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Research paper



Software Development Team Competencies to Support Software Development Project Success

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Abstract

Software development projects have relatively low success rates compared to other projects. One of the causes is human factors, lack of competence from the development team. The competency of the existing development team cannot meet project needs. Therefore, this research has analyzed the list of competencies that have an important role in the software development team. The list of competencies analyzed was obtained from the results of the literature review and evaluations from 17 practitioners in software development. From the literature review, 57 competency elements were obtained in the context of software developers, which will be further evaluated. Based on the evaluation of the importance level and frequency from practitioners that mapped in the importance-frequency matrix, 24 competency elements include as a top priority (in maintaining or include (MI) quadrant) and 7 competency elements in possibly included (PI) quadrants. The results of this study are expected to be a reference for composing the right composition of the development team to achieve the success of the software development project.

Keywords: *Software Development, Software Developer, Competencies, people factor, software engineer*

1. Introduction

Research conducted by Standish Group in 2009 [1], states that only 32% of all software projects are completed on time, cost, and fulfill the project scope. Communication is one of the competencies that must be owned by members of software development [2]. Software development competence is divided into two parts, hard and soft competencies [2]. Hard competences are competencies related to technical skills in software development. While soft skills describe competencies related to behavior, creativity, and innovation from individuals [2]. Competencies that must be possessed in the development of software projects, in general, are technical, application domain, coordination/project management, communication, collaboration and intercultural competencies [2]. This shows that the performance of human resources and communication skills in software development are important things that need to be considered to achieve the success of software development projects.

The collaboration method used by the software development team in developing software will also affect the type or way of communicating with the developer team. Collaboration and communication are one of the competencies that must be possessed in software development [2]. Therefore, it is important to determine the collaboration and communication methods that used in software development. It will affect the success of the software development project. Agile software method is most use separate collaboration methods or each member does not have to be in one place to complete the project [4].

The collaboration model in software development has several correlations that make collaboration models is important, such as the correlation of human behavior and collaboration processes, the correlation of collaboration processes and product quality, and the correlation of human behavior and product quality [5] [6]. Effective collaboration is one of the important factors for achieving project success [7]. The effective collaboration includes both individually focused tasks and interactive groups [7]. Good collaboration can reduce ambiguity in the work of software because of interaction between members in the development team [7].

A good collaboration of software development teams can be formed with having a match between individual abilities and available roles [8]. Therefore, this research will rank competencies that guarantee the success of software projects. These competencies will be linked to various job roles in the development team and the collaboration methods used. Team competencies are grouped based on perceptions of importance and frequency level.

The structure of the presentation of this research paper includes the first part of explaining the problem and the purpose and objective of this study. The second part describes the study of literature that has been studied to support research such as competence and roles in software development. The method and details of the steps taken to resolve the problem are explained in the third section. The fourth section explains the results of the study. The fifth section contains analysis and discussion of the results obtained. While the sixth part is a conclusion that can be drawn from this study.

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2. Study Literature

2.1. Software Development Competencies

Software development team require two competencies are soft skills and hard competency [2]. These two competencies have a positive impact on the performance of an individual's work. Positive job performance of an individual has a positive impact on software development to achieve success [2]. Soft competency is a group of skills that affect the way people perceive, plan, and carry out tasks in software development while Hard skills are technical skills needed in the development of software, especially web-based software [2]. Methods that can be used to measure competencies, namely personality test, ability test, self-evaluation and assessment [9].

Based on research conducted by Philip by conducting a thorough analysis of all research related to competency in software development, there are several competency categories that software developers must have, namely technical competences, application domain (business) computations, coordination / projects management competency, communication competencies, collaboration competences and intercultural competencies [2]. Brian and colleagues also analyzed competency types using the framework Skills Framework for the Information Age (SFIA), stating that the types of competencies of the development team included business risk manager, configuration management, change management, database design, system design , system development management, data analysis, ergonomics systems, system installation, methods and tools, problem management, software integration, project management, office projects, programming / software development, stakeholder relationship management, safety engineering, integration, testing system, non functional need analysis, usability evaluation, service desk and incident management [10].

