

Competency Profile for Software Development Team that Support Project Success

Tien Fabrianti Kusumasari^a, Bambang Riyanto Trilaksono^b, Atya Nur Aisha^c, Fitriadi^d

^a Information System, School of Industrial Engineering, Telkom University, Bandung, Indonesia
E-mail: tienkusumasari@telkomuniversity.ac.id

^bElectrical Engineering, School of Electrical Engineering and Informatics, Institut Teknologi Bandung, Bandung, Indonesia
E-mail: briyanto@laskk.ee.itb.ac.id

^cIndustrial Engineering, School of Industrial Engineering, Telkom University, Bandung, Indonesia
E-mail: atyanuraisa@telkomuniversity.ac.id

^dInformatic, School of Electrical Engineering and Informatics, Institut Teknologi Bandung, Bandung, Indonesia
E-mail: Fitriadi@students.itb.ac.id

Abstract—The success of software development depends very much on the competencies possessed by human resources within the development team. These competencies include hard and soft skills. In this study, a team competency model will be proposed, which consists of the minimum competency level for the project manager, analyst, and programmer job roles. The types of competencies that are focused on in this paper consist of soft competencies and hard competencies. The method used to determine the competency model is to use the Focus Discussion Group (FGD) by adopting the Behavior Event Interview (BEI) technique. The result of FGD validates with expert judgments, questionnaires, and team member interviews. This research provides the results of profiling the competency of the software development team on project manager job analysts, analysts, and programmers. This study's competencies profile stated that the average minimum level of soft competency for project managers is 3, 3 for analysts, and 2 for programmers. In comparison, the average minimum level of hard competency for a project manager is 3, analyst 2, and programmer 2. Job Role for project managers requires high enough competence both in terms of technical (hard competency) and soft competency. A job as an Analyst requires a level of soft competence higher than hard competency. At the same time, the job role programmer requires soft and hard competency at a low level, 2. The results of this paper can be useful for the recruitment team to get the right individuals to ensure the success of the project.

Keywords—competencies; competency model; software team competencies; project manager; analyst; programmer.

I. INTRODUCTION

Software development succession is always associated with the performance of the team or human resources that develop the software [1]. The performance of a team can be seen based on several factors, such as communication, competence, team composition, and other factors [1]. The factor of human resources is also one of the things that are the cause of software development failure [2]. In 2007, a study stated that the three main categories of project failures were human factors, communication, and project processes. These factors are factors that influence team performance [3]. In 2015, the Standish group also stated that 7.2% of the success factors of software development projects were competent team members, while 10.65 failure factors for software development projects were caused by a lack of competent resources [4]. Also, Nasir and colleagues

conducted a structured survey of software developers regarding the factors that influenced the success of the project [2]. Seven of the twenty-six lists of influencing factors are factors related to human resources, such as skill and leadership [2].

The results of several studies and surveys that have been explained previously, it can be concluded that humans are one of the essential factors in developing software to achieve success. And the main thing that causes human resources to be one of the critical success factors in software development is the competencies or skills possessed by these human resources.

Individual competencies describe the main capabilities of an organization or team, in addition to describing the nature, skills, and knowledge of individuals or team personnel [5]. In the field of the software development industry finding the right people to collaborate in developing software can have a

good impact on the development of the software. Also, the quality of software depends heavily on the competencies possessed by software developers during the software development process [6].

Most of the research on team performance states that individual competence is one of the main factors affecting team performance [7], [8]. Every factor that affects individual performance will ultimately affect the team's performance. Especially in software development teams, this is due to the nature of user needs for software that cannot be measured with certainty, which results in changes in team performance [9].

Competencies that owned by software developers consist of two categories of competencies, namely soft competence, and hard competence [9]. Previously there have been several studies that analyzed the types of hard competency and soft competencies that must be owned by members of the software development team [10] [5] [11] [12] [13] [15] [9]. Each team member has a different type of competency according to his role in the team [13]. In the research conducted by Brian and colleagues [13], Brian and colleagues have determined the minimum level of hard competency that must be owned by members of the software development team. The job role project manager (PM) in Brian's research requires PM to master all hard competencies with an average of above 4 [13]. However, for soft competencies from several studies related to competency in software development, these studies only analyze the list of soft competencies that must be in the software development team, not specifically discussing the minimum level for each soft competency that must be owned by each member of the development team [15] [9].

