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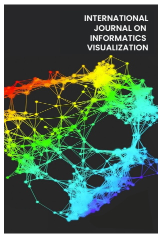

Issues in Chinese Requirements Specifications: Insights from Survey Data and Static Analysis

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***Abstract*—Requirements engineering is crucial for software project success. Issues like requirements ambiguity, inconsistency, and unverifiability contribute to unclear, conflicting, or untestable specifications, which can undermine the effectiveness and success of a software project. These issues have been identified as factors contributing to software project failure. However, there's limited research on the current state of these issues in China. The research objectives of this study are to address the most commonly used methods for expressing Chinese software requirements and uncover issues related to ambiguity, inconsistency, and unverifiability, which can be solved by using artificial intelligence techniques to investigate possible solutions to these problems. An online survey of 422 software professionals in China identifies key issues in Chinese software requirement expressions that AI techniques can address. The study examines various expression methods, tools for enhancing clarity, and challenges specific to Chinese requirements. Findings reveal that ambiguity, inconsistency, and unverifiability significantly impact project success. While natural language specification and prototyping improve clarity, they may increase the time required for requirements engineering. Effective communication is typically achieved through natural language, prototyping, storyboarding, and pseudo-coding, whereas decision tables and block diagrams are less commonly used and linked to problematic requirements. Using tables, prototype diagrams, and natural language descriptions helps mitigate these issues, though it may extend engineering time. The study suggests strategies to improve the efficiency and quality of requirements expression and highlights the need to develop Chinese boilerplates and refining tools to enhance clarity in the future.**

***Keywords*—Requirements engineering; survey; Chinese software development; requirements specification; artificial intelligence.**

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I. INTRODUCTION

The Chinese software industry has shown substantial growth from 2015 to 2022, with an average annual growth rate exceeding 20%, according to statistics from the Ministry of Industry and Information Technology (MIIT). The Chinese software industry is expected to continue its rapid growth in the foreseeable future [1]. Requirements engineering plays a critical role in ensuring software systems meet user expectations [2], [3] and project success [4]. The qualified requirements should possess the following characteristics: unambiguous, complete, singular, feasible, correct, conforming, necessary, appropriate, consistent, comprehensible, and valid [5]. The factors that can be detected and solved by using artificial intelligence programs include unambiguous(the requirement is stated in such a way so that it can be interpreted in only one way), conforming(the individual items conform to an approved standard template and style for writing requirements, when applicable), consistent(the set of requirements contain unique personal requirements, do not conflict or overlap with other requirements in the set, the units and measurement systems are homogeneous) and validate(the satisfaction of the requirement set will lead to the achievement of the entity needs within constraints).

Numerous studies have highlighted the importance of software requirements, while other countries have surveyed the impact of requirements on software projects. However, only one Chinese journal has addressed this type of investigation [6]. The specific problems in Chinese software requirements expressions, especially those that could be solved through software programs, are unexplored. Therefore, this paper aims to evaluate their impacts on the progress of projects and their relationships with Chinese software requirements expression ways to explore how to express Chinese software requirements clearly. With the rapid advancement of artificial intelligence technology, this study aims to explore the real-world challenges in requirements engineering that can be addressed through AI-based computer programs and identify potential solutions.

Based on data from an online questionnaire completed by 422 Chinese software developers, we have identified and summarized the challenges preset in Chinese software development roles. Additionally, we analyzed the issues that can be addressed using artificial intelligence techniques. We also explored various methods for expressing requirements and examined the tools that can enhance the clarity of Chinese requirements.

This research contributes the following:

- Identify the most commonly used methods for expressing Chinese software requirements.
- Uncover requirements ambiguity, inconsistency, and unverifiability issues and explore their associations with expression ways.
- Investigate the possible ways to solve requirements expression problems.

The paper is structured as follows: Section I discusses related works, followed by Section II, which describes the methodology. Section III describes the results and findings, followed by our conclusion in Section IV. We extensively reviewed reputable sources and identified articles closely aligned with our study. However, the literature reveals that a standardized Chinese requirements boilerplate has not yet been developed.

