

A Confirmatory Factor Analysis of Competency Model of Software Developers: A Case of INTO Company

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Abstract

This research aims to delineate the competency factors and dimensions of software developers' competency at INTO company, to create a competency model of software developers' competency at INTO company, and to verify the reliability and validity of the competency factors and dimensions in the context of INTO company. The samples in this research were 480 software development employees of INTO company. A questionnaire was used to collect data and test the hypothesis by confirmatory factor analysis. The results affirmed the model's compatibility with the empirical data, evidenced by robust statistical parameter (χ^2 equal to 280.42 and a p-value equal to .000, χ^2/df is equal to 1.650, GFI is equal to 0.96, AGFI is equal to 0.90, CFI is equal to 0.99, NFI is equal to 0.98, RMR is equal to 0.04, and RMSEA is equal to 0.04). The software developers' competency model comprises three main facets: Professional knowledge and skills, interpersonal competence, and personality traits.

Keywords: Competency Model, Software Developers, Confirmatory Factor Analysis, Human Resource Management

JEL Classification Code: M10, M12, M51, M52, M54

1. Introduction

In the later stages of the pandemic, as the global strives to transition from recession to recovery. Human resources have emerged as a vital factor in the core competitiveness and long-term of modern enterprises, but they also promote an enterprise's long-term development as a strategic resource. To take the lead in the new round of business warfare, enterprises must give full play to the "Talent dividend" advantage. The most effective way to obtain the benefits of talent resources is through talent recruitment. Steve Jobs recognized the significance of acquiring creative talent as the cornerstone of his corporate showcase, and he spends a quarter of his working day recruiting. Five recruitment principles are summarized through practice:

firstly, the talents and posts required by enterprises are aligned; secondly, the combination of external and internal recruitment; third, the variety of future development and supply and demand situations; and, fourthly, the importance of maintaining a flexible work environment, talent recruitment and follow-up services; Lastly, talent recruitment should follow internal and external principles, not avoid relatives, and not avoid hatred. It can be seen that recruitment is one of the main ways for enterprises to supplement staff, but also that the strategic management of enterprises is a crucial link (Steinwart & Ziegler, 2014).

During the 1990s, China introduced the concept of competency and its associated model and theories. The adoption of competency-based recruitment method in Chinese enterprises has proven beneficial not only in talent selection,

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but also in predicting employee performance. As a result, this approach has gained popularity and has been extensively explored in practical business and management activities (Wang & Yang, 2012).

This paper focuses on a specific company which serves as the study sample, select its software developers as the object of study. Company INTO is an influential knowledge-intensive high-tech enterprise operating in the software industry. Specifically, it holds significant influence in the field of real-time digital simulation and testing within China's power industry. In the face of intensify market competition becomes more and more intense, the product life cycle becomes shorter and shorter, stabilizing the existing market business status and research and development (R&D) of new products is the main problem and difficulty for enterprises. The impact of software R&D on Company INTO's value chain is of paramount importance and should not be underestimated. As the core competitiveness of the company, software R&D personnel are strategically valued by the company's management.

In July 2022, the personnel department of Company Into received the "Application Form for personnel replacement" from the R&D Department, the recruitment post for software research and development posts, the reason for the replacement is the talent reserve, personnel Department in accordance with the company's traditional recruitment process to start the recruitment of personnel work, about 16 new employees as scheduled.

At the conclusion of the probationary period, the new employee submits their application for evaluation. The head of the software development department and HR form an evaluation team to evaluate the new employee's performance to determine whether he can be successfully promoted with in the company. Based on the evaluation results, the evaluation results for qualified new employees were less than 15%, the evaluation results for excellent new employees were 25%, and the evaluation results for unqualified new employees were 60%. During the probation period, the new employees' satisfaction with the enterprise was investigated, and the new employees' satisfaction rate was only 42%.