Determination of the minimum level of soft competency that must be owned by members of the software development team is essential because two of the three factors causing project failure, according to Richard, are communication and people factors [3] which are part of soft competency [14] [11]. Therefore, in this study, there will be an analysis related to the minimum level of competency that each role must play in each software development for each competency, both soft and hard competency. The roles that will be analyzed include the project manager, programmer, and system analyst. The three roles were chosen because each software development team, both large and small, must have that role in it.

II. MATERIAL AND METHOD

A. *The competencies factor in the software development team*

Competence affects performance in certain positions, group, or functional work [16]. Sparrow performs savings that show that competencies provide many benefits to work results. Such as improving the quality of work, improving the quality of the organization, and improving the performance management process because of better assessment [16].

B. *Competencies factor for project success*

Competencies that owned by individuals describe the capabilities of an organization or team [5]. In the field of the

software development industry finding the right people to collaborate in developing software can have a good impact on the success of software development [6]. Gabriel Kolibacova also conducted research related to the relationship between individual competencies with the team and performance using interviews and analysis, showing that increasing individual competencies can improve team competency and even improve company performance [17].

Some factors can affect team performance and the success of software development projects. Nasir and colleagues [2] conducted comparative studies related to the factors that influence the success of software development projects. These factors are grouped into three, namely people-related factors, Process-related factors, and Technical-related factors [2]. Factors related to humans are factors that have a significant value on project success [2]. People-related factors include practical project management skills, skilled and sufficient staff, good leadership, committed and motivated teams, and good performances [2]. These factors show that human factors are essential in software development, and the critical point that makes human factors a factor that influences project success is the competencies or skills possessed by these human resources.

C. *Competencies Model for Software Engineer*

Rivera-Ibarra presents a competency framework for identifying the training needed and designing planning development capabilities for software engineers [18]. The concept of competency used is an integration of functional and behavioral approaches, where competency consists of knowledge (one's understanding of the technical information needed to perform job functions), abilities (cognitive factors that describe the ability to use knowledge effectively) and behavior (attitude showed as a reaction to an object and determine the way of action of the reaction) [18].

This framework [18] provides important competencies for roles in software engineers such as project managers, analysts, software designers, programmers etc. The competency level is presented by sorting it into two levels of the hierarchy. The first level, competency is divided into three types, namely (1) technical competence (technical knowledge and use of technology); (2) social competence (interpersonal relations, cooperation in teams, handling and resolving conflicts); (3) personal competence (personal development, strengths and weaknesses or limitations) [18]. The second level, each type of competency, is divided into several sub-groups. The framework also presents the level of each competency needed by each role. This role can be used as a guide but can be adjusted or adapted according to the needs of the organization [18].

Brian R. von Kinsky [13] evaluates skill level with the Skill Framework for the Information Age (SFIA) in managing and developing software. Careers are junior, senior and software engineer managers having 78 ICT skills but only focusing on high-level skills without specifying technical knowledge or technology used to support the skill [13]. From the results of data processing, it was found that senior software engineering and software development planners needed high responsibility compared to junior software engineers [13]. Whereas software development managers only need a few technical and non-technical skills [13]. The evaluation results of the framework show that

SFIA is an excellent tool for defining capabilities needed by software engineers at various levels of experience, but needs to be equipped with knowledge related to technology or Software Engineering Competency Model [13].

The research conducted by Moustroufas [12] has made a model of competency profiling provide facilities and facilities for ICT companies to produce optimal decisions during recruitment and training for software engineering. The model was built based on the ComProfits standard and the model of R.E. Fairley. This model consists of three concentrations namely (1) professional competences (basic abilities and requires software knowledge), (2) innovative competencies (capabilities needed for development and improvement for both products and software engineers) and (3) social competences (information describing emotional attributes, personality characteristics, cooperation and professionalism) [12].

In evaluating, [12] gives a score from 1 to 5, where 1 is the lowest level, and 5 is the highest level. This score is used to measure the gap between the competencies needed and the scores obtained, and then it can be evaluated more deeply [12]. The modelling results have received a positive response as a model that ensures effective labor management, optimizes the recruitment process, and improves employee competency through evaluation and training [12].

The research method used consists of four stages. The first stage is to determine the case study that will be used to determine the competency profiling for the software development team. The second stage is to determine the competency model for the job role in the software development team. The third stage is to determine the minimum level of competency of the software team. While the last stage is to validate the competency profile, the stages of the research method in this paper are illustrated in Fig. 1.