A. The Global Survey of Software Engineering Practices in Requirements Engineering

Several global studies have examined software engineering practices, providing a context for understanding the challenges in Chinese requirements engineering. Cadavid et al. explored system architecture issues in system-of-systems architecting [7]. Shafqat et al. identified risks and methodologies in requirement gathering [8]. Hidellaarachchi et al. explored how human factors, such as motivation and personality, impact RE activities [9]. Zahrin et al. focused on the challenges in requirements specification in Malaysia, particularly about personnel competencies [4]. Li et al. identified key challenges and solutions in context-aware requirement modeling [10]. Barata et al. surveyed agile RE practices in Brazil, examining the methods and challenges faced [11]. Alves et al. investigated the state of RE in machine learning systems through an international survey. However, China is excluded [12].

B. NLP for Chinese Requirements engineering methods

In recent years, natural language processing (NLP) has made remarkable progress in Chinese software requirements processing, mainly focusing on improving the accuracy and efficiency of language processing tasks. These studies have provided the development foundation of software requirement specification based on NLP technology. Wang et al. improved Few-shot Learning for Chinese text by applying a template selection mechanism, leveraging masked language models to refine template quality [13]. Xu and Wang developed a data-driven model for automated Chinese word segmentation and POS tagging, addressing the challenges in label prediction accuracy for Chinese text [14]. Chai and Wang introduced a method that fuses word and character features using a FLAT network, effectively preserving the location information of input tokens to enhance model performance [15]. Zhu et al. proposed a method using K-Means clustering based on TF-IDF to analyze Chinese software requirements documents, successfully extracting functional points from the text [16]. Finally, Wang et al. tackled the challenge of grammar correction in high-error density situations, focusing on the specific characteristics of Chinese grammar error correction (CGEC) tasks [17].

II. MATERIALS AND METHOD

We have employed the online survey used in [18]. The survey was conducted using a structured approach over 11 weeks, as shown in Fig. 1. The process began with the questionnaire's design, which took one week, followed by the selection of respondents during the second week. A pre-test was conducted in the third week to ensure the questionnaire's validity and reliability.

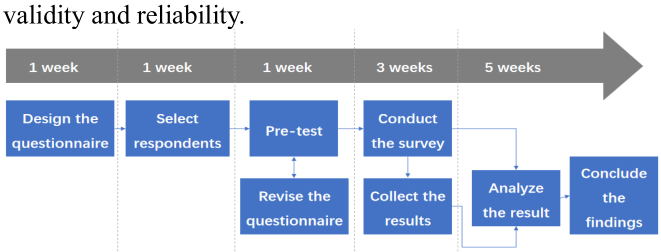

Fig. 1 The milestones and planned durations of this study

During this period, the questionnaire was revised. The questionnaire was conducted for three weeks, during which data was collected. Subsequently, the survey results were analyzed for five weeks, leading to the final step of concluding the findings. This systematic approach ensured a comprehensive examination of the research questions, with sufficient time allocated to each study phase.

C. Design the Questionnaire

The author revised the survey questions based on "Issues in Requirements Specification in Malaysian Public Sector: An Evidence from a Semi-Structured Survey and a Static Analysis" [4]. Table I presents the relations between the objectives and the questions.

TABLE I
THE RELATIONSHIP BETWEEN OBJECTIVES AND QUESTIONS

Objectives	Questions
Identify the background information of the questionee to guarantee the validity of the questionnaire.	● Your current job positions?
	● What is the domain of your job?
	● What is the nature of your company?
	● What is the name of your company?
	● How many years have you worked in the fields of software engineering, computer science, or software development?
	● How many software development projects have you worked on?
Identify the most commonly used methods for expressing Chinese software requirements.	● What is your requirements for expression language?
	● How do you represent requirements in your descriptions?
Uncover requirements ambiguity, inconsistency, and unverifiability issues, and explore their associations with	● How often do ambiguous requirements occur?
	● How often do inconsistent requirements occur?
	● How often are unverifiable

Objectives	Questions
expression ways.	requirements encountered?
	● How do you represent requirements in your descriptions?
Investigate the possible ways to solve requirements expression problems.	● How can we enhance the clarity of Chinese requirements?
	● Are tools or boilerplates available to standardize Chinese software requirements and specifications?

