserves, project network, financial closures, Gantt chart, organisation charts, checklists and contract and negotiation tools) and some of its with poor usage (such as project charter, RACI Matrix, EDT/WBS, contingency reserves, stakeholders and risks management tools) (Ismael & Raúl, 2019). Although there are significant benefits of PM tools and techniques, the lack of awareness, exposure, education or training might contribute to the issues of its minimum utilisation. In addition, quite a few studies were conducted on the influence of project management practises towards the success of projects (Besner & Hobbs, 2012a). For example, an analysis of the PM tools and techniques implementation among businesses in Vietnam showed two factors contributing to the issues: a deeper understanding of the use of tools and techniques and the inability of the businesses to recognise its uses (Xuan et al., 2019).

Despite the benefits, the aircraft maintenance industry is still not mesmerised by the high utilisation of modern PM in other engineering fields (Yadav et al., 2022). Nonetheless, the project's success and achievement are always determined by using PM techniques (Munns & Bjeirmi, 1996). Thus, it is essential to analyse further and investigate the implementation of PM approaches, specifically to what extent the contribution of its tools and techniques implementation. The novel contribution of this study is twofold: firstly, it would provide an understanding among organisations planning to adopt the PM tools and techniques extensively, and secondly, it contributes to additional literature in discussing the issues, roles or significance of the tools and techniques used in managing projects. This paper is organised as follows: Section 1 briefly introduces the topic. Section 2 focuses on the related literature review of the topic. Section 3 describes the adopted methodology in analysing feedback acquired. In Section 4, this paper provides the analysis and findings discussion. Finally, Section 5 concludes the discussion and discusses the future suggestions.

2. Literature review

The past literature was searched using the Google Scholar database to understand the earlier use and existence of the PM toolset. PM toolset is one of the eight essential toolsets for supporting the integrated software engineering environment (Oquendo et al., 1989; Thomas, 1989). The objective inclusion of PM toolsets in the software engineering framework is to allow seamless integration among other tools used to support individuals with different technical capabilities (Thomas, 1989). PM toolset is a group of software, methods, templates, tools and techniques that project managers and their teams use to plan, carry out, monitor, and handle projects effectively. The different phases of PM, such as planning, scheduling, resource allocation, communication, collaboration, and reporting, can all be made more efficient and effective with the help of the tools and techniques. In the PM framework, the tools and techniques transform the input acquired by producing outputs

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in each project process; thus, selecting related tools and techniques is necessary (*A Guide To The Project Management Body of Knowledge - PMBOK Guide*, 2017).

2.1 Project Management toolsets

Tereso et al. (2019) discuss the types of PM practices among private companies, which compiled and listed 79 PM tools and techniques. The tools and techniques discussed in Tereso et al. (2019) were mainly influenced by the list of tools and techniques derived from Besner and Hobbs (2006) and other studies. On the other hand, 70 PM tools and techniques were segregated into three categories: limited to extensive use, very limited to minimal use and less than minimal use (Besner & Hobbs, 2006). In their study, Tereso et al. (2019) also grouped the most commonly used PM practices into five different groups based on the PM stages, which are the initiation stage *(kick-off meeting, project charter)*, planning stage *(milestone planning, scope statement, risk identification, WBS, baseline plan, Gantt chart, requirement analysis, activity list)*, execution stage *(issues log, lessons learned)*, controlling stage *(change request, customer satisfaction survey, PM software for monitoring, progress meetings, progress report)*, and closing stage *(client acceptance form, close contracts, project closure documents)*.

To provide a more precise list of tools and techniques commonly used by the project management professional in managing and implementing projects, patterns of the tools and techniques extensively used among project management professionals were listed, comprising 108 PM tools and techniques derived from the survey that they conducted; and categorised them into 19 different groups (Besner & Hobbs, 2012a). A similar list of tools and techniques used to investigate the differences in the usage of the toolsets between the project types had successfully emerged a new concept within the project implementation - known as performing maturity (Besner & Hobbs, 2012b). Besner & Hobbs (2012b) investigated variations of toolsets used among different project types and identified the typical project management patterns of practices from a more comprehensive and contextual perspective. On the other hand, a list of 27 PM toolsets was explicitly elaborated to enhance the performance of small and medium enterprises (SMEs) (Sensini et al., 2021).