Case studies are selected from successful projects with short duration (1-3 months), project costs 100-400 million rupiahs, less than ten people, and the project scope is custom software. The project case is chosen with a short duration, which is less than three months because the duration project has a considerable percentage. The number of projects with duration projects is less than three months in micro-scale industries as much as 54.2%, small-scale industries as much as 24.5%, and medium industries at 22.2%. [19]. While the number of project members of less than ten people is the most significant percentage in micro to medium scale industries [19].

The competencies model in this research is based on previous studies [11]. The competency model consists of three main roles, namely, project analyst, programmer, and project manager. The competencies of soft skills that will be explored in this study include Planning and control (SC008), Generating feedback (SC017), Integrity (SC016), willingness to learn (SC004), Critical thinking (SC011), Information seeking (SC003), Trustworthiness (SC005), Time management (SC018), Teamwork (SC013), Mediator (SC009), Analytical skills (SC007), Leadership (SC012), Open communication (SC020), Conflict management (SC019), Team building (SC025), Customer service

orientation (SC035), and Innovation / creative thinking (SC014) [11]. Hard skills competencies which are the main competencies in the development team include Project management (HC001), Software usage tools (HC003), Business analysis (HC008), System design (HC009), User requirements (HC019), System analysis and design (HC020), Product knowledge (HC030), and Technology trend understanding (HC033) [11].

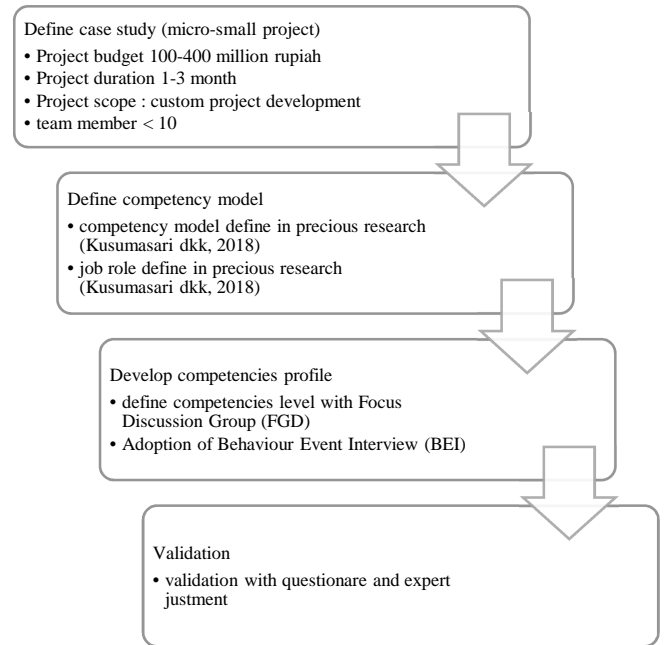


Fig. 1 Research methodology

Determination of team competency level is done by the Focus Group Discussion (FGD) method by adopting the Behavior Event Interview (BEI) method. BEI is an interview technique that will be used to explore the situation and experience of the resource person while doing the project so that it reaches success. The results of the interview analysis will be used to determine the level of ideal competence in a team.

The results of the interview are then determined according to the dictionary of the specified competencies. Validation of the results of determining the competency level is done by distributing questionnaires to the respondents. Gap results of the questionnaire with the results of determining the level of competency from the interview were validated again with online interviews with the speakers and finally validated with expert judgment.

III. RESULTS AND DISCUSSION

The results of this study are in the form of competency profiling for the crucial roles in software project development team, namely project manager, system analysts, and programmers. In this study, we used the list of competency profile based on the previous study in [11]. Twenty-five competency elements classified into two parts, namely soft competencies, and hard competencies. Table 1 shows the main competency description of the software development team.