Based on the analysis conducted by company INTO in 2022, the following problems exist in the recruitment of software R&D personnel:

1. Lack of quantitative selection criteria: The INTO company's selection criteria need to be improved. The company pays close attention to the candidates' scientific research and knowledge level. It believes that if you have done it, you can quickly achieve "High performance" as long as you have experience; most of the selection criteria are qualitative rather than quantitative; it does not pay much attention to the competence of candidates; and it does not build software research and development closely related to

the selection criteria.

2. The selection process is simple: company INTO employs two main methods for candidate section "Resume screening" and "Interviews." The former is based on HR's subjective feelings and judges the applicant's educational background, work experience, basic personal information, etc. The latter stage of the assessment process comprises a written test and a secondary interview; the written test is to determine whether the candidate has mastered the professional knowledge and skills; the second interview is primarily conducted by the head of the R&D Department and HR, based on their own experiences and understanding of the process. The selection criteria for both approaches are derived from job descriptions. HR compiles the qualifications for software R&D positions by analyzing the information given by the head of R&D and their understanding. The qualification standard for the software development position at Company Into is both common and flexible. It is revised repeatedly after many trials and errors in practical application. In essence, the heads of software R&D departments develop hiring criteria and job requirements for software R&D positions based on their extensive experience and the need for a more scientific foundation. Such operations can exacerbate the challenge faced by the human resources department difficulties and result in the unnecessary expenditure of company resources.

3. The software R&D personnel and the job matching degree is low: The enterprise's current talent recruitment system and actual post-demand and strategic goal match degrees are standard. When an employee leaves, it causes the remote workforce cost to increase, which not only raises the recruitment cost and the total workforce cost but also reduces the enterprise profit, which could be more conducive to the sustainable and sound development of INTO company.

Therefore, it is crucial to establish the recruitment system that is built upon the competency model of software R&D personnel. To achieve long-term development, enterprises must prioritize the selection of software developers who are suitable for their own corporate culture and corporate orientation to make full use of the competency model, apply it to human resource management, and identify the motivation of different people as well as their traits, skills, and abilities. Therefore, it is crucial to conduct a comprehensive study on the competency elements and models of the R&D personnel that are suitable for Company INTO's unique corporate culture and strategic planning.

2. Research objective

1. To explore the competency factors and dimensions of software developers' competency of Company INTO.
2. To establish a competency model of software developers' competency at INTO company.

3. To verify the reliability and validity of the competency factors and dimensions in the context of company INTO.

3. Literature review

In the late 1960s, the State Department recognized the need for an effective system to predict actual job performance. Harvard professor McClelland and his team were invited to design the study. McClelland and his team emphasize the need to get down to brass tacks, starting with the diplomats' first-hand accounts and dividing them into high performers and low performers by Job Performance, then exploring “Those personal conditions and behavioural characteristics that can affect job performance”. Then, in 1973, he published “Measuring Competence rather than Intelligence” in the “Psychologist” magazine (McClelland, 1973), proposing the concept of competence, and marking the birth of competence theory, at the same time, it establishes the key theory and technology of competence research.

Competence, being a prominent area of interest in management and psychology, competence has attracted a growing number of sustained and in-depth research by scholars from the East and the West, who interpret and define the term “Competence” as shown in Table 1 below:

Table 1: East-west representative scholars and research on the definition of team competence

No.	On behalf of the scholars and their teams (Time)	Definition of competence
1	American Management Association (1970)	Knowledge, motivation, characteristics, image, social role, and skills are related to achieving good performance in a job.
2	McClelland (1973)	The underlying characteristics of an individual distinguish between levels of performance in a particular job, role, or situation.
3	Dreyfus and Dreyfus (1980)	A person has inherent basic characteristics that enable him to do his work effectively or well.
4	Boyatzis (1982)	A person with individual latent traits (such as motivation, traits, knowledge, skills, self-image or social role) can successfully express a certain life role.
5	Spencer and Spencer (1993)	Some of the underlying, deep and enduring personal traits of personality can predict and distinguish between good behaviour and performance in a given situation or task.

