Evaluating Intangible Software Quality Metrics for Effective Project Management Information Systems

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***Abstract*—In modern organizational environments, project management information systems (PMIS) play an important role in ensuring project success with the user requirements, keeping overall costs within the planned budget, and delivering projects at the agreed time. Selecting a high-quality PMIS is vital for the success of project management. A software quality model tailored to PMIS, summarizing the intangible software quality metrics (ISQM) that are effective in evaluating a PMIS, can help better decision-making on PMIS for project managers. However, there is limited research on the PMIS-tailored quality model. To fill the gap, this study evaluates effective SQM for PMIS quality assessment. There are two types of PMIS: Web-based PMIS and PMIS software applications. To narrow the context of PMIS, we focus on web-based PMIS since they are widely used across the industry, such as Microsoft Project and Jira. According to the PMIS features, we merely explored the tailored quality models that have been proven to be more appropriate for web-based PMIS rather than the basic models, such as ISO/IEC 9126, ISO/IEC 25010, and Bertoa. This research uses a qualitative approach to conduct the commonality screening among these models and find out the key evaluation metrics, such as usability and functionality, and the corresponding qualitative attributes suitable for Web-based PMIS quality assessment. The selected metrics and attributes are used to form a Web-based PMIS-tailored quality model. The scoring mechanism is introduced based on the PMIS-tailored quality model, where project managers can have a clear comparison among different web-based PMISs, leading to effective web-based PMIS selection for project management.**

Keywords*—*Web-based PMIS; software quality model; intangible software quality metrics; software quality

I. Introduction

In traditional project management (PM), most projects are managed by using a mass of manual documents. A successful project requires complete documentation to execute all project life cycles and make decisions. In terms of this issue, the project team is often faced with the challenge of whether to do documentation or do the project. Thus, some project managers of information systems and information technology projects choose to use the PMIS to help their project management [1].

Project Management Institute (PMI) in their PMBOK GUIDE defines a PMIS as software that can help strategize, organize, and manage resource streams and develop resource approximations [2]. PMIS allows for real-time tracking of project progress, which helps in identifying and mitigating risks promptly. In addition, for large and complex projects, some PMIS like MS Project or Primavera support comprehensive project methodologies and require skilled team members, thus ensuring better management of complex project requirements [3].

The project systems can be grouped into two types [4]:

- Web-based project management systems.
- Project management systems software applications.

Different types of project management systems are utilized to manage projects. They are unique in operation, depending on the kind of project one is managing.

This study is structured systematically to address the research gap. The subsequent sections will first detail the problem statement, research questions, and objectives that form the foundation of this study. Following this, the research methodology is presented, outlining the literature review process and the analysis of existing tailored software quality models. The study then describes the development of the proposed Web-based PMIS-tailored quality model, including the selection of metrics and the calculation of weights based on an expert survey. Finally, the results are presented and discussed, followed by the study's limitations and a conclusion that summarizes the key findings and suggests directions for future research.

II. Problem Statement

In project management processes, the implementation of PMIS implies several changes in the organization's routines. For example, the PMIS was a new software tool in the organization, and therefore, there were also difficulties during the adaptation of the users to the new tool [5]. This reveals the necessity of quality metrics such as usability in PMIS. The successful implementation of any software product relies on the quality of the software. Many existing models can be used to evaluate software quality.

The latest software quality models have undergone standardization processes, such as ISO standards 9126 and 25010 [6]. Each model focuses on a specific metric, and one of the most important factors influencing software quality measurement is selecting the most relevant metric. However, existing studies have not conducted an effective assessment of quality metrics for PMIS. To ensure the success of PM, it is crucial to have better control over the quality metric of PMIS

since "you cannot control that which you cannot measure" [7].

III. Research Questions

The main objective of this study is to analyze the software quality models and ISQM and establish a suitable model for PMIS. The research objective has been achieved by solving these research questions (see Table I):

TABLE I Research Questions

RQ1	What are the commonly used software quality models?
RQ2	What ISQM are involved in these existing models?
RQ3	What is a suitable software quality model for web-based PMIS?
RQ4	What model can be developed for PMIS through modifications or enhancements to the existing quality models?