TABLE I
SOFT AND HARD COMPETENCY DESCRIPTION

Code	Competency Element	Competency Element Definition
SC003	Information seeking	The ability to gather more information in order to support the work done or decide.
SC004	<i>Willingness to learn</i>	The ability to actively learn and develop competitiveness.
SC005	Trustworthiness / Dependability and reliability	Showing behavior that is consistently responsible for fulfilling the beliefs and expectations of others, and fulfilling applicable rules
SC007	Analytical skill	The ability to understand the situation by breaking it down into more detailed parts (factors).
SC008	Planning and control	Ability to identify important parts of work, their relevance, estimation of completion and control of the settlement
SC009	Mediator	The ability to connect the various roles involved includes users, business people, and technology professionals
SC011	Critical thinking	The ability to determine actions after developing various alternative actions based on information on facts and logical assumptions
SC012	Leadership	The ability to take on the role of a leader in order to lead others
SC013	Teamwork (role and contribution)	The ability to work cooperatively with other people, become part of a team, work together.
SC014	Achievement orientation (innovation) / creative thinking	The ability to produce innovations and creative solutions uses creativity to introduce new ideas, processes, and products.
SC016	Integrity	The ability to be honest and consistent in all aspects based on moral values or beliefs held.
SC017	Generating feedback	The ability to get feedback from stakeholders related to the design or requirements of the information system to be built
SC018	Time management	The ability to measure time and resources effectively so that work can be completed efficiently
SC019	Conflict management	The ability to deal with others in contradictory situations, using appropriate interpersonal approaches to reduce pressure and conflict between two or more parties
SC020	Open communication	The ability to deal with others in contradictory situations, using appropriate interpersonal approaches
SC025	Team building	The ability to build a cohesive team and facilitate the achievement of team goals
SC035	Customer service orientation	The ability to understand the needs of others, and to serve others to meet their needs
HC001	Project Management	The ability to plan, organize, and implement a project effectively and efficiently to achieve goals by considering time and cost.
HC003	Software tool usage	The ability to use a set of software tools or build their own tools to get productivity in software engineering jobs
HC008	business analysis	The ability to investigate, analyze, review and document all or part of the business in the form of business functions and business processes, information used, and the data underlying the information
HC009	system design	The ability to determine specifications and designs of information systems to meet business needs in various contexts
HC019	user requirement,	The ability to understand the willingness or expectations of users of the software that will be created or delivered
HC020	system analysis and design,	The ability to analyze complex industrial and business operations to repair and solve problems systematically
HC030	Product knowledge	Know how to design a product from composition to the product manufacturing process.
HC033	Technology trend understanding	Ability to know technological developments and the ability to use new technology in order to increase productivity and minimize costs

From the focus group discussion, we get the information about the level of competency element that needed for each role in the software development team. The list of competency level for each role based on FGD result can be seen in Table 2. Several competencies were not found during the FGD, and this could be due to limitations in the case exploration process that was told. For example, achievement orientation and conflict management were not found during

the FGD because the project case discussed had a clear target framework, and structured division of tasks, so no conflict was found during the execution of the case. Therefore, these two elements of competence are not found in each role in the software development team.

TABLE II
COMPETENCY LEVELS BASED ON FGD

Code	Competency Element	Project Manager	System Analyst	Programmer
SC003	Information seeking		3	1
SC004	Willingness to learn		3	3
SC005	Trustworthiness / Dependability and reliability	3		
SC007	Analytical skill		3	3
SC008	Planning and control	5	3	2
SC009	Mediator	4	3	
SC011	Critical thinking	4	2	1
SC012	Leadership	4	2	
SC013	Teamwork (role and contribution)	4	3	2
SC014	Achievement orientation (innovation) / creative thinking			
SC016	Integrity	2		
SC017	Generating feedback		3	3
SC018	Time management	4	2	2
SC019	Conflict management			
SC020	Open communication	4	3	2
SC025	Team building	5	4	4
SC035	Customer service orientation	3	2	1
HC001	Project Management	3	2	1
HC003	Software tool usage	4	3	3
HC008	business analysis		5	4
HC009	system design		3	3
HC019	user requirement,		2	1
HC020	system analysis and design,		2	2
HC030	Product knowledge		2	1
HC033	Technology trend understanding	2	2	2

To be more certain that the competency element is needed or not, the distribution of questionnaires is carried out to find out the subjective perceptions of the respondents. If there is a difference in the level of competency needed, a competency level is determined by the expert. If the competency is not found in the FGD, while based on the results of the questionnaire it turns out that the competency is considered necessary, then the level of competency follows the results of subjective perceptions on the questionnaire. The following Table 3 is an example of determining the level of competency for a project manager.