No.	On behalf of the scholars and their teams (Time)	Definition of competence
6	Bailey (1996)	Much of a person's job performance is influenced by some measurable and acquired knowledge, skills, and attitudes.
7	Raven and Stephenson (2001)	Any motivation, attitude, skill, knowledge, behaviour, or personal characteristic that distinguishes the average performer from the high performer.
8	Wang and Chen (2002)	Managerial competence leads to high management performance. Managerial competence refers to knowledge, skills, ability, values, personality, motivation and other characteristics.
9	An (2003)	According to the job requirement, it is the individual characteristics that can distinguish excellent performance from general performance, such as motivation, trait, self-image, attitude or values, knowledge of a certain field, cognitive or behavioural skills, etc.
10	Zhang and Xaio (2004)	Objective measurable behavioural characteristics of high performers in a given job, organizational environment, and culture.
11	Shi et al. (2002).	A potentially persistent behavioural trait that distinguishes the top performers from the bottom performers in an organization, culture, or job.
12	Zhao and Juan (2007)	A series of substances possessed by individuals that contribute significantly to job performance.
13	Xiao (2009)	Competence refers to the potential and apparent individual characteristics of high performers in a specific job, organizational environment and cultural atmosphere.

As evident from the aforementioned table, the study of competence theory organized started in Europe, subsequently, expanded to the study of competence-related theory commenced slightly later in China (Xiao, 2009) Upon examining the above definitions, there are some common features in scholars' cognition of “Competence”: knowledge, skill, self-concept, trait and motivation are personal potential traits or behaviours; “Competence” varies from situation to situation, it is dynamic and work-related; “Competence” is the reference standard of job performance. (Liang, 2019)

To sum up, “Competency” refers to the measurable or

exploitable personal potential of high performers within a specific job/organizational environment/culture, knowledge, skills, perceptions, motivations, traits, self-image, attitudes, or values. Competence exhibits the following attributes:

First, the individual characteristics that clearly distinguish the high-achievers from ordinary individual encompass not only the required level of abilities for the job requirements but also the behaviour exhibited by employees in their individual work.

Second, competence is closely tied to work performance, which can predict the future work performance of employees, but also can lead to the personal characteristics of those who have excellent performance.

Third, competence is dynamic and subject to change based on various factors, including age, working environment, job content and career level of the employee.

Chinese scholars have progressively shifted their research focus from original theoretical research to practical application to verify (Liu & Huang, 2014). A comprehensive review of the application research based on the competency model is shown in Table 2.

Table 2: Summarizes the applied research of Chinese scholars based on the competency model.

No	Team (Time)	Subjects	Research results	Verification direction
1	Hong Kong Management Development Centre (Mid-'90s)	More than 2,000 mid-level executives	The competency model of managers, which contains 11 competency elements, is established.	Development
2	Shi et al. (2002)	Administrative cadres in the communication industry	The competency model of managers in the communication industry is established using behavioural event interviews.	Validate the generic competency model.
3	Wang and Liu (2007)	More than 200 family business successors	The competency model of the successor in a family business is established by questionnaire and interview.	Talent selection and allocation
4	Wang et al. (2013)	Knowledge worker	The competency model of knowledge-based	Training

No	Team (Time)	Subjects	Research results	Verification direction
			employees, including 18 competency indicators, is established.	
5	Liu and Huang (2014)	Multiple competency models developed in China	The competency model of R&D in China is divided into three types: post-based and industry-based key success factors, based on the overall value of the organization and core competencies.	Theoretical Research
6	Guo et al. (2018)	Top Management of an enterprise	Research on the construction of a moral quality model of enterprise top managers.	Quality assessment
7	Yao et al. (2018)	An oil safety technology company staff	The application of the competency model in each link of the recruitment process.	Recruitment
8	Yuan (2019)	Professional and technical personnel of a railway company	Based on the theory of competence and post-matching, the quality competence model is constructed.	Talent selection
9	Zuo (2020)	Grass-roots managers of state-owned enterprises	This paper studies the training needs of grass-roots managers in state-owned enterprises with the method of empirical research.	Training
10	Li et al. (2020)	Positions of an aviation Planning and Design Institute	This paper constructs a post-competency model including 20 competency	Performance management

No	Team (Time)	Subjects	Research results	Verification direction
			traits by using the Likert scale.	

