Needs Analysis for Developing a Competency-Based Programming Skill Development System Aligned with International Standards

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Abstract—This research aims to analyze the needs and expectations for developing a programming skill competency development system aligned with international standards for software developers. The study gathers data through questionnaires from 45 developers, including Junior Developers, Senior Developers, and Supervisors, as well as from 11 executives in the software development field. The objective is to collect opinions regarding desired features in the skill development system and the adoption of international standards such as ISO, SEI-CMMI, and OWASP for development and evaluation. The analysis of the questionnaire responses highlights the respondents' emphasis on features such as access to learning materials anytime and anywhere, the ability to create personal projects for hands-on practice, and the use of AI technology for analyzing and recommending skill development. The findings also reveal that executives perceive the adoption of international standards as enhancing efficiency, security, and reducing errors in the development process. These findings underline the opportunity to develop a system that meets the developers' needs and remains competitive in the job market.

Index Terms—Programming Skill Competency Development System, International Standards

I. INTRODUCTION

Developing a system that can enhance the competency and programming skills of personnel in alignment with international standards is crucial in an era where technology is advancing rapidly and becoming increasingly complex [1], [2]. The ability to develop skills and adapt to new technologies has become essential for enhancing personnel capabilities and strengthening an organization's competitiveness [1], [3], [4], [5], [6], [7], [8].

International standards such as ISO/IEC 12207 and ISO/IEC 25010 have been adopted as guidelines in the software development process to ensure efficient and reliable development [9], [10], [11]. In terms of both quality and security, standards related to software measurement, such as ISO/IEC 19761 COSMIC, and process assessment guidelines like ISO/IEC 33001-33099, enable organizations to effectively plan and manage resources while minimizing potential errors in the development process.

Developing a system to support the learning and skill development of software developers that meets the demands of the job market should focus on designing features that enable continuous skill improvement [1], [2], [12], [13], [14]. For example, developing a system that emphasizes access to learning materials anytime and anywhere, as well as creating a personalized learning progress dashboard, can help developers clearly track their progress and growth.

Additionally, support from artificial intelligence (AI) and machine learning technologies plays a crucial role in enabling the system to effectively analyze and recommend improvements in programming skills [12], [15], [16] to provide learners with a tailored and personalized learning experience, the application of critical standards in the development process, such as SEI-CMMI, along with security guidelines based on OWASP and ISO/IEC 27001, enables developers to adapt to the demands and expectations of the industry [17].

This study focuses on analyzing the requirements for a programming skill competency development system aligned with international standards by gathering data from both developers and executives. This approach aims to obtain diverse and comprehensive perspectives on system design, technology utilization, and evaluation.

II. METHODOLOGY

A. Research Design

This research is a survey study utilizing questionnaires as the primary tool for data collection to gather opinions and requirements from respondents, including software developers and executives involved in software development within organizations.

B. Population and Sample

The population consists of two main groups: software developers (Junior Developers, Senior Developers, and Supervisors), totaling 45 individuals, and executives and policymakers in organizational software development, totaling 11 individuals.

Sample Group**:** The sample was selected using purposive sampling to ensure respondents with relevant knowledge and direct experience in the software development field. Among the 45 developers, there are 30 Junior Developers, 10 Senior Developers, and 5 Supervisors. This approach facilitates a clear analysis of the differences and specific needs of each role.

C. Research instruments

The questionnaire used in this research is divided into three

main sections:

- Demographic Information Includes details such as job position, age, and work experience to facilitate demographic analysis.
- Expectations and Requirements for a Programming Skill Development System Based on International Standards consists of multiple-choice questions designed to gather respondents' opinions and expectations regarding the system.
- Awareness and Opinions on International Standards in Software Development focuses on analyzing respondents' attitudes and the perceived benefits of adopting these standards in the development process.

D. Data collection

Data collection was conducted by distributing the questionnaire to the sample group through online channels, such as email or online survey platforms. The purpose and objectives of the research were clearly communicated to the participants to ensure they understood the study and responded to the questionnaire with intent and focus.

E. Data Analysis

Data analysis employed descriptive analysis, utilizing appropriate descriptive statistics such as percentages and frequencies to summarize responses in tabular form. This approach highlights the needs and expectations of respondents for each question. Additionally, the frequency of the most commonly selected answers for each question was analyzed to identify the features and standards deemed most important by respondents for programming skill development.

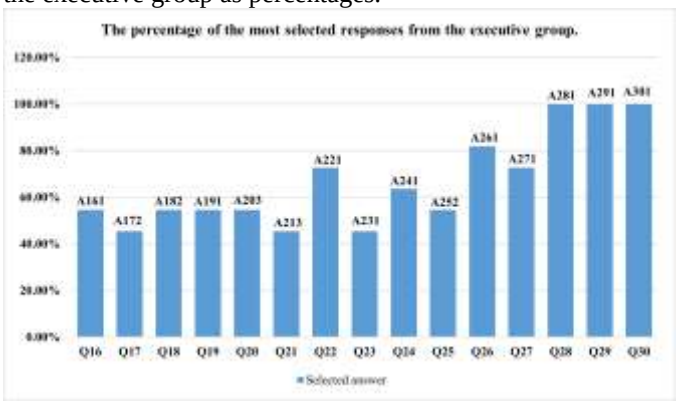
III. RESULTS

Graph 1 shows a comparison of the most selected options by software developers as percentages.