TABLE III
EXAMPLE OF COMPETENCY LEVELS DETERMINATION FOR PROJECT MANAGER

Code	Competency Element	Competency Level Identification		Result
		FGD	Questionnaire	
SC005	Trustworthiness / Dependability and reliability	3	3	3
SC007	Analytical skill		2	2
SC008	Planning and control	5	3	3
SC009	Mediator	4	2	3
SC016	Integrity	2	4	3
SC018	Time management	4	3	3
SC020	Open communication	4	3	3
SC035	Customer service orientation	3	3	3
HC001	Project Management	3	3	3
HC003	Software tool usage	4	4	4
HC008	business analysis		4	4
HC033	Technology trend understanding	2	2	2

Based on Table 2, that there are differences in perceptions in the assessment of competency level needs for project managers. This can occur because in the cases used, they have shown a high level of behavior, but when assessed perceptions of behavioral needs in general, indicate the level of average behavioral needs.

After compiling the results of the FGD, questionnaire and expert judgment, the competency profile for a project manager, system analyst and programmer can be obtained. The results of profiling the soft competencies can be seen in Fig. 2, and profiling the hard competencies can be seen in Fig. 3. Soft competencies for project manager role have a higher minimum level, followed by analysts, and finally, programmers.

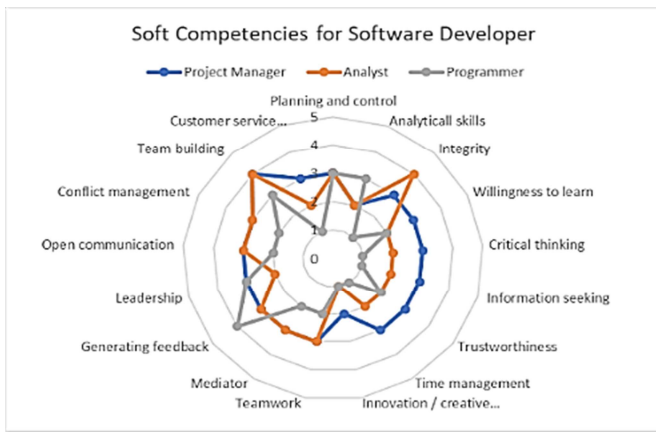


Fig. 2 Soft competencies profile for software developer

The average minimum competency level in soft competency is at level 3 for project managers, while analysts have a minimum level of 3 and programmers at level 2. The highest minimum level of competency is job manager project manager, followed by an analyst, and finally is a programmer. Meanwhile, the average minimum competency level for hard competency is at level 3 for project manager; level 2 for the analyst, and level 2 for the programmer. From this profile, the competency requirement for the project manager is higher than analyst and programmer.

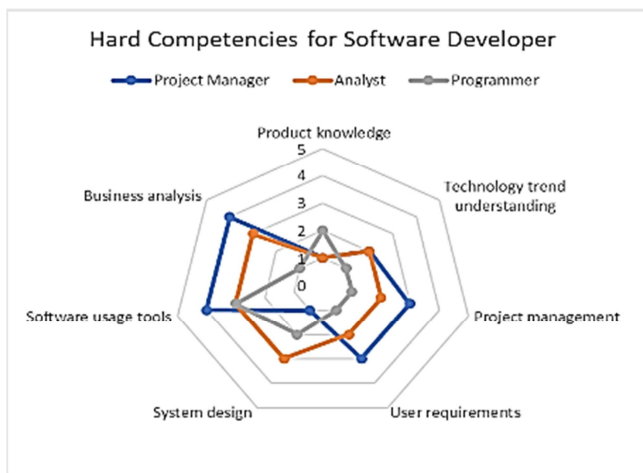


Fig. 3 Hard competencies profile for software developer

Soft competency for project manager job roles on average is at level 3 of 5 levels. Team building competency in a minimum level project manager is 4. Competency in analytical thinking and innovation has the lowest level for project management job roles, that is level 2. Analytical thinking level 2 includes project managers must be able to describe problems, make causal relationships and decisions counter and set priority tasks. Project manager involvement is technically high enough to ensure the success of the project for small or medium-scale projects. The statement of involvement that is quite high in the technical area for small-scale projects is supported by a minimum level of software usage competency, namely at level 4. High hard competency (level 4) in project manager job roles includes business analyst, project management, and user requirements. This states that the project manager must have the ability to be

responsible and determine all decisions so that the project runs following the objectives.