2.2 Types of project complexities

Project complexity describes the size or magnitude of a project compared to the resources available to an organisation. Gathering the information on the type of project complexities helps the researcher to understand the level of respondents' participation and the types of projects involved within the organisation. The definition of project complexities varies. The project complexity can be visualised as the interrelated parts of elements that can learn (such as people, stakeholders) or not able to (such as products, documents, among others) over time while communicating internally or externally within their environment (Bolzan de Rezende et al., 2022). In contrast, the project complexity construct can be divided into three elements: the system of Systems view, the Project Management Institute (PMI) view, and the Complexity Theories view (Bakhshi et al., 2016). These three critical constructs significantly discussed the difference in the project complexity concept adopted in this study. The components of the project complexities comprise four quadrants adopted in this study, which can be classified into four types: semi-open, open, closed and semi-closed.

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What To Do \ How To Do It	Clear	Unclear
Unclear	**Semi-Open (Movie Making)** ▪ Stakeholders: – very sure how the project is to be done – unsure of what needs to be done ▪ The organisation has the expertise and clear of the method to be used ▪ Needs to spend time defining what	**Open (Lost in the Fog)** ▪ Stakeholders: – unsure of what needs to be done – unsure how the project is to be done. ▪ The organisation: – attempt to do something not done before – needs to spend time defining what and how
Clear	**Closed (Painting by Numbers)** ▪ Stakeholders: – sure, what needs to be done – very sure of how the project is to be done – unsure of what needs to be done ▪ The organisation is going through repetitive projects and knows the skills needed. ▪ Written procedures, methods and systems exist to replicate what needs to be done in the past.	**Semi-Closed (Going on a Quest)** ▪ Stakeholders: – sure, what needs to be done – unsure of how the project is to be done ▪ The organisation is going through repetitive projects and knows the skills needed. ▪ The organisation needs to spend time defining how.

Fig 1: Types of Project Complexities (Obeng, 1994)

3. Methodology

In emphasising the scope of this study, three key areas of discussion are highlighted: demographic information, types of project complexities and the PM toolset adopted by the respondents. The survey form consisted of the demographic information (personnel general information, years of experiences, types and size of the projects involved) and the PM tools and techniques list formulated based on Besner & Hobbs (2012a). This study adopts the Fuzzy Delphi Method (FDM) to assess the consensus feedback from the practitioners employed within the aviation manufacturing and services industry in Malaysia. The data were collected using the survey form, distributed online or by meeting with the personnel individually. FDM is a well-known method used to evaluate expert consensus feedback that consists of eight steps to be performed (Marzuki & Mohammad, 2023):

a. Define variables and the scale
b. Identification of experts or respondents
c. Selection of fuzzy scale
d. Calculation of Likert scale score
e. Calculation of average (m1,m2,m3) value
f. Determine *d* value (threshold value) less than 0.2
g. Determine above 75% items consensus
h. Score ranking (defuzzification)

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4. Discussion and Findings

Using tools and techniques in implementing projects in the industry shall benefit the organisation by facilitating employees' tasks and assisting them in managing projects effectively. As derived in the methodology section, the scope of this study focuses on understanding the level of PM tools and techniques implementation; secondly, by extending a better understanding of the structure (size and complexity) of projects implemented.