From Graph 1, it is evident that designing a programming skill development system aligned with international standards should primarily focus on providing access to learning materials anytime and anywhere (44.44%), allowing learners to study flexibly. The second most important feature is the ability to create personal projects for hands-on practice (36.36%), followed by automated code reviews based on defined standards (32.73%), which helps learners develop programming skills in line with international standards.

Additionally, incorporating artificial intelligence (AI) and machine learning (ML) technologies (51.85%) is an effective approach for analyzing and recommending skill improvements for learners. Customizing the curriculum according to learners' skill levels (54.35%) is another key feature of the system, ensuring that learning meets individual needs. Furthermore, a personalized learning progress dashboard (36.00%) is an essential tool for tracking learners' progress clearly and effectively.

Graph 2 shows a comparison of the most selected options by the executive group as percentages.



From Graph 2, the most essential skill software developers should possess to meet the current demands of the job market is the ability to quickly learn and adapt to new technologies (47.83%), which ranks as the top priority. This is followed by effective time management skills (34.78%) and writing efficient and error-free code (17.39%).

Employers also expect developers to have capabilities in developing cross-platform web applications and AI-powered systems at a comparable level (43.48%). Meanwhile, DevOps management skills are less emphasized (13.04%).

In terms of problem-solving, developers should be able to resolve issues quickly and effectively (54.17%), which is the most critical expectation in the job market. Additionally, an understanding of software security standards (41.86%) and data management standards (32.56%) is necessary for developing software that meets industry requirements.

Additional skills to address changing demands include learning and adopting trending technologies (39.13%) and quickly acquiring new programming languages (30.43%). These abilities enable developers to adapt effectively in a rapidly evolving job market.

Table 1 summarizes the information for evaluating the suitability of tools used in developing a programming skill competency development system that supports international standards.

Evaluation	Level of Suitability		
	$\bar{X}$	S.D.	Result
1. In terms of research objectives, the study analyzes the requirements for developing a programming skill competency development system that supports international standards.			
1.1 Design and develop a system capable of enhancing programming skills in accordance with international standards.	4.33	0.5	High
1.2 Explore the needs and expectations of the job market and industry sectors.	4.78	0.44	Highest
1.3 Identify and analyze international	4.56	0.73	Highest

Evaluation	Level of Suitability		
	$\bar{X}$	S.D.	Result
standards related to programming skills.			
2. A Programming Skill Competency Development System Supporting International Standards			
2.1 User Management System (A system for managing user information)	4.56	0.50	Highest
2.2 Learning Management System (LMS): A system used to manage, distribute, and track learning content or various courses.	4.56	0.50	Highest
2.3 Learning Pathways and Curriculum Management: A system for managing learning pathways and lessons.	4.44	0.68	High
2.4 E-Learning: A learning process conducted through online systems utilizing technology to support teaching and learning, enabling learners to access education anytime and anywhere.			
2.4.1. Gamification: The integration of game elements into teaching and learning to enhance motivation and create an enjoyable experience for learners.	4.44	0.68	High
2.4.2. Community: In E-Learning, a community helps learners exchange knowledge and build networks with fellow learners.	4.56	0.68	Highest
2.4.3. Simulation: In E-Learning, simulations allow learners to practice skills or engage in virtual activities, enhancing practical learning experiences.	4.78	0.42	Highest
2.5 Assessment and Certification: A system to support evaluation and issuance of certificates.			
2.5.1. Performance Evaluation: The assessment of work performance.	4.33	0.67	High
2.5.2. Activity Tracking: Monitoring and recording activities.	4.22	0.79	High
2.5.3. Notification System: A system for sending alerts and notifications.	4.44	0.83	High
2.5.4. Certification: The process of issuing certificates.	4.89	0.31	Highest
2.6 Content Recommendation Engine: An automated system for recommending up-to-date content.			
2.6.1. User-based Collaborative Filtering	4.67	0.47	Highest
2.6.2. Item-based Collaborative Filtering	4.44	0.68	High
2.6.3. Neural Collaborative Filtering	4.44	0.68	High
2.6.4. Recurrent Neural Networks (RNN)	4.67	0.47	Highest
2.7 Support and Feedback: A system to assist users and provide feedback.			
2.7.1. Sentiment Analysis	4.33	0.47	High
2.7.2. Recommendation System for Solutions	4.67	0.47	Highest
2.7.3. Automated Ticket Classification	4.56	0.50	Highest
2.8 Analytics and Reporting			
2.8.1. Power BI (Microsoft)	4.56	0.68	Highest
2.8.2. Tableau	4.78	0.42	Highest
3. Users			
3.1. Administrator	4.67	0.47	Highest
3.2. Students	4.56	0.50	Highest
3.3. Software Developers	4.67	0.47	Highest
3.4. Instructors	4.56	0.68	Highest
3.5. Executives	4.56	0.68	Highest
3.6. Evaluators	4.33	0.67	High
4. Cloud database	4.89	0.31	Highest

The conclusion of the requirements for the programming skill development system aligned with international standards highlights a focus on skill enhancement and efficiency improvement for both programmers and executives. The primary goal is to develop and enhance work efficiency while increasing competitiveness in the technology market.