The survey includes demographic questions (to identify respondents), substantive questions (related to research objectives), and sensitive questions (about the personal information of the respondents). Its purpose was to allow participants to choose whether to participate or exit at any time. Participants' data was kept confidential for research only.

D. *Select Respondents*

The study targeted Chinese professionals in Requirements Engineering (RE), Software Engineering (SE), or Computer Science (CS) with RE experience. Purposive sampling was employed by distributing surveys to relevant technical groups, excluding respondents with insufficient experience or limited project involvement. Following guidelines by Petersen [18] and Baltes and Ralph [19], a respondent-to-question ratio of 5-10 was used, requiring a sample size of 80-160 participants for this survey, with 16 questions. The author randomly selected experts from diverse companies for questionnaire distribution to reduce systematic errors.

E. *Pre-test*

A pre-test was conducted to validate the questionnaire's ability to collect targeted information. Researchers may adjust the questionnaire's content based on pre-test feedback and behaviors. Quality evaluation includes a reliability test [20], [21] used to assess consistency and dependability. Empirical validity is tested by comparing it with related questionnaires and expert evaluations. Internal reliability is evaluated using Cronbach's alpha [22], [23], [24], values >= 0.9 indicate excellent consistency. Structural validity is assessed through factor analysis, KMO values > 0.60, and Bartlett's test < 0.05 support data analysis suitability.

F. *Questionnaire Revise*

Based on empirical validity testing, missing questions can be added to the questionnaire; their necessity can be determined by observing alpha value changes upon their removal. The order and expression of questions can be adjusted based on the participant feedback and behaviors from the pre-test. The overall alpha value for each of these questions hasn't changed much after deletion. Therefore, none of these questions should be removed. According to the feedback from the pre-test, the questionnaire is reorganized into demographic, substantive, and sensitive questions.

G. *Conduct the Survey*

The survey was conducted online using a Chinese website called Questionnaire Star (https://www.wjx.cn/), from September 12, 2023, to February 20, 2024, spans approximately five months. The survey link was disseminated across social media platforms such as WeChat, QQ, LinkedIn, and Baidu Post Bar. The questionnaire (in Chinese) is available at https://www.wjx.cn/vm/YrB4ZV3.aspx# and the English version at https://www.wjx.cn/vm/PyF7KYK.aspx#.

H. *Collect the Results*

Out of 521 response sheets, 78 were invalid due to incomplete answers (less than 75% completed), not using Chinese to express requirements, lack of engagement with real software projects, or having less than one year of software requirements experience. The results of the survey are available at https://github.com/jiaying68/Chinese-software -requirements -specification-issues--survey-results.git

I. *Analyze the result*

This study applied data visualization and descriptive analytics techniques, as suggested by Regnell et al. to analyze and synthesize the collected data under the research objectives [25]. The validity of the questionnaire is assessed using a quantitative method, alongside an analysis of participants' identities. How requirements are expressed and their improvement methods were analyzed using quantitative techniques, with the results presented in charts and descriptive explanations. This study also analyzed the impact of different requirements expression methods, including natural language description documents, UML models, tables, block diagrams, story scripts, decision tables, pseudo-codes, and prototype diagrams on software requirements. These impacts are also assessed in terms of the likelihood of encountering inconsistencies, unverifiability, ambiguity, the time spent on requirements and the likelihood of requirements causing project delays, with the findings visualized using radar charts.

J. *Conclude the findings*

The findings and the insights are deliberated in the Results and Discussion section.