Soft skills needed by the software development team according to Emmanuel by conducting interviews and analysis related to the types of soft skills needed in software development include Listening Skills, Personal Integrity, Group work, Team Player, Conduct Meetings, Planning, and Control, just to work under pressure, Dependability and reliability, Writing Skills, Team Building, Time Management, Open Communication, Listening Skills, Problem Solving, Trustworthiness, Effective Questioning, Listening Skills, Critical Thinking, Generating Feedback, and Conflict Management [11]. According to [12] based on the results of deep interview with the software industry, the types of competencies that must be possessed in the software industry include three categories, namely entrepreneurial competency, managerial competency and industrial context. Entrepreneurial competency includes innovation skills, creative thinking, strategic thinking, willingness to learn, consistency. Managerial competencies include external and internal relationships, networking, customer orientation, others directing, marketing, managing resources, compliance on legal aspects, business plan development, risk management, project management. Whereas for the industrial context include software development cycles, technology trends, language programming, product knowledge, business process knowledge, project knowledge, and software development tools [12].

2.2. Software Development Project

The collaboration of software development team is measured by team performance and team success (personal success of team members) [13]. Team performance is measured by quality, timeliness, cost accuracy, and accuracy of the scope of work [13].

In 2011 there was a study that carried out a comparative study of the factors that influence the success of a software development project from studies relating to the success of a software project. These factors are grouped into three groups. That are people-related factors, process-related factors, and technical-related factors [14]. Of the three factors related to humans are factors that have significant value to the success of the project [14]. People-related factors include Effective project management skills, Skilled and sufficient staff, Good leadership, Committed and motivated teams and good performances [14]. This shows that human factors are important in software development.

2.3. Job Role in Software Team

The type of role in software development varies depending on the size of the software project, and the software development method used [8]. The greater the project or organization tends to have a large number of roles [8]. Muratz and colleagues conducted role grouping research based on development methods by conducting investigations and structured interviews to several companies and software developer projects and comparative studies, concluding that the Plan Driven development method consisted of role system analyst, quality assurance software, business analyst, requirement engineer, software architect, database designer, user interface designer, software testing, software developer, project manager [8]. Scrum consists of the role of scrum master, project owner, customer, scrum team, management, user [8]. Feature Driven Development consists of the role of Technical Writer, Deployer, Tester, System Administrator, Toolsmith, Building Engineer, Language Teacher, Domain Manager, Class Owner, Lead Programmer, Development Manager, Project Manager [8].

Role in agile Xtreme programming is leading group (Coach, Tracker), Customer Group (End user, On-site customer, In charge of acceptance testing), Group Code (In charge of unit testing, In charge of design, In charge of code of standards and tools, In charge of code effectiveness and accuracy, In charge of continuous integration), Maintenance Group (In charge of presentation, In charge of documentation, In charge of installation shield) [15]. Jupitermedia corporation also includes a list of roles in software development, namely Subject Experts Matter, Functional Analysts, Solutions Architect, Development Lead, Developer, Quality Assurance, Deployment, Training, Project Manager, Development Manager [16].

3. Method

The research was conducted in several stages, namely the development of a conceptual competency model, the determination of criteria for software development projects, data collection, and data processing and analysis. The research phase scheme can be seen in Figure 1.

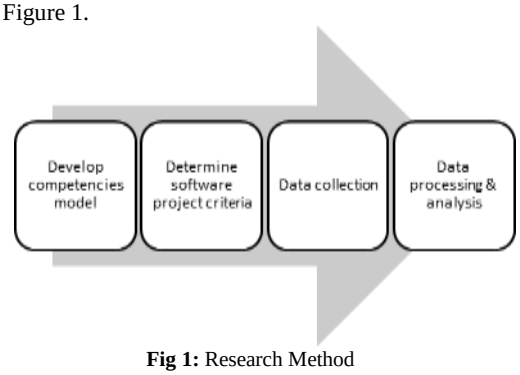

Fig 1: Research Method

In the literature review section, there is five literature that discusses individual competencies in the context of software. The results of the comparison synthesis of the competencies used in the five literature obtained 57 competency elements consisting of 21 elements of hard competencies and 36 elements of competencies, as shown in Table 1.