4.1 Demographic information - types and complexities of project information

Demographic information on the expert roles in their respective organisations is essential in this study. In total, 16 practitioners participated in this study; however, only one participant did not fill in the demographic information. Nonetheless, the 15 personnel who responded and filled in their information are considered sufficient. Table 1 indicated a fair distribution of the total experts who participated in the study with different project roles – five participants as program manager and project manager, respectively; four had experience as a team member, and the other two participants responded as others. Hence, the participation of experienced participants in this study provides more precise information on the respective PM toolsets used among practitioners in the implementation of project management. Moreover, the minimum requirement for the number of participants analysed using FDM is between 15 and 50 participants (Ismail et al., 2019; Kadir et al., 2019; Mohammad et al., 2019).

Table 1
Experts' roles in projects

Roles in a project	Company	No of Experts	Types of company
Program Manager	Company B	1	Engine and component manufacturing
	Company G	1	MRO services
	Company H	1	MRO services
	Company I	1	Engine and component manufacturing
	Company J	1	MRO services
Project manager	Company A	2	Airframe manufacturing
	Company E	1	MRO services
	Company F	1	Engine and component manufacturing
	Company N	1	Engine and component manufacturing
Team member	Company B	1	Engine and component manufacturing
	Company C	1	Airframe manufacturing
	Company D	1	MRO services
	Company L	1	Engine and component manufacturing
Others	Company K	1	MRO services
	Company M	1	MRO services

This study acquired feedback from the employees employed as project management personnel in Malaysia's Maintenance, Repair, and Overhaul (MRO) industry, with 7 out of the companies providing MRO services, accounting for 43.75%. Meanwhile, the engine and component manufacturing subsector is represented by six companies (37.5%), while the airframe manufacturing subsector comprises three companies (representing 18.75% of the total). Based on the survey findings, various employees' roles and designations were reported in this study, such as project managers (five participants), program managers (five participants),

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project team members (four participants), and a small category labelled 'others' (two participants). Validation of each respondent's experience with projects was conducted to authenticate the relevancies of data with the scope of the study, aiming to assess the significance of implementing PM toolsets among MRO companies.

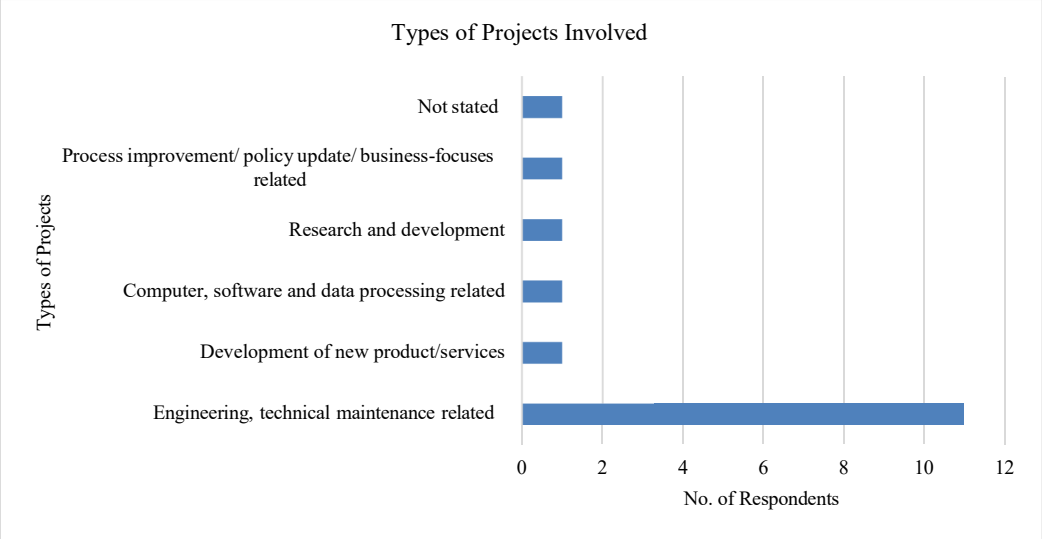

Fig 2: Types of Projects Involved

As shown in **Fig** 2, the survey findings illustrate that most respondents (11 out of 16, or 68.75%) were involved in engineering or maintenance-related projects. Meanwhile, one respondent (6.25% of the total respondents) is involved with innovating new products or services, computer software and data processing, establishing new policies or procedures, and research and development-related projects. However, another respondent has not provided information on their project involvement. These results, however, provide an overview of the business nature of the involved organisation within the manufacturing and services sector of the aviation industry.