III. Results and Discussion

A. *Results*

This section illustrates the quality of the questionnaire, provides an overview of the participants' identities, identifies requirements engineering-related issues that can be addressed through computer programs, and outlines improvement methods. Finally, it identifies the problems in requirements engineering that can be discussed programmatically and their correlations with external factors, including job positions, work fields, and the percentage of time allocated to requirements.

1) The quality of the questionnaire: The questionnaire demonstrated high reliability (Cronbach alpha = 0.747) and structural validity (KMO = 0.794, Bartlett's test significant at <0.001), indicating a robust tool for measuring constructs. The internal reliability and consistency of the questionnaire can be evaluated via Cronbach's alpha according to the Methodology section. The Cronbach's alpha for the Likert scale questions in this questionnaire (422 valid questionnaire answer sheets) is 0.747, indicating a relatively high reliability for measuring the construct. Furthermore, the structural validity of the conceptualization was evaluated through factor analysis, including the KMO value and Bartlett's sphericity test. The KMO value is 0.794, which indicates a reliable correlation matrix for analysis. Bartlett's sphericity test is significant (<0.001), suggesting that factor analysis is suitable, with a moderately strong relationship among variables. After deleting individual items, the alpha values are lower than the original alpha value, suggesting none of these questions should be removed from the questionnaire.

2) Overview of the participants' identities: The study involved 422 participants with a diverse array of organizations, job roles, and levels of work experience across eleven industries, with the majority from private enterprises and department head positions, most having 5-10 years of experience and involvement in over five related projects. The majority of these are experienced experts representing 270 Chinese companies ranging in size from large to small to ensure the survey's representativeness (Table II).

TABLE II
THE OVERVIEW OF THE PARTICIPANTS' IDENTITIES

Respondent's Field of Work		
Option	**Number of respondents**	**Percentage**
Electronic commerce	67	15.88%
Education	65	15.40%
Medical care	51	12.09%
Hardware	49	11.61%
game	40	9.48%
Manufacturing industry	38	9.00%
Network security	33	7.82%
e-government	33	7.82%
communication	19	4.50%
transportation	16	3.79%
Source of energy	11	2.61%
Respondents Organizational Nature		
Option	**Number of respondents**	**Percentage**
Private enterprise	219	51.90%
State-owned enterprise	110	26.07%
Research institution	37	8.77%
Colleges and universities	24	5.69%
other	12	2.84%
Public institution	11	2.61%
Government agency	8	1.90%
(Empty)	1	0.24%
Respondents Job Positions		
Option	**Number of respondents**	**Percentage**
head of the department	113	26.78%
architect	81	19.19%
designer	65	15.40%
product owner	62	14.69%
developer	60	14.22%
general manager	40	9.48%
others	14	3.32%
quality assurance	9	2.13%
technical support	3	0.71%
Respondent's Years of Experience		
Option	**Number of respondents**	**Percentage**
5-10 years	138	32.70%
3-4 years	106	25.12%
1-2 years	77	18.25%
More than 10 years	66	15.64%
Less than a year	35	8.29%
Respondents Number of Projects Undertaken		
Option	**Number of respondents**	**Percentage**
>5	174	41.23%
1~3	146	34.60%
4~5	102	24.17%
none	0	0%

3) Requirements expression ways and improved methods: One of the objectives of this study is to identify the most commonly used methods that Chinese requirements engineers employ to express requirements. Normally, natural language documents, prototypes, story scripts, block diagrams and tables are commonly used to express requirements, the strategies can be used to enhance requirements readability include using simple sentences, shortening sentences and using simple words. Fig. 2 shows the prevalent methods utilized by Chinese engineers to articulate software requirements, including natural language, prototype diagrams, and pseudocodes. Conversely, block diagrams, tables, and decision tables are less frequently employed methods for expressing software requirements.

