The Obstacles of Software Process Improvement in Software House: A Systematic Literature Review and Empirical Study

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Abstract. A software house, that established in 2005 based in Indonesia, got 31 projects in 2019. By the end of year, Project Management Officer released documents to inform company’s project health. There are 14 projects confirmed late, 6 projects on time and 11 projects scheduled complete on the next year. That late projects cause serious problem like loses revenue and gets disrupted of company’s cash flow. Based on the root cause analysis, it found that no standardization of software development process in the company. Before designing the standardization to improve process, we need to analyze the obstacles that might be happened. Therefore, this study aims to identify the obstacles on software process improvement in software house. We performed a systematic literature review to determine the obstacles, then we do empirical research to 58 employees on company’s development department to sort the priority of obstacles in the company. From the systematic literature review, we found studies that relevant and there are 13 obstacles of software process improvement, then from the empirical research we got top three obstacles. We also proposed recommendations to solve that obstacles.

1. Introduction

Nowadays, information technology has become an important part of human life especially for organization, both government or others [1]. Organizations began to allocate budgets to procure computer-based information systems, especially hardware and software applications. It aims to be able to complete work effectively and efficiently [2]. Therefore, many companies are engaged in information technology and provided service to accommodate these needs. A software company based on Indonesia, established in 2005, engaged in providing software and hardware procurement services. Software development is an important process of company’s business. This statement is supported by the fact that in 2019, the company received 31 software projects [3].

Table 1 explained about the status of project health. It can be seen that only 19.35% of projects were successfully delivered on time, even though the target of the company was at least 50% projects on time delivery. This delay delivery can make losses for the company, like disruption of the company’s cash flow. In addition, when there is when there is a software development delay due to an internal company problem, the user has no obligation to pay mandays for overtime. For example, if at the beginning of the project the number of mandays is 20 days, then in fact the project is done for 25 days, then the remaining five days cannot be billed to the user. This is considered a loss because the commercial value of the software delivered and delivered is the company's largest source of revenue.
Based on these problems, an analysis of the root causes of the problem was carried out using the Marchewka Diagram. The domains used are the four factors that are metrics for project success, namely people, organizational, process, and technical [4].

Table 1. Project work status in 2019

| Project Status   | Total | Percentage |
|------------------|-------|------------|
| Late project     | 14    | 45.16%     |
| On time project  | 6     | 19.35%     |
| Unfinished project | 11 | 35.49%     |

Based on the four domain that have been analyzed, the process domain is selected based on company needs. Currently, the company does not have a standardized software development process. A company should have standardized procedures, tools and methods of project work so that project implementation is consistent[5]. Standardization can be achieved by improving the software development process. Before improving the development process, it is necessary to identify obstacles that can make a negative impact on the improvement process. Identifying and solving these obstacles can make the improvement process more effective[6]. Therefore the research questions in this study are:

RQ1: What are the obstacles in implementing the SPI identified in the results of the literature study?
RQ2: Based on the SLR, how are the priorities of these obstacles for the company?
RQ3: What is the solution to these obstacles?

Along with the introduction, this paper has four other sections. In section II is the theoretical background. Then, section III explains the research method. Section IV presents the result and discussion of the studies. Finally, Section V the conclusion of this work.

2. Theoretical Background

This section will explain the theory that is the basis for the research.

2.1. Software Development Process

Software development is the activities carried out to plan, design, implementation, support and improve software functions[7]. Meanwhile, according to Pressman, the software development process is activities, actions and tasks carried out to form a product (software). Activity is an attempt to achieve broader goals. Action is a series of tasks that produce the main product, while tasks focus on a smaller goal in a project [8].

A process framework for software development is divided into five activities. The five activities are Communication, Planning, Modeling, Construction and Deployment[8]. These five activities are general activities commonly carried out in software development, both for small and large scale projects.

2.2. Software Process Improvement

Software Process Improvement or SPI is a work program designed to improve processes in an organization so that the organization can achieve business goals more effectively by reducing or eliminating unnecessary processes[9]. SPI can be a solution to problems that often occur in software development companies. Problems that often occur in software development companies include costs and schedules that are over planning, delays in software delivery, resource management and software quality that does not meet customer expectations[9].
The SPI framework is described in Figure 1. The figure is explained that a set of characteristics must exist if it is to achieve an effective software development process. Then a method for the assessment of these characteristics must exist. Mechanisms for summarizing assessment results and strategies to assist organizations in implementing process characteristics that are lacking or not yet implemented.