With the advancement of theoretical research, the focus of competency model research is shifting to the specific job in the particular industry. It focuses on verifying its role in human resource management in practice, such as recruitment, training, development, and performance management.

4. Research methodology

The population and sample for this study consisted of 2,317 software development employees at Company INTO. Among the participants, 730 (31.51%) were from the R&D department, 464 in engineering (20.03%), 422 in projects (18.21%), and 200 in engineering (20.03%). There were 341 managers (14.71%), 341 marketing staff (14.71%), and 31.51% R & D staff, by the researcher's knowledge of the finite population. The formula used to calculate the number of samples suitable for this research is the formula of Hair et al. (2010), indicating that the number of samples is suitable and sufficient for the use of structural equation modelling (SEM) and must be defined 20 times per number of observed variables in the model. This research has a total of 30 observed variables, resulting in a total of 600 samples. But when collecting data, it was found that there were 480 complete questionnaires, representing 80 percent, which was more than 70 percent, so it was considered suitable and sufficient for data analysis and using the convenience sampling method.

The research instrument utilized in this study was a questionnaire designed by the researcher studied based on the concept of related theories determined by the study's objectives. The study's conceptual framework was to define the operational definition, create a questionnaire according to the given definitions of terms, and propose it to the advisor for approval and suggestions on improving the deficiencies. It is more complete and is divided into two parts: Part A of the questionnaire in this study focuses on collecting demographic information about the of employees, which are selected through a checklist and include gender, age, education level, and other issues. Part B of the questionnaire assesses the competency level of R&D personnel using five rating scales.

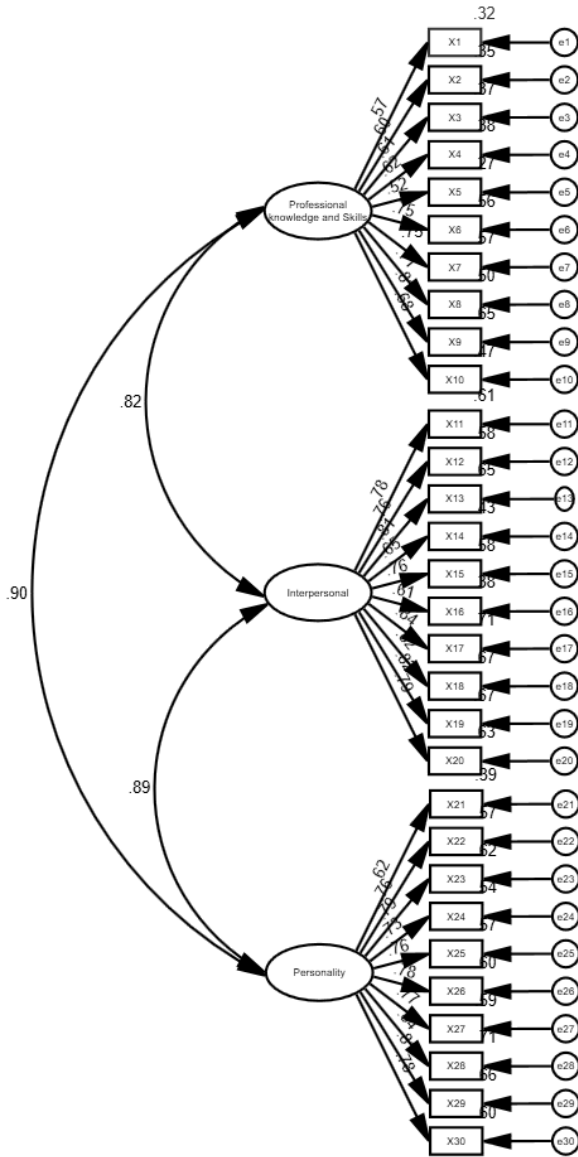
The data analysis in this research incorporates various statistical measures, including frequency, percentage, mean, and standard deviation. Additionally, to test the research hypothesis a confirmatory factor analysis is conducted on the elements of the competency model of software developers.