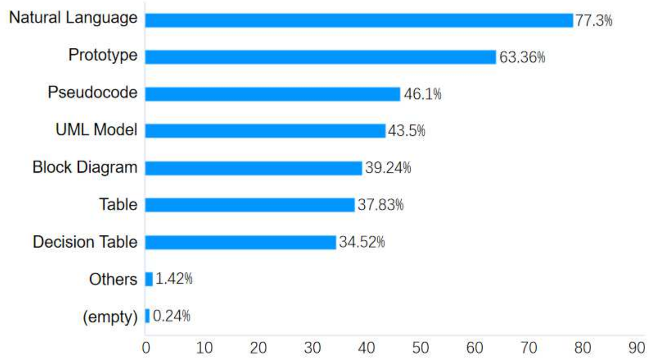

Fig. 2 Requirements expression ways used by requirements engineers

This study not only aims to identify the most commonly used methods for expressing requirements but also seeks to uncover commonly perceived strategies for enhancing the readability of requirements. According to Fig. 3, the largest group of individuals chose to "use simple sentences to express requirements," comprising 352 participants, following closely are the methods of "shorten sentences" and "use simple words," with 232 and 210 respondents, respectively.

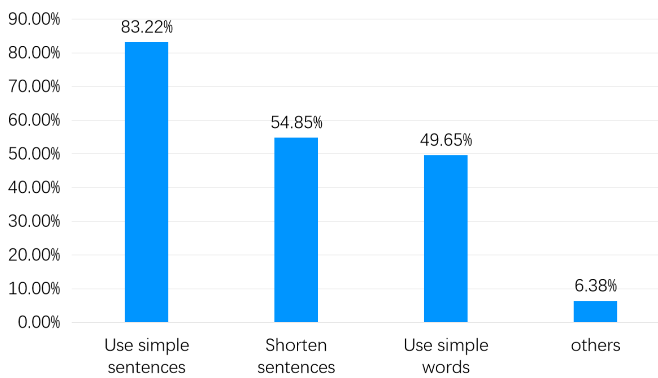

Fig. 3 Strategies for enhancing the readability of requirements

Specifically, because most people use natural language to express software requirements, we conducted a detailed examination of strategies to improve the understandability of requirements expressed in natural language. As shown in Fig. 4, the most frequently recommended strategy is "using simple sentence patterns", followed by "shortening sentences" and "using simple words".

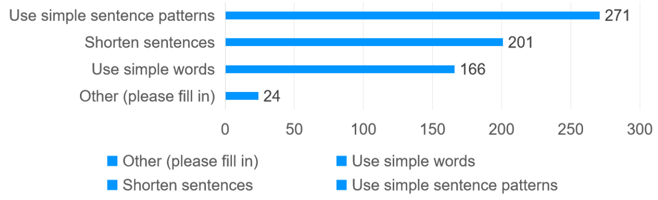

Fig. 4 Methods to improve understandability when using natural language

4) The correlation between requirements expression problems and project delay probability: We have identified a strong correlation between the frequency of encountering ambiguous, inconsistent, or unverifiable requirements and the likelihood of project failure (Fig. 5), underscoring the critical importance of practical requirements engineering. In the "always" facing project failure category, the possibility of encountering ambiguous, inconsistent, and unverifiable requirements is the highest, while it is the lowest in the "seldom" facing project failure category. The findings suggest that the more frequently project members encounter problematic requirements, the more likely projects are to fail. The strong correlation between problematic requirements and project failures underscores the need for rigorous requirements engineering practices. Future research should explore mitigation strategies.