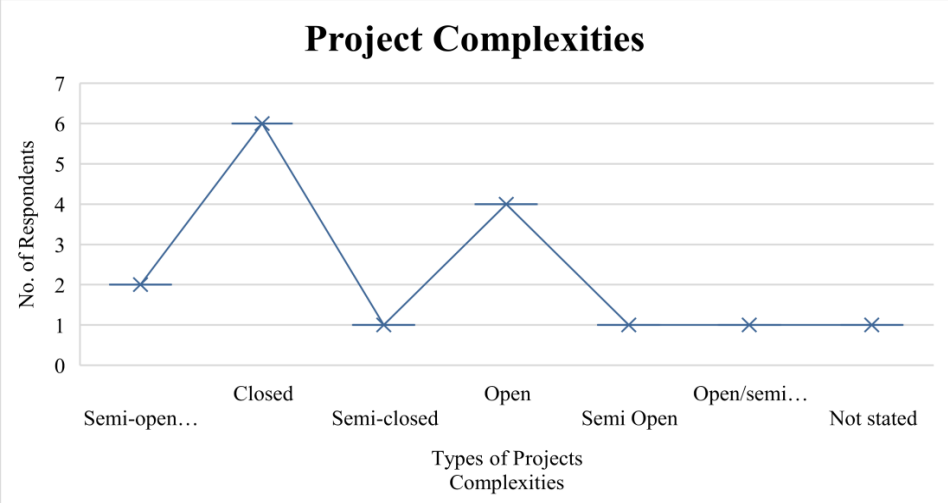

Fig 3: Types of Project Complexities

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As per the survey findings, most respondents (10 out of 16, or 62.50%) were involved in projects categorised as either semi-open or closed in complexity. These classifications align with Obeng's (1994) typology of four distinct project types: walking in the fog, making a movie, going on a quest, and painting by numbers. Specifically, the more significant portion of respondents (6 out of 16, or 37.5%) were engaged in projects classified as closed in complexity. Two respondents (12.5%) were involved in projects categorised as semi-open or closed, while one participant (6.25%) contributed to a semi-closed complexity project. Additionally, four respondents (25%) were involved in projects characterised as open in complexity, one (6.25%) in a semi-open complexity project, and one (6.25%) in a project that included elements of open, semi-closed, and closed complexities. There was also one respondent (6.25%) who did not specify the complexity of their project. These findings offer an overview of the project complexities managed by the respondents, aiding in understanding the level of uncertainty and challenges encountered during project execution. The outcome of this finding shows that most projects in this industry are mainly in the ideal situation, as suggested by Coates (2013) and the outcome of this study.

a. Fuzzy Delphi method (FDM) analysis

The list of 19 project management toolsets adopted in this study has been conceptually categorised into five groups: the toolsets used to define the project, the IT-related, contract and costs, team management, integrity of the project and managing performance. The classification of the PM toolsets is shown in **Fig 4**. Although this study had grouped the list of the accepted items, the analysis and feedback gathered from the expert were analysed based on each list of the toolsets. The list of toolsets used by the respondents was analysed individually and based on the conceptual groups defined earlier.