IV. Objectives

This study aims to identify the effective ISQM for Web-based PMIS. Our approaches include exploring 14 types of existing quality models to find the most relevant metrics for web-based PMIS and evaluating the selected metrics, which will be formulated as a quality model specifically for assessing the ISQM aspects of web-based PMIS. A tool is developed based on the created quality model and identified ISQM to assess the web-based PMIS. Such a tool provides project managers with actionable insights and practical guidelines for selecting web-based PMIS that align with their specific project goals, enabling organizations to enhance project efficiency and success rates.

V. Scope Of Study

1) The software quality model under research is developed based on tailored software quality models.

2) This research adopts a qualitative approach that focuses on selecting qualitative attributes for each ISQM.

3) To narrow the context of PMIS, we focus on web-based PMIS since they are widely used across the industry, such as Microsoft Project and Jira.

VI. Materials And Methods

A. Literature Review

1) Software quality models. Numerous Quality models, such as McCall's Quality Model, Bowen, GHezzi, and ISO/IEC 25010 Quality Model, are used for software quality assessment. These models have been experiencing the standardized process to formulate general metrics for software products like usability, reliability, functionality, and maintainability [7]. For instance, software quality is divided into eight major metrics in the ISO 25010 Quality Model, including functional suitability, performance efficiency, compatibility, usability, reliability, security, maintainability, and portability. These metrics are further subdivided to assess general quality attributes. For example, usability embodies the influence of user adaptability, while reliability measures the system's ability to perform under operational demands [8].

2) Project management information system. PMIS is popular as an essential tool for modern project management. The outlook of project management systems is rapidly evolving, influenced by technological advancements, changing work environments, and emerging methodologies [6].

With the widespread use of PMIS, software quality assurance has become an important aspect of ensuring the efficiency, reliability, and effectiveness of software systems in project management. The quality of software is a necessary factor in the success of project management systems, which can influence user satisfaction, maintenance costs, and overall project success.

B. Related Work

While general software quality models like ISO/IEC 25010 exist, applying them directly to specialized systems like PMIS is challenging [6]. A review of previous studies reveals significant limitations, as shown in Table II. For example, past research has been critiqued for using inadequate models for ubiquitous applications [9], offering limited scope for domains like learning management systems [12], and lacking sufficient attribute coverage and applicability in healthcare systems [13]. A key issue is the failure of older models like ISO/IEC 9126 to include critical modern metrics such as reusability, which is vital for component-based software [11]. This highlights a major gap: a lack of customized evaluation frameworks specifically for PMIS [6].

This study addresses this gap by developing a tailored quality model specifically for web-based PMIS. The research focuses on "tailored models", which are more appropriate for modern COTS PMIS tools like Jira and Microsoft Project, rather than basic models [12]. Using a qualitative screening process, the study identifies the most relevant ISQM to form a "Web-based PMIS-tailored quality model". This new model includes a scoring mechanism to provide project managers with a practical, domain-specific tool for effective PMIS selection, directly filling the identified research gap.

TABLE II SUMMARY OF RELATED WORKS IN MODELS FOR THE QUALITY ASSESSMENT

No.	Title	Reference Model	Description	Limitation
[9]	Evaluating Quality Characteristics of Ubiquitous Application Through Means of Quality Models Using Meta-metrics Approach	-ISO/IEC 25010 -AQUARIUM	A review mapping between several quality models to determine the set of quality characteristics for ubiquitous applications.	-Inadequate Quality Model -Lack of Defined Interaction Characteristics -Measurement Function
[10]	Measuring software quality with usability, efficiency, and portability characteristics.	-ISO/IEC 9126	Using the existing basic model to evaluate the Application of software cost estimation (AoSCE).	-Incomplete feature coverage -Methodological limitations
[11]	Analysis and assessment of existing software quality models to predict the reliability of component-based software.	-ISO/IEC 9126	Assessment of software quality model and its quality parameters related to Component-Based Software.	-ISO 9126 does not include reusability as a parameter, which is especially important in component-based systems.
[12]	A Review on Software Quality Models for Learning Management Systems.	-ISO/IEC 9126	Based on the ISO/IEC 9126, evaluate software quality for LMS.	-Limited Scope of Models -It does not provide an in-depth discussion on how these attributes can be effectively measured or implemented.
[13]	Assessing the impact of software quality models in healthcare software systems.	-McCall's -Boehm -FURPS quality -Dromey -IOS/IEC 9126	Define the criticalities of healthcare software, establish key software characteristics with common terminology, and map each characteristic to the corresponding criticality.	-Insufficient Coverage of Quality Attributes by Models -Model Applicability Issues

VII. RESEARCH METHODOLOGY

In this section, the main research objective is to analyze the role of web-based PMIS in project management. By defining the key intangible metrics of those project management information systems, combine the existing quality models to develop a Quality assessment tool for an effective project management information system.