5. Result

The results of the general analysis of the respondents. In conclusion, the majority of respondents were male (79.58%), aged 25 to 30 years (including 30 years) (49.17%), had a master's degree (41.04%), and had 5 to 10 years of work experience (including 10 years) (35.83%).

Table 3: Shows the averages and the standard deviation of the competency of the software development employees of INTO Company.

Competency factors	Mean	SD
1. Professional knowledge	3.84	1.13
2. Try New things	3.65	1.17
3. Learning efficiency	3.81	1.00
4. Apply what you learn	3.99	0.94
5. Explore the root cause of the problem	4.00	0.85
6. Data Analysis	3.86	0.87
7. Goal Awareness	3.77	0.97
8. Goal Setting and resolution	3.85	0.98
9. Innovation	3.79	1.05
10. Flexibility in problem-solving	4.06	0.97
11. Cooperation and support	3.99	0.99
12. Team Spirit	3.67	1.12
13. Active participation	3.78	1.13
14. Obey	3.39	1.17
15. Communicate effectively	3.67	1.08
16. His Credibility	3.67	1.04
17. Nurture others	3.68	1.10
18. Recognize job responsibilities	3.95	1.01
19. Pay attention to norms	3.87	1.05
20. Pay attention to the details	3.95	0.95
21. Self-discipline	3.88	1.07
22. Time Management	4.01	0.84
23. Responsibility	3.65	0.98
24. Execution	3.87	0.98
25. Careful thinking	3.82	1.06
26. Be thoughtful	3.72	0.92
27. Enterprising	3.74	0.85
28. Be confident and assertive	3.88	0.92
29. Ability to withstand pressure	3.91	0.88
30. Emotion Management	3.95	0.96



$\chi^2 = 280.42$, $df = 170$, $p\text{-value} = .000$, $\chi^2/df = 1.650$, $GFI = 0.96$, $AGFI = 0.90$, $CFI = 0.99$, $NFI = 0.98$, $RMR = 0.04$, $RMSEA = 0.04$

Figure 1: Hypothesis result after adjusted model

Table 4: Shows the factor loading, average variance extracted, and reliability of the competency factor.

Competency factor	Factor loading	R ²	AVE	CR
Professional knowledge and skills			0.45	0.89
1. Professional knowledge	0.57	0.32		
2. Try New things	0.60	0.36		
3. Learning efficiency	0.61	0.37		
4. Apply what you learn	0.62	0.38		
5. Explore the root cause of the problem	0.52	0.27		
6. Data Analysis	0.75	0.56		
7. Goal Awareness	0.75	0.57		
8. Goal Setting and resolution	0.71	0.50		

Competency factor	Factor loading	R ²	AVE	CR
9. Innovation	0.81	0.65		
10. Flexibility in problem-solving	0.68	0.47		
Interpersonal competence			0.59	0.93
11. Cooperation and support	0.78	0.61		
12. Team Spirit	0.76	0.58		
13. Active participation	0.81	0.65		
14. Obey	0.65	0.43		
15. Communicate effectively	0.76	0.58		
16. His Credibility	0.61	0.37		
17. Nurture others	0.84	0.71		
18. Recognize job responsibilities	0.82	0.67		
19. Pay attention to norms	0.82	0.67		
20. Pay attention to the details	0.79	0.63		
Personality traits			0.59	0.93
21. Self-discipline	0.62	0.39		
22. Time Management	0.76	0.57		
23. Responsibility	0.79	0.62		
24. Execution	0.73	0.54		
25. Careful thinking	0.76	0.57		
26. Be thoughtful	0.78	0.60		
27. Enterprising	0.77	0.59		
28. Be confident and assertive	0.84	0.71		
29. Ability to withstand pressure	0.81	0.66		
30. Emotion Management	0.78	0.60		