Define the project: ▪ Business case definition	**Project Integrity:** ▪ Risk management ▪ Monitoring progress ▪ Quality ▪ Business benefit measures
IT related: ▪ Advanced project management software ▪ Databases ▪ Basic project management software functionality	**Managing Performance:** ▪ Initial Planning ▪ Project closure ▪ Project analysis ▪ Multi-project management ▪ Baseline change management ▪ Network planning
Contract and costs: ▪ Bidding and fixed-price contract ▪ Financial evaluation ▪ Variable-price contract ▪ Cost estimation	
Team management	

Fig 4: Conceptual categories of project management toolsets

In analysing the survey findings from the respondents, this study emphasises the output of the FDM analysis into three areas: the ranking of accepted items, experts'

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consensus and the value of item defuzzification (α-cut value). Regarding the extent of use of the PM toolsets, the following discussion shall focus on the highly most accepted and the lowly accepted items. Based on the result in Table 2, the bidding and fixed-priced contract items have been recorded as the most accepted among the experts, followed by the basic project management software functionality, initial planning managing performance, team management and project closure. Meanwhile, the lowly accepted items are quality, network planning, business benefit measures, business case definition and variable-price contracts. Two sub-items of the PM toolsets categories included in the questionnaire answered by the experts are reviewed to understand the result further.

a. Accepted and rejected items

In FDM, acceptance and rejection of items are based on the threshold value, per cent of experts consensus and average fuzzy number (α-cut value). Analysis result summarised in Table 2 has shown that two items need to be rejected while the remaining items are accepted. Risk management and cost estimation are the two items that need to be rejected based on the analysis performed. For risk management, the items do not fulfil the minimum requirement of the three indicating values: the expert consensus is 50%, the threshold value is 0.245, and the α-cut value is 0.638. Meanwhile, item 18, which needed to be rejected, also needed to be rejected, given its low consensus feedback among the experts (with only 37.50%) and the α-cut value of 0.588. Although the threshold value for item 18 complies with the suggested value, we have decided to remove the items given its low consensus percentage among experts.

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Table 2
FDM analysis results

Rank	Item	Project Management Toolsets	Conceptual Category	Expert Consensus, > 75%	Threshold value, d < 0.2	α-cut value = 0.5	A-max	Status
1	7	Bidding and fixed-price contract	Contract and costs	100.00%	0.086	0.675	0.33	Accepted
2	2	Basic project management software functionality	IT related	93.75%	0.086	0.671	0.34	Accepted
3	6	Initial planning	Managing performance	87.50%	0.092	0.663	0.33	Accepted
3	13	Team management	Team management	93.75%	0.086	0.663	0.35	Accepted
3	15	Project closure	Managing performance	93.75%	0.086	0.663	0.35	Accepted
6	**1**	**Risk management**	**Project Integrity**	**50.00%**	**0.245**	**0.638**	**0.61**	**REJECTED**
6	4	Multi-project management	Managing performance	93.75%	0.079	0.638	0.36	Accepted
6	16	Monitoring progress	Project Integrity	100.00%	0.100	0.638	0.33	Accepted
9	10	Baseline change management	Managing performance	100.00%	0.100	0.625	0.31	Accepted
10	5	Databases	IT related	93.75%	0.092	0.613	0.32	Accepted
10	12	Financial evaluation	Contract and costs	93.75%	0.124	0.613	0.32	Accepted
10	17	Project analysis	Managing performance	81.25%	0.107	0.613	0.34	Accepted
13	3	Advanced project management software	IT related	81.25%	0.107	0.600	0.34	Accepted
14	14	Variable-price contract	Contract and costs	87.50%	0.154	0.575	0.28	Accepted
14	**18**	**Cost estimation**	**Contract and costs**	**37.50%**	**0.199**	**0.588**	0.57	**REJECTED**
15	8	Business case definition	Project definition	93.75%	0.143	0.563	0.31	Accepted
16	9	Business benefit measures	Project Integrity	93.75%	0.150	0.550	0.31	Accepted
17	11	Network planning	Managing performance	87.50%	0.171	0.538	0.32	Accepted
18	19	Quality	Project Integrity	93.75%	0.100	0.563	0.33	Accepted

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Table 3
Comparative analysis of the toolset ranking in the same conceptual category

Conceptual category	Contract costs	
Project management toolset	Toolset 7: Bidding and fixed-price contract	Toolset 14: Variable-price contract
Ranking	1st	14th
Sub-items	1. Contract documents 2. Fixed-price contract 3. Bid documents 4. Bid/seller evaluation 5. Contractual commitment data	1. Contract penalties 2. Cost-plus contract 3. Gain-share contract