A. Analysis of Existing Software Quality Models

The software quality models can be grouped into basic models and tailored models, and software quality models developed until 2000 are classified as basic software quality models, while those developed after 2000 are referred to as tailored software quality models [12]. The basic software quality models have the characteristics of generalizability and standardization that are suitable for a wide range of software system development and quality assessment, while the tailored software quality models or non-basic models are more appropriate for the use of Commercial Off-The-Shelf (COTS) components [12].

Fig.1 shows the two categories of the software quality model.

COTS components refer to commercially available software or hardware products that are ready-made and available for sale, lease, or license to the general public. Nowadays, there are thousands of project management software packages available for purchase. By 2024, in the comprehensive market share analysis provided by Datanyze, an investigation is conducted in the global market size of the Project Management industry is 242110 companies. Fig. 2 shows the survey results on market share and usage, where the top 5 PMIS include Jira, Microsoft Project, Kanban, Airtable, and Smartsheet, accounting for 57.92% of the market share, belonging to the COTS components software system[14]. Thus, we chose the tailored models as the baseline to develop our specific model.

As illustrated in Fig. 1, this study identified 14 distinct tailored software quality models to form the basis of the analysis. Each of these models consists of specific metrics, and each ISQM can be used to measure software quality. To identify the most critical metrics for PMIS, the objective was to analyze these frameworks and list the frequency of each quality metric's appearance across the 14 models. In total, 27 distinct metrics can be derived from these models [15].

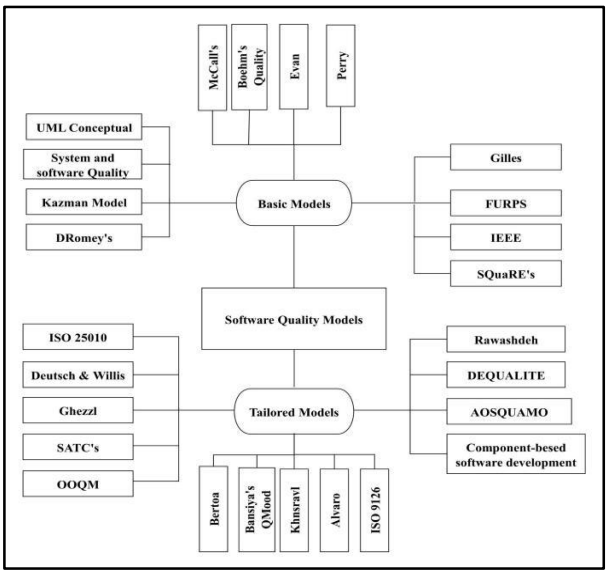

Fig. 1. Two categories of software quality model.

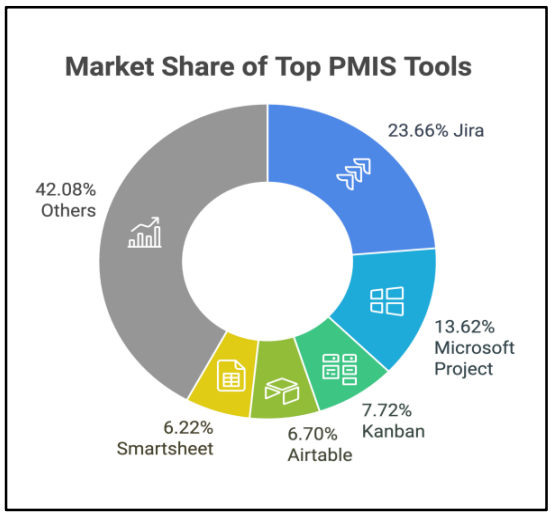

Fig. 2. Market share of top PMIS tools.

Table III provides a detailed mapping of the metrics present in each tailored model, while Fig. 3 visually represents the frequency of these metrics in a bar chart, showing how often each metric is used among the tailored models.