Programmers emphasize the importance of flexible access to learning content and the ability to create personal projects for practice. Technologies such as AI and Machine Learning are utilized to customize courses according to individual skill levels. Other critical features include:

- Summarizing learning progress through dashboards.
- Adapting to and learning new technologies.
- Developing cross-platform web applications quickly.
- Ensuring software security standards to reduce errors, enhance efficiency, and ensure safe operations.

Executives prioritize high-level management of learning data, the development of clear and auditable skill development plans, and the customization of content and learning methods to meet learners' specific needs. Their focus also includes:

- Increasing organizational competitiveness.
- Adapting to new technologies.
- Generating real-time performance reports.

Both groups agree that adaptability and improved work efficiency among developers are key to enhancing organizational performance and ensuring quality in software development.

Both programmers and executives believe that adopting international standards and fostering teamwork will:

- Improve operational efficiency.
- Reduce errors.
- Develop organizations with high competitiveness.

From the expert evaluation, the most suitable modules identified are Certification Systems and Cloud-Based Databases, achieving the highest average score ($\bar{X}$ = 4.89). Experts highlighted the significance of certification issuance and efficient data management through cloud systems. Other modules, such as Simulation, Recurrent Neural Networks (RNN), and User Management, also received high scores, reflecting their suitability for skill development and effective system utilization.

IV. Discussion

A. The Effectiveness of Applying International Standards in Skill Development

The data shows that the majority of respondents believe that adopting international standards such as ISO/IEC 12207, ISO/IEC 25010, and SEI-CMMI significantly enhances the efficiency and quality of software development while substantially reducing errors (70.21% - 78.26% among developers). Furthermore, the application of security standards like ISO/IEC 27001 greatly strengthens the security and stability of software programs (79.17%). This indicates that organizations and developers can simplify processes and

improve the efficiency of development workflows by implementing these standards.

B. Support from Artificial Intelligence (AI) and Machine Learning

The data indicates that AI and Machine Learning technologies are utilized in system development at a rate of 51.85% to assist in analyzing and recommending improvements in programming skills. AI and Machine Learning serve as crucial tools capable of real-time assessment of user capabilities. The application of AI not only helps learners develop skills aligned with standards but also increases the potential for developing more accurate recommendation systems (such as Reinforcement Learning and Predictive Analytics) in the future.

C. Features and Capabilities That Promote Effective Learning

The discussion can highlight that the most desired features by users, such as access to learning materials anytime and anywhere (44.44%) and the ability to create personal projects for hands-on practice (36.36%), play a significant role in creating a flexible environment that enhances learning efficiency. Additionally, having a personalized learning progress dashboard helps learners better track their development (36.00%) and increases engagement in the learning process.

D. Preparing to Meet the Demands of the Job Market and Industry

From the analysis of market demands, it was found that developers need to possess the ability to learn and adapt to new technologies quickly (47.83%), a skill highly expected by organizations and employers to enhance competitiveness in the market. This includes developing cross-platform web applications. This adaptability reflects that preparing with skills aligned with international standards can equip learners with the modern and relevant competencies needed to meet current demands.

E. Limitations and Opportunities in Adopting International Standards Systems in Organizations

There may be limitations in terms of costs and the need for organizational adaptation, especially for those that have not previously implemented these standards. Among executives, 27.27% have never adopted such standards. Meanwhile, those who have implemented them reported that the standards provided clear development guidelines (100%). Therefore, promoting the continued use of international standards could enhance developers' capabilities and improve team collaboration efficiency.

V. Conclusion

This study highlights the critical importance of developing a system to support and enhance programming skills in alignment with international standards, as a means to strengthen competencies and improve the efficiency of personnel in the software development field. Data gathered from developers and executives reveal aligned needs and expectations across various aspects, particularly in adopting international standards such as ISO/IEC 12207, SEI-CMMI, and security guidelines (ISO/IEC 27001). These standards contribute to improved software quality, security, and reliability while reducing errors and complexity in the development process.

Key features identified as instrumental in enhancing learning efficiency include access to learning materials anytime and anywhere, the ability to create personal projects for practice, and tracking user progress through dashboards. Additionally, the integration of AI and Machine Learning technologies in the system provides precise and tailored analysis and recommendations for skill improvement, which can be applied to enhance capabilities and competitiveness in the job market and industry.

Thus, developing a programming skill competency system based on international standards has the potential to help organizations adapt to technological changes, minimize errors, and effectively boost personnel performance. Promoting the widespread adoption of these standards is crucial for elevating software development quality and meeting ever-evolving demands.

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