3. Research Method

3.1. Systematic Literature Review
Systematic Literature Review (SLR) is a method used to identify, evaluate, and interpret available studies relevant to a particular topic area or research question[10]. This method is used to gain current insights into predetermined research questions. This study was conducted using the SLR guidelines proposed by Kitchenham and Charters [11].

Before SLR process, it is necessary to define research questions that are relevant to the research objectives. In the introduction, Section 1., there are explained some problems which the organization cannot complete the project on time due to the absence of standardization of development methods used by the company. Thus, this research was conducted to identify obstacles or barriers that might occur and provide recommendations for solutions to these obstacles.

After that, the research strategy is formulated based on the research questions. The search will be carried out on a trusted digital database. The digital databases used are Elsevier (Scopus), ScienceDirect, IEEE Xplore, and ACM Digital Library. Then we define search keywords and their alternatives to derive research studies from digital databases. Keywords are combined with Boolean operators, "AND" and "OR". The keywords are defined as follows:

"software development" AND "process" AND ("software process improvement" OR "SPI") AND ("obstacle" OR "barrier") AND ("vendor" OR "software house")

We define inclusion (In) and exclusion (En) criteria to determine whether a study should be included in this study. Criteria are built based on research questions. The inclusion criteria were, (I1) published between 2015 and 2020, (I2) written in English, (I3) published in conference proceedings or journals, (I4) focused on evaluating processes or barriers. The exclusion criteria were, (E1) a study that did not address the software development process or SPI, (E2) a study that did not use a software vendor or company as a case study, (E3) the study did not meet the research objectives. The results of the search based on keywords and criteria I1-I3 are described in Table 2.

Then the research is carried out by following the established research strategy. SLR measures are shown in Figure 2. We conducted a literature search by applying the I1-I3 criteria in a selected database and taking 242 studies. Then the duplicate studies were screened and 168 studies were obtained. Furthermore, 168 studies were filtered by title, keywords, and abstracts using the E1 and E2 criteria and
obtained 52 suitable studies and 116 unsuitable studies. Then the investigation is carried out by reading each document to get relevant references using I4 and E3. The results obtained were that there were 18 studies that were suitable and 33 studies that were not suitable. Thus, at the end of the SLR process, 18 studies relevant to the research objectives were selected to be included in the synthesis.

| Database                | Search Result |
|-------------------------|---------------|
| IEEE Xplore             | 3             |
| ACM Digital Library     | 68            |
| Sciedirect              | 47            |
| Scopus                  | 149           |
| Total                   | 242           |

3.2. Empirical Research

Empirical research has an important role in software engineering. This research is used to obtain data or knowledge based on observations or experiences[12]. The steps in empirical research on software engineering are as follows[13]:

3.2.1. Research Context. This study aims to determine the three obstacles that are most often encountered by employees in the development department of the company.

3.2.2. Research Design. Research data were collected from 58 employees in the development department of the company. The method used for data collection is by using a questionnaire. In the questionnaire, 13 obstacles were found from the SLR process, then each employee will give a rating from 1 to 13 according to the employee's experience. The questionnaire given is anonymous and does not pay attention to the job specifications of employees at the company.
3.2.3. Experiment and data collection. Questionnaire data was shared online and in person to 58 employees in the development department via Google Form. Data were collected for seven days. At the end of the charging period, 55 data were obtained which could then be analysed.

3.2.4. Analysis. From 55 data collected, the total number of points was calculated. Points are calculated based on the rank given, rank 1 is considered 1 point, rank 2 is considered 2 points and so on. The points from each obstacle are added together to get the total points for each obstacle. Then the total points are sorted from low points to high points. The obstacles that have the lowest points are the obstacles that are considered the most faced by employees.

3.2.5. Result. Based on the analysis results, there were three obstacles with the lowest points. Next, recommendations for solutions to the three obstacles are given.