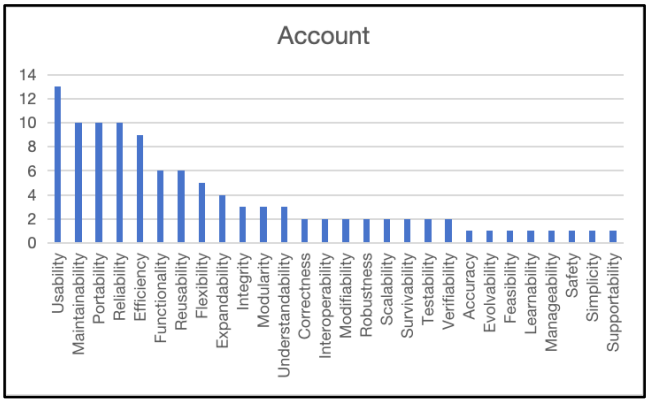

Fig. 3. The metric list ranked by account.

TABLE III THE METRIC OF EACH TAILORED MODEL

Model Name / Metric	a	b	c	d	e	f	g	h	i	j	k	l	m	n	Account
Correctness	✓	✓													2
Efficiency	✓	✓		✓	✓	✓			✓	✓	✓			✓	9
Integrity	✓	✓	✓												3
Reliability	✓	✓	✓	✓	✓	✓			✓	✓	✓			✓	10
Usability	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓		✓	✓	13
Maintainability	✓	✓	✓	✓	✓	✓			✓	✓	✓			✓	10
Flexibility	✓	✓	✓				✓	✓							5
Testability												✓	✓		2
Portability	✓	✓	✓	✓	✓	✓			✓	✓	✓			✓	10
Reusability	✓	✓	✓				✓	✓					✓		6
Functionality				✓			✓			✓			✓	✓	6
Interoperability	✓	✓													2
Verifiability	✓	✓													2
Survivability	✓	✓													2
Expandability	✓	✓					✓						✓		4
Manageability		✓													1
Safety		✓													1
Accuracy			✓												1
Supportability				✓											1
Modifiability							✓						✓		2
Understandability							✓	✓					✓		3
Modularity							✓	✓					✓		3
Robustness								✓					✓		2
Scalability								✓					✓		2
Evolvability										✓					1
Learnability													✓		1
Simplicity													✓		1

(a) ISO 9126. (b) Deutsch & Willis's Model. (c) Ghezzl. (d)SATC's. (e)OOQM.(f)Bertoa(g)Bansiya's QMOOD.(h)Khosravi.(i)Alvaro.(j)ISO 25010.(k)Rawashdeh. (l)Component-based Software development.(m)DEQUALITE.(n)AOSQUAMO.

B. The Intangible Software Quality Metric of Quality Models for PMIS

This section discusses the ISQMs for web-based PMIS and identifies which existing quality metrics are suitable for web-based PMIS. The five papers were selected as the reference to identify suitable ISQMs for web-based PMIS. The papers are selected based on the content that discusses the software quality model, the definition of ISQMs, and the web-based PMIS. Additionally, these papers are selected as the reference as they discuss the quality model and ISQM suitable for developing a web-based PMIS that has good quality. Table IV shows the comparison of the proposed quality metrics for web-based PMIS. Five papers were used as a reference to identify which metrics are commonly used. We filtered the metric that appeared more than twice among the five selected papers. We set the threshold of "more than twice" to ensure the validity and robustness of our selection. Table V presents the selected quality metric and the corresponding account.

According to Fig. 3, the top ten metrics most frequently selected for the tailored models are usability, maintainability, portability, reliability, efficiency, functionality, reusability, flexibility, expandability, and integrity. Compared to Table V, 5 out of the 7 selected metrics belong to the above-mentioned top 10 metrics, which proves that our selection is well-founded.