Table 1: Element of Competency

Competency code	Competency element		Competency code	Competency element
HC001	Project management		SC009	Mediator
HC002	Programming		SC010	Listening skill
HC003	Software tool		SC011	Critical think-

Competency code	Competency element		Competency code	Competency element
	usage			ing
HC004	Application, system installation		SC012	Leadership
HC005	System testing		SC013	Teamwork
HC006	Configuration management		SC014	Innovation
HC007	Database design		SC015	Presentation
HC008	Business analysis		SC016	Integrity
HC009	System design		SC017	Generating feedback
HC010	Data analysis		SC018	Time management
HC011	Software integration		SC019	Conflict management
HC012	Safety engineering		SC020	Open communication
HC013	System integration		SC021	Stress tolerance
HC014	Service desk and incident management		SC022	Concern for order
HC015	Business risk management		SC023	Meetings leadership
HC016	System development management		SC024	Writing skills
HC017	Problem management		SC025	Team building
HC018	Stakeholder relationship management		SC026	Change management
HC019	User requirement		SC027	Aesthetics
HC020	System analysis and design		SC028	Culture understanding
HC021	Software development process		SC029	Foreign language
SC001	Achievement orientation		SC030	Product knowledge
SC002	Initiative		SC031	Cross-sector knowledge
SC003	Information seeking		SC032	Intellectual capital
SC004	Willingness to learn		SC033	Technology trend
SC005	Trustworthiness		SC034	Self-confidence
SC006	Conceptual thinking		SC035	Customer service orientation
SC007	Analytical skill		SC036	Business functional
SC008	Planning and control			

The project criteria used as case studies used to determine the priorities of the development team in this study were taken from one of the successful projects in an SOE in Indonesia. Project success is measured by the accuracy of the schedule, financing, and scope of the project work. The software project used in the case study is a software project with a duration of 1-3 months, the number of team members is between 5-10 people, and the project value is between 100 million - 400 million. The project criteria are used as a reference to determine competency priorities in a development team.

Data collection was carried out by distributing questionnaires to a minimum of 10 experts [17] to determine competency priorities in the software development project team. Expert criteria in this study include experience in the profession of project manager, analyst, and programmer for at least 3 years. The selection of 3 years is based on research conducted by [8], that the developer experience in the project is one of the determinants of project success.

Questionnaires were designed using a 5-point Likert scale to measure the level of importance and frequency of competency elements obtained from the results of a literature study. The results of data collection through the next questionnaire will be processed using importance-frequency matrix analysis [18] which aims to determine the priority quadrants of competencies needed on the software development team. The determination of quadrant competencies is adjusted to the proposals of [18]. There are four quadrants obtained based on the analysis of the importance-frequency matrix, among others:

a. Quadrant I: Maintain or include (MI) for competency elements with high importance and high frequency. This shows that the competency elements in this quadrant are important to have.
b. Quadrant II: Possibly include (PI) for competency elements with high importance and low frequency. Elements of competence in this quadrant become the focus of concentration to increase the frequency of using competencies.
c. Quadrant III: Low priority (LP) for competency elements with low importance and low frequency. Elements of competence in this quadrant do not need to be the focus of attention to be managed.
d. Quadrant IV: Possible overkill (PO) for competence elements with low importance and high frequency. In this quadrant, there are competency elements that are considered not too important, but the frequency of competency use is relatively higher. Therefore, this is considered excessive.

4. Result

Based on the measurement results, the average level of importance and the mean frequency value of each element of competency is obtained, as in the following table. The description of each competency code can refer to Table 1 (in section 3). Table 2 shows the results of sorting competency elements based on the level of importance and intensity of frequency usage.

Table 2: IPA Calculation Results from the list of identified competencies

Competency code	Mean Importance	Mean Frequency
SC008	4.71	4.29
SC017	4.71	4.24
SC016	4.65	4.76
SC004	4.65	4.47
SC011	4.59	4.47
SC003	4.59	4.35
SC005	4.53	4.47
SC018	4.53	4.29
SC013	4.41	4.29
HC001	4.41	4.00
HC019	4.35	4.18
SC009	4.29	3.94
HC009	4.24	4.18
SC030	4.24	4.12
SC033	4.24	4.06
HC010	4.24	3.88
HC003	4.18	4.12
SC007	4.18	4.06
SC012	4.18	4.00
SC020	4.18	3.94
SC022	4.18	3.88
HC018	4.18	3.88
SC001	4.18	3.65
HC008	4.12	4.18
SC019	4.12	4.06
SC025	4.12	4.06
SC035	4.06	4.12
SC014	4.06	3.94
HC005	4.06	3.88
SC002	4.06	3.71
HC017	4.06	3.47
SC006	4.00	4.24
HC014	4.00	3.94
HC016	4.00	3.88
HC011	4.00	3.59
HC020	4.00	3.59

Competency code	Mean Importance	Mean Frequency
SC023	3.94	4.06
HC013	3.94	4.06
HC015	3.94	3.88
HC012	3.94	3.47
SC021	3.88	3.94
SC010	3.82	4.00
SC024	3.71	4.12
HC021	3.71	3.53
SC015	3.65	3.71
SC027	3.65	3.71
SC028	3.65	3.71
SC029	3.65	3.59
HC004	3.59	3.47
SC034	3.53	3.53
SC026	3.47	4.00
SC036	3.41	3.12
HC007	3.35	3.71
HC002	3.35	3.18
SC031	3.24	3.24
HC006	3.24	3.24
SC032	3.12	3.12

Based on the average level of importance and frequency for each element of competence, then it is mapped in the importance-frequency matrix to determine the prioritization of the elements of competence according to the quadrant. The mapping results of the competency elements can be seen in Figure 2.