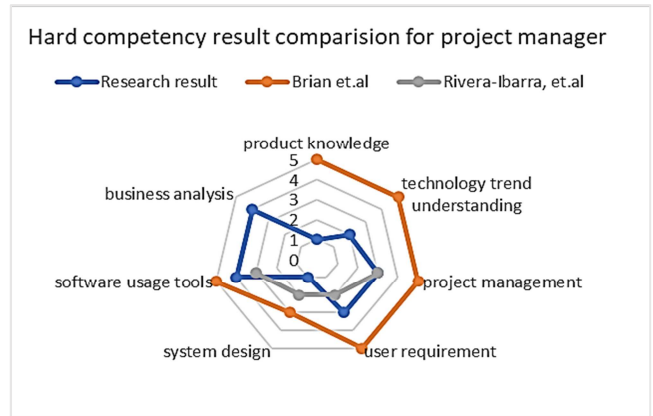


Fig. 4 The results of the comparison of the minimum level of hard competency research results with the results of brian and colleagues' research on role project managers

Job role for analyst has the ability that is almost equivalent to the project manager, but the scope of responsibility is lower than the project manager. An analyst must have integrity and team-building competencies at level 4 so that he can direct the team to complete the project objectives. Besides, that analyst must have a hard competency business analyst, user requirements, and system design at level 3 so that it can determine the design and specifications desired by the user. Job role for programmers has soft and hard competencies at level 1, such as following the instructions and methods set by analysts and project managers. As well as having level 3 for mastering technology on hard competency, for hard competencies selected jobs with role programmers must at least master the minimum level above - 2.

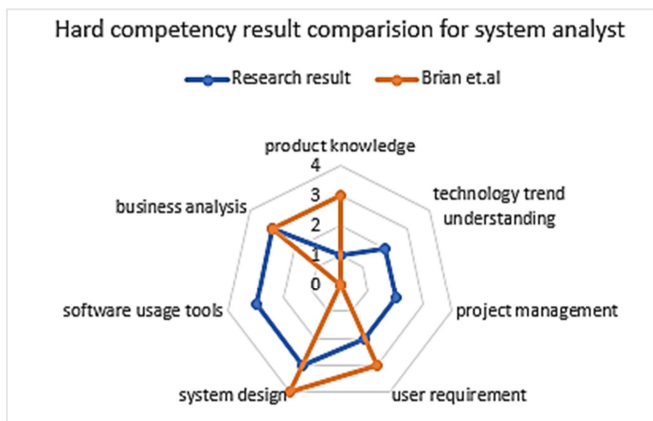


Fig. 5 The results of the comparison of the minimum level of hard competency research results with the results of Brian and colleagues' research on role system analyst

In Fig. 4, Fig. 5 and Fig. 6, it can be seen from the results of the comparison of the minimum level that must be mastered in each job role. In previous research that conducts Brian's research, job role project manager (PM) requires to master all hard competencies with an average of above 4, while the results of this study average levels are at level 3. Meanwhile, for analysts and programmers, there are

differences in several types of competencies, project management competency does not exist in previous studies for role analysts and programmers while in this study it is at an average level of 2. Likewise, business analyst competencies and user requirements for programmer roles, in previous studies, did not exist while in this study, they were at an average level of 2.

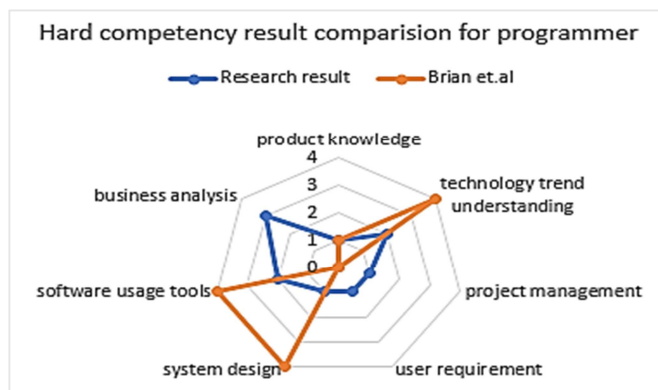


Fig. 6 The results of the comparison of the minimum level of hard competency research results with the results of Brian and colleagues' research on role programmer