TABLE IV THE COMPARISON OF THE PROPOSED QUALITY METRICS FOR WEB-BASED PMIS

Metric	P1 [3]	P2 [16]	P3 [17]	P4 [18]	P5 [19]
Correctness	✕	✕	✕	✕	✕
Efficiency	✓	✓	✓	✓	✕
Integrity	✕	✕	✕	✕	✕
Reliability	✓	✓	✓	✓	✓
Usability	✓	✓	✓	✓	✓
Maintainability	✕	✕	✓	✕	✕
Flexibility	✕	✕	✕	✕	✕
Testability	✕	✕	✕	✕	✕
Portability	✓	✕	✓	✕	✕
Reusability	✕	✕	✕	✓	✕
Functionality	✓	✓	✓	✓	✓
Interoperability	✓	✓	✓	✓	✕
Verifiability	✕	✕	✕	✕	✕
Survivability	✕	✕	✕	✕	✕
Expandability	✕	✕	✕	✕	✓
Manageability	✕	✕	✕	✓	✕
Safety	✕	✕	✓	✕	✕
Accuracy	✓	✓	✓	✕	✓
Supportability	✕	✕	✕	✕	✓
Modifiability	✕	✕	✕	✕	✕
Understandability	✕	✕	✕	✕	✕
Modularity	✕	✕	✕	✕	✕
Robustness	✕	✕	✕	✕	✕
Scalability	✕	✕	✕	✓	✕
Evolvability	✕	✓	✕	✕	✕
Learnability	✓	✕	✕	✕	✕
Simplicity	✕	✕	✕	✕	✕

TABLE V THE ACCOUNT OF THE SELECTED ISQM

No.	Selected ISQM	Account
1	Reliability	5
2	Usability	5
3	Functionality	5
4	Efficiency	4
5	Interoperability	4
6	Accuracy	4
7	Portability	2

C. The Attributes of Selected ISQM for Web-based PMIS

Up to now, we have integrated 7 ISQM that can be used for web-based PMIS, including reliability, usability, functionality, efficiency, interoperability, accuracy, and portability. Each ISQM has different attributes to measure the software. Table VI shows the attributes of each ISQM and their related tailored models.

TABLE VI THE ATTRIBUTE OF THE METRIC AND ITS RELATED TAILORED MODELS

Metric	Attribute	Related Models
Reliability	Robustness	SATC's;OOQM
	Resilience	ISO 9126
	Fault Tolerance	Ghezzi;ISO 9126
Usability	Learnability	Bansiya's QMOOD
	Satisfaction	SATC's;AOSQUAMO
	Aesthetic Design	Khosravi;DEQUALITE
Functionality	Suitability	SATC's;ISO 25010
	Completeness	DEQUALITE;SATC's
	Appropriateness	SATC's;ISO 25010
Efficiency	Perceived Speed	Bertoa;Alvaro
	Effort Minimization	SATC's;AOSQUAMO
	Optimization Awareness	OOQM;ISO 9126
Interoperability	Ease of Integration	ISO 9126
	Compatibility Perception	ISO 9126
	Cooperation	Deutsch;ISO 9126
Accuracy	Correctness Perception	Ghezzl
	Precision in Context	Ghezzl
	Trustworthiness	Ghezzl
Portability	Ease of Adaptation	Bertoa;ISO 9126
	Flexibility of Deployment	SATC's;Alvaro
	Installation Simplicity	OOQM;ISO 9126

D. Software Quality Model for Web-Based PMIS Assessment

So far, by using the qualitative-oriented approach, we have gained effective ISQM and attributes for web-based PMIS quality assessment. It is then that we finalize our web-based PMIS software quality model.

E. Data Collection and Analysis

The purpose of this work is to request the software project manager or the expert in the Software project field to review and evaluate the Web-based Project Management Information System Quality Assessment model. Rate the identified intangible metrics and attributes according to their influence and priority for PMIS. The questionnaire consists of two sections with 27 questions.

The first section collects background information from respondents, including professional certification, gender, age, project management experience, number of managed projects, and email. Table VII outlines the demographic profile of the study's respondents. It categorizes participants based on four key variables:

- Age: Respondents are grouped into three age brackets: 30-34 years and 35 to 39 years.
- Experience in project management: Professional experience is classified into three levels based on duration: 5 to 7 years, 7 to 10 years, and more than 10 years.
- Number of Software Projects Managed: This variable quantifies the volume of project management experience, with categories for 5 to 10 projects, 11 to 20 projects, and more than 20 projects managed.
- Workplace: The geographical location of the respondents' work is categorized as Malaysia, China, or Others.

TABLE VII THE RESPONDENTS' BACKGROUND INFORMATION

Demographic Variable	Category	n	%
Workplace	Malaysia	2	18%
	China	8	73%
	Others	1	9%
Certification	PMP	10	91%
	Others	1	9%
Age	30-34 Years	9	82%
	35-39 Years	2	18%
Experience in project management	5-7 Years	8	73%
	7-10 Years	2	18%
	More than 10 years	1	9%
Number of Software Projects Managed	5-10	3	27%
	11-20	6	55%
	More than 20	2	18%

The second section of the questionnaire was designed to assess the 7 major quality metrics and their 21 associated attributes, which were rated by respondents based on their priority and influence using a five-point Likert scale. The survey was conducted with 11 project managers from various countries.