In Figure 2, there are 24 competency elements included in maintain or include (MI) quadrants, including 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), Project management (HC001), User requirements (HC019), Mediator (SC009), System design (SC009), Product knowledge (SC030), Technology trend understanding (SC033), Software usage tools (HC003), Ana-technical skills (SC007), Leadership (SC012), Open communication (SC020), Business analysis (HC008), Conflict management (SC019), Team building (SC025), Customer service orientation (SC035), and Innovation / creative thinking (SC014). While in the included include (PI) 2 quadrant there are seven elements of competence, consisting of Data analysis (HC010), Concern for order (SC022), Relationship ship management Stakeholders (HC018), Achievement orientation (SC001), System testing (HC005), Initiative (SC002), as well as Problem management (HC017).

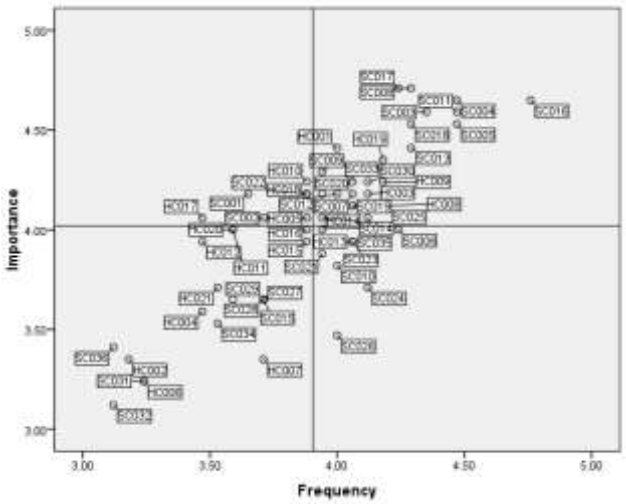

Fig 2: Cartesian diagram of the level of importance of competence

5. Discussion

Figure 2 shows the importance level matrix for the frequency intensity of the competency elements needed by the software development team. The main competencies that must be present in a development team can be seen in maintain or include (MI) quadrant 1, which is competence with a high level of importance and frequency. Whereas the competency of the team that has the potential to support the success of the software project is called the support capacity of the development team, can be seen in the include 2 (PI) possible list. Supporting competencies are competencies with a high level of importance but are rarely used in the development team.

The team's main competencies include 19 soft competencies and five hard competencies. This shows that the element of soft competencies is a more dominant factor compared to hard competencies, in line with the results of [6]. From elements of soft competencies included in the main competencies, there are five characteristics of soft competencies that are peculiar to the software sector, namely willingness to learn (SC004), trustworthiness (SC005), mediator (SC009), product knowledge (SC030), and technology trend understanding (SC033). While the hard competencies that must be in the development team include project management (HC001), user requirements (HC019), system design (HC009), product knowledge (SC030), technology trends of knowledge (SC033), data analysis (HC010), software tool usage (HC003), and business analysis (HC008).

To support the success of software development projects, team members are required to have high learning orientation so that that team members can adapt to diverse project characteristics and fast-changing software development tools. This phenomenon is caused by the software industry faced with high uncertainty [12], so that the ability to always learn new things is needed in line with environmental demands. Besides, it is also needed the ability to understand emerging technological trends, so that the tools used in project development are in accordance with the demands required, and the project runs effectively and efficiently [19], [12]. The ability to analyze technological trends is needed to produce innovations that are important factors in software development [19].

Elements of trustworthiness and mediator competencies are other soft competencies that are characteristic of the software sector. This is because the development of software involves various individuals who have diverse roles. Therefore, to ensure the implementation of the project runs in harmony, it is necessary to have the capability of all members of the software development team. This finding is in line with the research results of [11] where the elements of trustworthiness and mediator competence are critical soft skills for the software development team [11].