IV. CONCLUSION

The results of the analysis show that there are two groups of competencies needed by members of the software development team, that is soft competencies and hard competencies. Each group has a different level on each job role in the team. In soft competencies, a project manager needs a higher level than other job roles. Whereas an analyst requires a balance between soft and hard competencies. Unlike a programmer, it requires higher hard competences than other job roles except for generating feedback (soft competences) because a programmer needs to have the ability to understand customer desires and generate into the program. For further research, we will use the profiling results as a reference for placing someone's role in software development activities or projects

ACKNOWLEDGEMENT

I would like to thank Telkom University and the Ministry of Research and Technology (Kemenristek Dikti) of the Republic of Indonesia. This research funded by the Kemenristek Dikti Republic of Indonesia, and organize by *Penelitian dan Pengabdian Masyarakat (PPM)* division at Telkom University.

REFERENCES

- [1] E. Salas, N. J. Cooke and M. A. Rosen, "On Teams, Teamwork, and Team Performance: Discoveries and Developments," *Human Factors: The Journal of the Human Factors and Ergonomics Society*, p. 543, 2008.
- [2] M. H. N. M. Nasir and S. Sahibudin, "Critical success factors for software project: A Comparative study," *Scientific research and essays*, 2011.
- [3] D. Richard and J. B. Forman, "Seven causes of project failure," 2007. [Online]. Available: <https://www.pmi.org/learning/library/seven-causes-project-failure-initiate-recovery-7195>. [Accessed 12 Januari 2017].
- [4] Standish Group, "Chaos Report Worse Project Failure in Decade," Standish Group, 2015.
- [5] P. Holtkamp and J. M. Pawiowski, "A competence based view on the global software," *Journal of universal computer science*, 2015.
- [6] F. Lanubile, C. Ebert, R. Prikladnicki and A. Vizcaíno, "Collaboration Tools for Global Software Engineering," *IEEE Software*, vol. 27, no. 2, pp. 52-55, 2010.
- [7] M. Farhangian, M. Purvis, M. Purvis and T. B. R. Savarimuthu, "Agent-Based Modeling of Resource Allocation in Software Projects Based on Personality and Skill," *Communications in Computer and Information Science*, pp. 130-146, 2015.
- [8] S. Cook, High Performance Team, United Kingdom: IT Governance Publishing, 2009.
- [9] P. Holtkamp, "Competency Requirements of Global Software Development Conceptualization, Contextualization, and Consequences," *Journal of Universal Science*, 2015.
- [10] P. Holtkamp, "A competence based view on the global software development process," *Jurnal of Universal Computer Science*, 2015.
- [11] T. F. Kusumasari, B. R. Trilaksono, A. N. Aisyah and Fitriah, "Software Development Team Competencies to Support Software Development Project Success," *International Journal of Engineering & Technology*, vol. in process, no. in process, p. in process, 2018.
- [12] E. Moustroufas, I. Stamelos and L. Angelis, "Competency Profiling for Software Engineers: Literature Review and a new Model," in *PCI '15 Proceedings of the 19th Panhellenic Conference on Informatics*, Athens, 2015.
- [13] B. R. v. Kinsky, D. Hay and B. Hart, "Skill Set Visualisation for Software Engineering Job Positions at Varying Levels of Autonomy and Responsibility," in *Australian Software Engineering Conference*, Australia, 2008.
- [14] E. S. Mtsweni, T. Hörne and J. A. v. d. Poll, "Soft Skills for Software Project Team Members," *International Journal of Computer Theory and Engineering*, vol. 8, no. 2, 2016.
- [15] L. Markus, H. C. Thomas and N. K. Allpress, "Confounded by Competencies? An Evaluation of the Evolution and Use of competency model," *New Zealand Journal of Psychology*, 2005.
- [16] G. Kolibacova, "The Relationship Between Competency And Performance," *ACTA Universitatis Agriculturae Et Silviculturae Mendelianae Brunensis*, vol. 62, 2014.
- [17] J. G. Rivera-Ibarra, J. Rodríguez-Jacobo, J. A. Fernández-Zepeda and M. M. Serrano-Vargas, "Competency Framework for Software Engineers," in *23rd IEEE Conference on Software Engineering Education and Training*, 2010.
- [18] J. R. Turner, A. Ledwith and J. Kelly, "Project management in small to medium-sized enterprises: A comparison between firms by size and industry," *International Journal of Managing Projects in Business*, vol. 2, no. 2, pp. 282-296, 2009.