Table VIII presents the aggregated results from the survey, providing the average "Priority" and "Influence" scores for each of the 7 quality metrics and their 21 corresponding attributes. These scores serve as the empirical data used to calculate the weights for the final quality model, ensuring it is based on the real-world perspectives of experienced practitioners.

TABLE VIII THE SURVEY RESULT

Metric	Priority	Influence	Attributes	Priority	Influence
Reliability	4.45	4.55	Robustness	4.45	4.36
			Resilience	4.27	4.09
			Fault Tolerance	4.27	4.09
Usability	3.91	4.09	Learnability	3.91	3.91
			Satisfaction	4	4
			Aesthetic Design	3.45	3.18
Functionality	4.09	4.27	Suitability	4.64	4.64
			Completeness	3.73	4
			Appropriateness	4.18	3.19
Interoperability	3.27	3.36	Ease of Integration	3.36	3.36
			Compatibility Perception	3.18	3.27
			Cooperation	3.18	3.36
Accuracy	4.64	4.55	Correctness	4.64	4.36
			Precision in Context	4.18	4.36
			Trustworthiness	4.45	4.36
Portability	2.91	3.45	Ease of Adaptation	2.64	3.18
			Flexibility of Deployment	3	3.45
			Installation Simplicity	2.82	3.09
Efficiency	3.73	3.64	Perceived Speed	3.91	3.91
			Effort Minimization	3.45	3.82
			Optimization Awareness	3.18	3.27

VIII. RESULTS AND DISCUSSION

A. Results

This study proposed a tailored quality evaluation model for Web-based PMIS by identifying and structuring key ISQM. Through a comprehensive qualitative analysis of 14 existing software quality models and empirical validation via expert surveys, seven critical metrics: reliability, usability, functionality, efficiency, interoperability, accuracy, and portability, were selected. A quantifiable assessment framework was then constructed by breaking down each metric into specific attributes and applying weights derived from practitioner-assigned priority and influence scores.

The primary result of this research is a quantifiable and customizable quality model for Web-based PMIS, developed by aggregating survey scores through a dual-layered formula. The final weighted model is visualized in Fig. 4.

The result of the survey shows that the top three metrics by weight were accuracy (19.30%), reliability (18.51%), and functionality (15.95%). Notably, accuracy and reliability emerged as the most critical metrics, reflecting the high-stakes environment in which PMIS tools operate. Project managers rely heavily on real-time data, progress tracking, and precise reporting; thus, even minor inaccuracies can have cascading effects on project delivery. Functionality also scored highly, confirming that systems must be aligned with core project management requirements rather than generic software capabilities.

In contrast, portability received the lowest priority and influence scores. This may reflect the current ubiquity of web-based platforms and standardized deployment environments, making portability less of a concern in modern enterprise settings.

A. Discussion

The high scores for accuracy, reliability, and functionality underscore that for project managers, PMIS tools must provide precise, dependable data and align closely with core project management tasks. The reliance on real-time data for tracking and reporting means that even small errors can have significant negative impacts on project outcomes.