Product knowledge becomes a critical element of competence for the software development team because it relates to the product characteristics that will be made. Understanding the entire development team on the software product that will be made is crucial because it determines the direction of the development of the software project to be carried out [20]. In addition, according to [12] in the context of software, knowledge of products becomes an element of competence that needs to be possessed by all individuals in the company, because each individual can act as a salesperson to market and explain the software products produced.

Apart from the five elements of soft competencies, there are 14 other soft competencies that are important to be owned by the software development team. The soft competencies element needs to be owned by a software development team to ensure that software projects can be implemented in accordance with the plan and accommodate various innovations and improvements that may occur during the development of the software.

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Project management capability is the ability to plan, organize, to implement a project effectively and efficiently to achieve goals by considering time and cost [2]. This ability must be primarily owned by a project manager [11]. User requirements for the users of software and deliver them as expected [18]. The ability to understand user requirements will determine the software that will be created by the entire development team. Differences in perceptions of understanding between users and the development team cause software products not to meet the specified scope. Business analyst competency is the ability to conduct investigations, comments, reviews and documentation of all or part of a business in the form of business functions and business processes, information used, and underlying data. This ability is needed by an analyst [19].

The ability to know about products that will be made or similar products will make it easier for the team to get images about the software that will be made in the project. Understanding of emerging technological trends can be used by the team to simplify and accelerate the achievement of project objectives. Knowing about these technology trends will encourage knowledge about tools that can be used to help project completion. The ability of technological usage is the ability to use a set of software tools or build their own tools to get productivity in software engineering jobs [18]. Software usage ability is the main technical competence for software engineers.

System design competence is the ability to determine specifications and designs of information systems to meet business needs in various contexts [11]. The ability of the system design is this capability is the ability to translate user needs from the business side into technical specifications that are easily understood by the technical team.

In addition to the main competencies that need to be possessed by the software development team, there are seven additional competency elements needed to support the success of the project. These seven elements of competence are included in the include II (PI) possible quadrants on the results of competency mapping in Figure 1, including three soft competencies (concern for order, achievement orientation, and initiative) and four hard competencies (data analysis, relationship stakeholders management, system testing, and problem management). These seven competency elements can be further developed to support the success of software projects, in addition to the 19 core competencies that need to be possessed by the software development team.

Supporting soft competencies elements needed to plan activities and manage the coordination of activities carried out by the development team. Referring to [21], competency elements concerned for order, achievement orientation, and initiatives related to achievement and action groups that determine the direction and purpose of actions taken. In [8], achievement orientation competency elements contribute significantly to the quality of the device's product. This shows that by managing the supporting competency elements in addition to soft competencies which are the top priority, it can contribute to the success of managed software projects.

Stakeholder relationship management is the ability to manage relationships with stakeholders. at the design, management and implementation stages of business changes and the entire service lifecycle, taking into account the services they use. This capability is needed by the software team during the software development life cycle, especially for the project manager [11]. Ability to do test planning, design, management, implementation and reporting, using appropriate technical testing tools and in accordance with agreed process standards and specific industry regulations [11]. Based on the results of [11], this ability is needed for project managers and analysts. Software testing internally on the team or with the user will guarantee the fulfillment of the specified project scope. Problem management is the ability to develop resolutions (for both reactive and proactive) of problems throughout the information system lifecycle. This ability is especially necessary for a project manager in handling obstacles that arise both within the team and with the user.

6. Conclusion

Proposed competency model for software development team resulted from importance-frequency matrix analysis. The proposed model consists of two groups of competencies, namely main competencies and supporting competencies. The main competencies must be obtained by the development team including 24 competency elements namely 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), Project management (HC001), User requirement (HC019), Mediator (SC009), System design (SC009), Product knowledge (SC030), Technology trend understanding (SC033), Software tool usage (HC003), Analytical skill (SC007), Leadership (SC012), Open communication (SC020), Business analysis (HC008), Conflict management (SC019), Team building (SC025), Customer service orientation (SC035), and Innovation/creative thinking (SC014). Whereas for supporting competencies include Data analysis (HC010), Concern for order (SC022), Stakeholder relationship management (HC018), Achievement orientation (SC001), System testing (HC005), Initiative (SC002), and Problem management (HC017).

Further research can be focused to determine the minimum level of each competency element that must be owned by the development team to achieve project success. Also, further research can be conducted to identify the assignment model to determine team composition based on competencies and identify competency-based training needs that in line with the software development team needs.

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