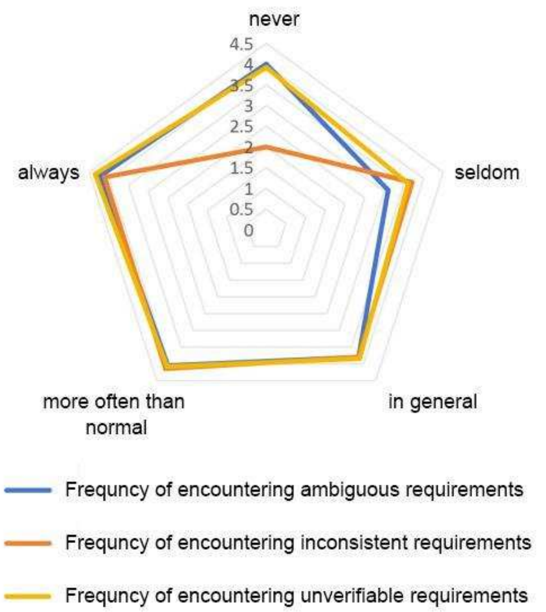

Fig. 5 The relationship between the possibility of encountering problematic requirements and the extent of facing project failure

5) Requirements expression ways and their impacts on software requirements: Choosing appropriate requirements expression methods is crucial for project success. Methods like UML models and decision tables are more prone to issues, while natural language documents are more reliable. Among the methods analyzed, UML Models and Decision Tables are most prone to ambiguity, while Tables and Natural Language specifications are the least. Decision Tables and Pseudo-codes are most likely to lead to inconsistency, with Tables and Prototype Diagrams being the least likely. In terms of unverifiability, Decision Tables and Pseudocodes are the most problematic, whereas Tables and Prototype Diagrams are the least. Tables and Prototype Diagrams are the most time-consuming methods, while Decision Tables and Pseudocodes require the least time. Finally, UML Models and Tables are the most likely to cause project delays, while Story Scripts and Natural Language Description Documents are the least likely to do so.

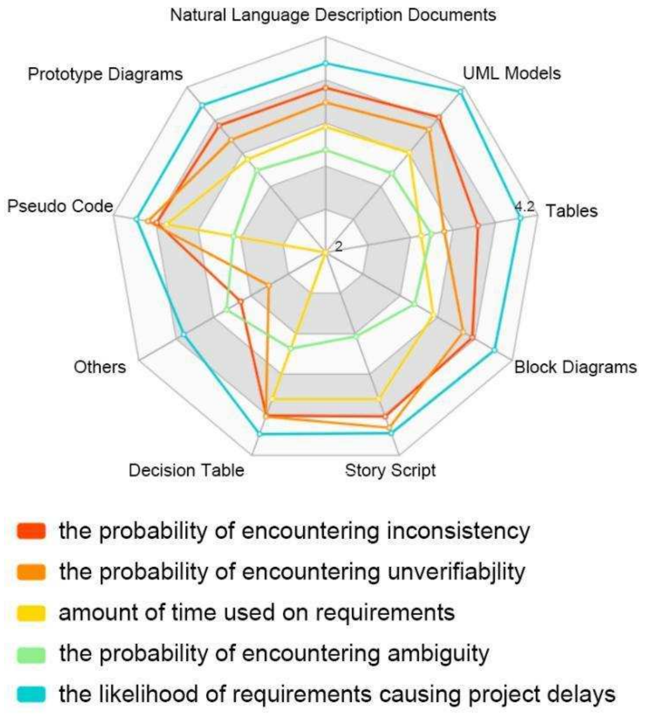

Fig. 6 Requirements expression ways and their impacts on software requirements

B. Discussions

This section below provides a detailed discussion of the findings and explores potential threats to the study's validity.

1) Quality of the Questionnaire: The questionnaire's high reliability and validity support its use in measuring constructs within Chinese companies. Further research is needed to generalize these findings to broader contexts.

2) Overview of the Participants' Identities: The diversity among participants provides a reliable snapshot of industry practices, though underrepresented sectors like Transportation and Energy require more research in future studies.

3) Correlation Between Requirements Expression Problems and Project Delay Probability: The strong correlation between problematic requirements and project failures highlights the necessity for rigorous requirements engineering practices. Future research should explore strategies to mitigate these risks.