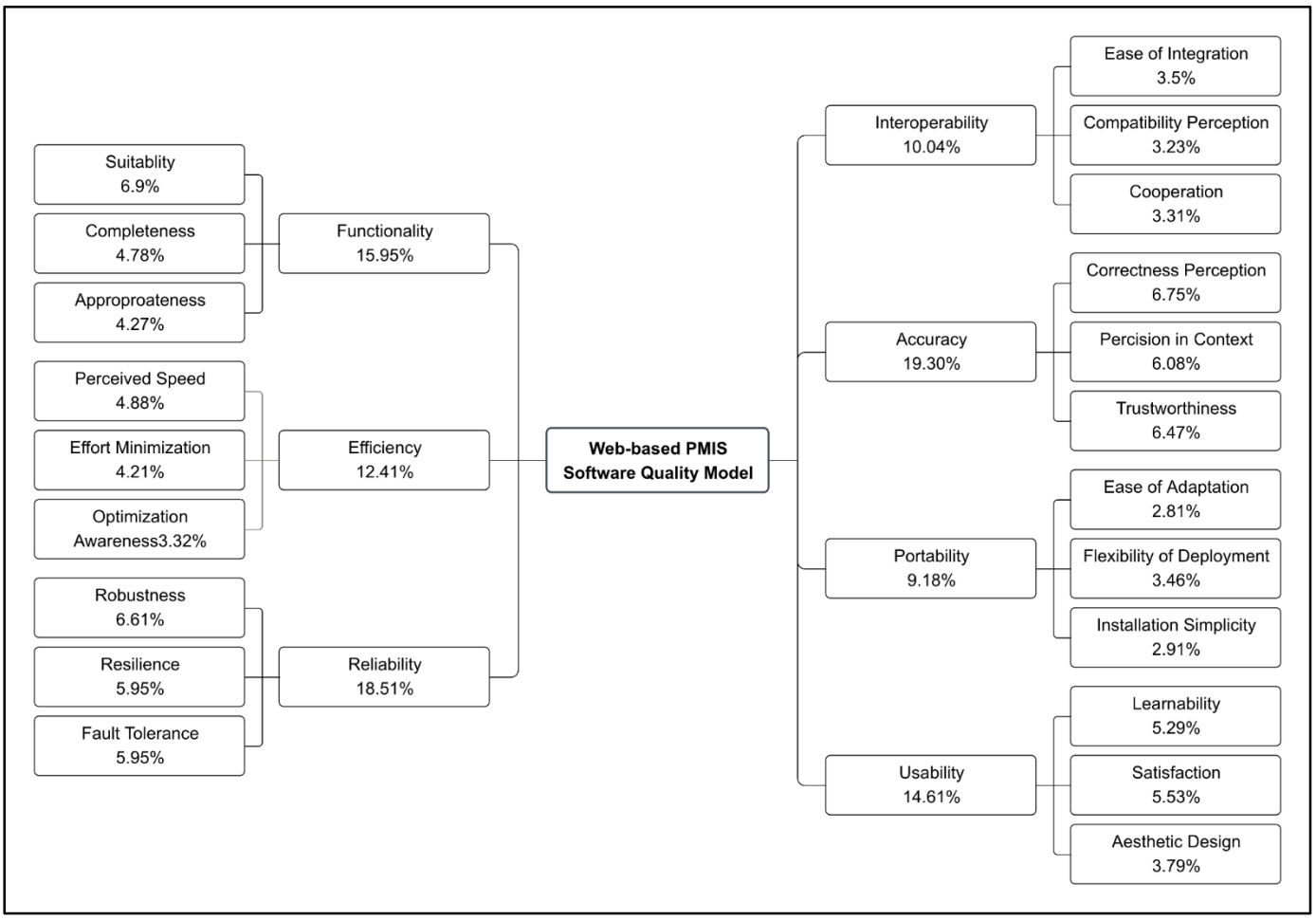

Fig. 4. The result of the software quality model for web-based PMIS.

The model's reliance on expert-derived weighting ensures that it can evolve with practitioner priorities. Organizations can adapt the weights according to their context, allowing for dynamic and scenario-specific PMIS evaluation and selection.

However, this study is not without limitations:

- The generalizability of the results may be affected by the small survey sample size of 11 project managers.
- All participants were primarily from China and Malaysia, potentially limiting the generalizability of the results across different industries and regions.
- The research focused exclusively on Web-based PMIS, excluding other forms such as mobile or hybrid systems that may introduce additional quality considerations.

IX. Conclusion

A. Summary of Research

This research established a specialized software quality model tailored for Web-based PMIS. The study systematically identified effective ISQM by analyzing 14 existing quality models. These metrics were then validated and refined through a survey of 11 project management professionals who rated each metric and its corresponding attributes based on their priority and influence in a project environment. The collected data was used to create a weighted, quantifiable assessment framework. The final model confirms that accuracy, reliability, and functionality are the most vital quality characteristics, offering a practical tool to guide project managers in making informed decisions for PMIS selection.

B. Future Work

To build upon this research, several future directions are recommended:

- The model's robustness and applicability could be enhanced by expanding the survey to a larger and more diverse group of stakeholders, both geographically and professionally.
- A valuable next step would be to integrate this framework into a real-world PMIS selection tool and validate its effect on project success metrics through case studies or longitudinal research.
- Future studies could also investigate dynamic weighting schemes, potentially utilizing machine learning, to enable the model to adapt automatically to an organization's specific context and evolving user priorities.

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