From Table 4, it was found that the competency factor had composite reliability (CR) between 0.89 - 0.93, which is more valuable than 0.7, and had an average variance extracted (AVE) equal to 0.45 - 0.59, whereas the criterion is set at 0.5. However, while the elements of professional knowledge and skills may have criteria values but are still considered to be within acceptable criteria. Therefore, the element is deemed reliable.

6. Discussion

From the study, the competency of software development employees of INTO company consists of three main components: professional knowledge and skills, interpersonal competence, and personality traits. Employees in software development must have professional knowledge, a willingness to try new things, a desire to learn efficiency, the capability to apply acquired knowledge, the ability to investigate the root cause of a problem, data analysis skills, goal awareness, goal setting and resolution, a willingness to innovate, and adaptability in problem-solving. This is because professional knowledge and skills in software development are important to the employees in the organization. They must apply their relevant knowledge to create works that employees can use (Jarinto et al., 2019; Wetsanarat, 2021). The study result is consistent with the study done by Patacsil and Tablatin (2017), who explored the importance of soft and hard skills as perceived by IT internship students and the industry. IT students should

know the soft and hard skills required for IT work (Pupapassiri et al., 2022). This study is like that of Isaac et al. (2017), who revealed that the technical performance of employees needs the ability to use the Internet and task-technology fit, which is significant for software development knowledge and skills effectively. Similarly, the study from Van Laar et al. (2017) showed the relationship between 21st-century skills and digital skills, and Alassaf et al. (2020) revealed the impact of open-border organization culture on employees' knowledge, attitudes, and rewards about open innovation.

Additionally, the study highlighted that the competencies of software development employees at INTO company encompassed a range of interpersonal competence, covering cooperation skills and the ability to support each other, work as a team, active participation, the ability to obey, the ability to communicate effectively, credibility, the ability to nurture others, the ability to recognize job responsibilities, the ability to pay attention to norms, and the ability to pay attention to the details (Chantarawong et al., 2022; Meekhanmark & Nasomboon, 2022). This is because working as a software developer cannot be done alone. Collaborating with others people to share ideas and knowledge is a crucial aspect of their work. Indeed, interpersonal competence does not mean only working together; it also means that the employees in the organization must have active participation, the ability to obey, and the ability to communicate effectively. The study is consistent with the study done by Ibraimova et al. (2019), which found that teamwork is crucial within agile project management techniques. Similarly, the study done by Capretz and Ahmed (2018) attempted to indicate the importance of soft skills in terms of interpersonal skills for the work related to software engineering.

Lastly, the study further unveiled that the competencies of software development employees of INTO company could include personality traits covering self-discipline, time management, responsibility, execution, careful thinking, thoughtfulness, enterprising, confidence, assertiveness, the ability to withstand pressure, and emotion management. Software development requires self-discipline, effective time management, a strong sense of responsibility, efficient execution, critical thinking skills, thoughtfulness, an enterprising mindset, confidence, assertiveness, the ability to handle pressure, and effective emotion management. Software development requires self-discipline, time management, responsibility, careful thinking, and thoughtfulness. These characteristics can assist employees in focusing on creating and working in software development so that their work is successful. In addition, confidence, assertiveness, the ability to withstand pressure, and emotion management are also necessary for software development. It is sometimes so stressful that employees

must manage their stress and problems. The study is consistent with Manokha's (2018) finding that self-discipline is important in the digital age. Similarly, Ni (2020) discovered that self-disciplined learning embodies a clear sense of responsibility in the learner when researching the autonomous learning mode in the environment of computer network technology. Another study by Prentice et al. (2020) indicated the significance of emotional intelligence on employee performance. Likewise, the study conducted by Pradhan et al. (2017) emphasized the impertinence of the role of emotional intelligence between organizational learning and adaptive performance within Indian manufacturing industries.