4) Impact of Requirements Expression Methods on Software Requirements: The choice of requirements expression methods is crucial for project success. Methods like UML models and decision tables are more prone to issues, while natural language documents are more reliable. Common methods such as natural language and prototypes are effective in communicating requirements. However, simplifying language and incorporating diagrams can reduce ambiguity and enhance readability.

5) Effectiveness of Various Requirements Expression Methods: The survey reveals that the most effective methods for communicating requirements include natural language specifications, prototypes, storyboards, and pseudocodes. Less commonly used methods, such as decision tables, tabulations, and block diagrams, may lead to more issues. For example, using story scripts, pseudo-codes, and decision tables is more likely to result in problematic requirements, whereas employing tables, prototype diagrams, and natural language documents can reduce these risks. However, it's important to note that using tables and prototype diagrams may extend the time required for requirements engineering, potentially leading to project delays, while story scripts, pseudo-codes, and decision tables are less likely to cause such delays.

6) Tools *or Templates for Improving Clarity in Chinese Requirements Expression*s: To tackle the ambiguity problems that exist in Chinese requirements, regulating expressions and structures, using key punctuation marks and contextual limitations, establishing norms, and employing hierarchical structural divisions are practical methods [26], [27], [28], [29], [30]. In addition, practitioners with extensive experience recommend solving these problems through techniques such as shortening sentences, integrating use cases and examples, using pseudocodes, simple language, straightforward sentences, and incorporating diagrams, charts, and industry-specific terminology. Besides, according to "GB/T 9385-2008" [31], a Chinese software requirements description guide, using a requirements specification language is beneficial for describing requirements in natural language. While there are English boilerplates like RUPP [32] and so on, as well as boilerplates in other languages like German [33], IsiZulu [34], Spanish [35], Thai [36], and Turkish [37], but there's no Chinese boilerplate currently exists, as confirmed by the literature review and survey.

C. Threats to Validity

Because of its empirical, internal, and structural validity [20], [21], this research may involve some risks.

1) Empirical validity: The questionnaire participants were found through industry technical forums, professional groups, etc., which makes the results of the questionnaire more representative. In addition, to avoid the measurement tool affecting the reliability of the questionnaire results, we used an online questionnaire to ensure the questionnaire's process is free from any humane and objective interfering factors, which may avoid the experimenter effect.

2) Internal validity: both the control and study groups were eligible for the study. The control group was randomly selected from the experimental group. In addition, the same online questionnaire was used for all participants throughout the survey, avoiding the instrumentation effect, which comes from changing the measurement tool or methodology. Questionnaires with fewer than 75% completed were excluded, avoiding the bias caused by attrition.

3) Structural validity: The pre-questionnaire and the formal questionnaire results are evaluated using factor analysis, including KMO value and Bartlett's sphericity test (illustrated in the Methodology section).

IV. CONCLUSION

This study provides valuable insights into the current challenges and practices of Chinese requirements engineering, particularly emphasizing issues that can be mitigated through AI-based programs. The findings demonstrate that the questionnaire employed in this research possesses high reliability and validity, supporting its application within Chinese companies from various industries.

The results underscore the strong correlation between issues in requirements representation methods and project delays, emphasizing the necessity of adopting rigorous approaches to requirements description. Specifically, methods such as UML models and decision tables were more susceptible to issues like software requirements ambiguity, inconsistency, and unverifiability, which can significantly impact project outcomes. Conversely, natural language descriptions and prototype diagrams were identified as more effective in communicating requirements, although the increased time investment and project delays are their potential disadvantages.

Furthermore, the study highlights the critical role of tools and templates in enhancing the clarity of software requirements in China. To reduce ambiguity, the use of standardized expressions, punctuation, contextual constraints, and hierarchical structures is recommended. Notably, compared with other languages, there are no Chinese-specific requirement specification templates (boilerplate) available. This gap presents a significant opportunity for future research to develop Chinese-based software requirement templates(boilerplate) that could further enhance the accuracy and clarity of software requirement expressions in China.

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