Table 3 derived the ranking of different PM toolsets of a similar conceptual category. The comparative analysis between different toolsets in a similar category is performed to understand further the direction of ranking whereby toolset seven is ranked as the most extensively used toolset among practitioners; meanwhile, toolset 14 has been ranked at the lower rank although it is conceptually categorised in the same group. The analysis shows that the sub-items of toolset seven comprise the essential documents needed for project implementation. Meanwhile, the sub-items for toolset 14 might be considered either new items among the practitioner or may not have been used or applied in their project. Therefore, further analysis in future might be necessary to further understand the opposited direction of the two items in a same group that has scored higher and lower rank respectively.

b. Experts' consensus

In FDM, expert consensus feedback is one of the vital essential indicators for the acceptance or rejection of items if the percentage of expert feedback is above 75% (Habibah @ Artini et al., 2014; Mohammad et al., 2019; Yusoff et al., 2021). In this study, most of the items acquired at least 75% agreement among the experts, except for items one and 18. For example, for item 18, although its threshold value is below 0.2 (which fulfilled the criteria of acceptance based on threshold value), given its low acceptance among expert consensus (37.50%) and the α-cut value of above 0.5, the item was rejected. The analysis also indicated that three items, bidding and fixed-price contract, monitoring progress and baseline change management, have reached 100% agreement among the experts on the extensive use of these tools in the project management implementation within Malaysia's aviation manufacturing and services industry.

c. Item defuzzification (α-cut value of 0.5 must be equal or lesser than Amax)

The term defuzzification can be interpreted as a process of converting a set of fuzzy numbers with a crispier and more precise value. In FDM, defuzzification is a process of analysing the experts' feedback (with the α-cut value of 0.5, which needs to be equal to or lower than the Amax value), which is used to identify the items' priority and ranking. The defuzzication value obtained is also used alongside the expert's feedback and threshold value to determine the item's acceptance or rejection. The α-cut value = 0.5 must be less than Amax's yielded value in deciding whether to accept the items. Meanwhile, the α-cut value = 0.5 is more excellent than the Amax value, showing that the items are consensusly rejected by the experts involved in the study. As shown in Table 2, both rejected items indicated a value above 0.5, which supports our decision to reject the items.

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5. Conclusion

As presented in this study, the exploration of PM tools and techniques within Malaysia's aviation industry manufacturing and services sector reveals a comprehensive overview of the extensive use of PM tools and techniques. The use of the FDM method in assessing the experts' feedback derived exciting findings on the widely accepted toolsets among the practitioners within the aviation industry. By gathering consensus experts' feedback, this research has contributed valuable insights into the prevalent PM toolsets implemented in the industry, orchestrating the significant resources for the organisations in selecting the right tools or techniques to ensure effective project management. Impressively, the study's outcome has shown that most toolsets are extensively used and widely accepted for their use within the related sector. The findings and outcome successfully address the aim of this study, which is to explore the extensive level of PM toolsets.

The implications of this research extend beyond the typical research study conducted by approaching the respondents who are also directly involved in the project management implementation at their organisation. A few limitations and weaknesses while conducting this study must be addressed in the future. For instance, future studies shall address the issues, drivers and challenges that might affect the quality of this study by focusing on the latest tools and techniques used in PM practices. At the same time, the PM toolsets used are based on a study done more than a century ago. Thus, an extensive literature review of the recent and latest studies on the toolsets used for project management is also significant.

Nonetheless, this study's findings highlighted that the trends and insights of the PM toolsets provide a better roadmap preparation for organisations, allowing them to ascertain diversified trends and preferences. It marks a very significant timeframe in acquiring a better understanding of the PM toolsets within the Malaysian aviation industry, providing a platform to streamline and enhance PM practices for better efficacy and success.

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