Moreover, the validated competency model for software developers presented in this study holds considerable importance for research into the economic, social policy, and technology-induced benefits of the digital economy. By aligning the skills, knowledge, and abilities of software developers with the demands of the digital era, organizations such as INTO Company can drive economic growth, enhance productivity, and foster innovation and competitiveness in the software development sector. Furthermore, the model promotes fair employment practices, contributes to social cohesion, and offers opportunities for inclusivity and diversity within the workforce. By keeping pace with technological advancements, the competency model ensures that software developers remain at the forefront of technological progress, enabling them to contribute to digital transformation initiatives and enhance technological capabilities. Overall, this research sheds light on the far-reaching implications of competency models in the digital economy, emphasizing the need for further exploration and research in this area.

7. Suggestion

To foster competency in software development within the organization, employees can consider the following suggestions:

1. The organization should build and provide training programs related to professional knowledge and skills for the employees. It should actively promote and encourage employees to have professional knowledge, the behaviour to try new things, the behaviour to learn efficiently, the ability to apply what they learn, the ability to explore the root cause of the problem, data analysis skills, goal awareness, goal setting, and resolution, the behaviour to innovate, and flexibility in problem-solving.
2. The organization should prioritize the development and provision of training programs aimed at cultivating interpersonal competence among employees. These programs should encourage employees to cooperate and

support one another, work as a team, actively participate, obey, communicate effectively, have credibility, nurture others, recognize job responsibilities, and pay attention to norms and details.

3. The organization should prioritize the development and implementation of training programs that foster and promoting the personality traits relevant to software development by focusing on encouraging the employees to have self-discipline, time management, responsibility, execution, careful thinking, thoughtfulness, enterprising, confidence and assertiveness, the ability to withstand pressure, and emotion management.

8. limitations of the study

The author acknowledges the limitation of their knowledge of the author and the lack of a profound understanding of the competency model theory, there are still the following issues that need to be explored and studied in this paper:

1. The sample size of research subjects, the sample size of interview subjects, the number of experts, and the number of questionnaires are limited when the competence traits of software developers in company A are extracted. This leads to a lack of comprehensive extraction of the competency elements of software developers and a lack of wide applicability of the research results.

2. Under the influence of the market economy environment, the competency model has yet to be put into practice in the actual recruitment work, so the final recruitment effect cannot be evaluated for the time being.

3. It needs more practicality because, due to the influence of time, the competency model has yet to be applied to the selection, training, performance evaluation, compensation system, or other management activities. It is a set of scientific and systematic management theories that should not be limited to a single management field.

Through this research, the author has broadened his knowledge of competency and competency model theory to a certain extent and will further study and practice these concepts in the follow-up research.

9. Future research

1. To enhance the comprehensiveness and reliability of the enterprise software R&D personal competency model, it is recommended to expand the questionnaire sample of enterprise software R&D personnel to all levels, try to select objective indicators when selecting criteria, improve the validity and reliability of the factor analysis of the enterprise software R&D personnel competency model, and make the

model verification results more stable and reliable.

2. The competency model possesses the unique capability to mirror the enterprise strategy, values, and cultural background, enabling its application across various modules of enterprise management, such as employee training, performance appraisal, salary incentive, and employee career development planning, which will significantly enhance the practicability of the software R&D personnel competency model.

3. Future research should direct its attention towards two potential areas simplifying complexity and exploring outsourcing options for related work.

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