4. Result and Discussion

This section discusses the findings of the SLR and empirical research to answer the research questions mentioned in Section1. Based on the SLR, researchers found 18 studies described in Appendix A [14]–[31].

| Code | Description                                      | Frequency (n=18) | % of occurrence |
|------|--------------------------------------------------|------------------|-----------------|
| OB1  | Excessive workload                               | 7                | 38.89%          |
| OB2  | Lack of communication and coordination            | 13               | 72.22%          |
| OB3  | Inexperienced staff                               | 13               | 72.22%          |
| OB4  | Organizational politics and cultures              | 10               | 55.56%          |
| OB5  | Staff turnover                                    | 5                | 27.78%          |
| OB6  | Lack of SPI methodology                           | 6                | 33.33%          |
| OB7  | lack of SPI implementation                        | 9                | 50%             |
| OB8  | Lack of organizational commitment                 | 9                | 50%             |
| OB9  | Time pressure                                     | 11               | 61.11%          |
| OB10 | Lack of knowledge transfer.                       | 12               | 66.67%          |
| OB11 | lack of resources or budget                       | 7                | 38.89%          |
| OB12 | Lack of roles and responsibilities                | 5                | 27.78%          |
| OB13 | Lack of trust                                     | 8                | 44.44%          |

4.1. Obstacles based on SLR

Based on the 18 studies that were synthesized, each of them has a correlation. The qualitative evaluation of the journal resulted in 13 categories of obstacles that occurred. Based on the 18 studies that were synthesized, each of them has a correlation. The qualitative evaluation of the journal resulted in 13 categories of obstacles that occurred. The results of the literature study, the explanation regarding the table is as follows:

1. OB1: Excessive workload
   An example of this obstacles is a project that is quite large and has few staff, causing a large workload on each staff [LT2][LT4][LT6][LT8][LT9][LT13][LT14], projects that are too complex and not unknown when it ends[LT4].

2. OB2: Lack of communication and coordination.
   Lack of communication can be caused by a lack of solidarity between teams[LT1][LT10], team member personality and lack of feedback from team members[LT2][LT13], kurangnya lack of project transparency and inappropriate communication patterns used[LT4], gaps in
communication and coordination [LT5] [LT6] [LT9] [LT10] [LT11] [LT12] [LT14] [LT15] [LT16], not responsive [LT10] [LT17], lack of relations among stakeholders [LT11].

3. OB3: Inexperienced staff
Poor staff experience can be caused by lack of technical capabilities [LT1] [LT8] [LT9] [LT12] [LT14] [LT15] [LT17], lack of expertise [LT2] [LT6] [LT8], lack of knowledge sharing among teams [LT4] [LT9], lack of team performance [LT5] [LT9], difficulty in adopting knowledge [LT9] [LT17], knowledge complexity [LT10].

4. OB4: Organizational politics and cultures
Examples of this obstacles is political issue of organization [LT1] [LT13], change of organizational structure [LT2] [LT11], organizational distance [LT2], lack of management relations [LT5], client assumptions, habit and preference [LT9], organization think that standardization is not really important [LT9], quality is considered expensive and not affordable [LT9], differences in time zone, language and culture [LT10] [LT11] [LT13] [LT14] [LT17], differences in rules and government regulations [LT10], internal problems [LT10].

5. OB5: Staff turnover
Rapid team change, lack of planning for team / staff changes [LT1] [LT2], the company often enters and leaves employees [LT8] [LT13] [LT14].

6. OB6: Lack of SPI methodology
Inappropriate methodology [LT2] [LT8] [LT12] [LT13] [LT15] [LT17].

7. OB7: Lack of SPI implementation
Examples of these obstacles include the lack of tools and standardization of the implementation of the SPI [LT2] [LT4] [LT8] [LT10] [LT11] [LT13] [LT15] [LT16] [LT17].

8. OB8: Lack of organizational commitment
Lack of support for employee rights [LT1] [LT9] [LT13] [LT17], lack of sponsorship provided by the company [LT2] [LT6] [LT13], lack of motivation for employees [LT4], perusahaan companies lack knowledge of the improvement process [LT6] [LT9], [LT13] [LT14].

9. OB9: Time pressure
Time pressures can be caused by lack of schedule planning [LT1] [LT2] [LT4] [LT5] [LT8] [LT9] [LT12] [LT13] [LT14] [LT17], incorrect estimation effort dan project management [LT3] [LT8], lack of short term strategy [LT9].

10. OB10: Lack of knowledge transfer.
Lack of knowledge dissemination in organizations [LT1], lack of training [LT13] [LT14] [LT17], lack of knowledge implementation [LT2] [LT4], lack of project documentation and procedure [LT9] [LT15], no document repositories [LT9], lack of knowledge management [LT10] [LT11] [LT12] [LT16].

11. OB11: Lack of resources or budget
There are hidden cost that affect in organization [LT1], lack of resources dan budget constraint [LT2] [LT4] [LT13] [LT17], inadequate company infrastruktur [LT4], lack of cost planning [LT9] [LT13].

12. OB12: Lack of roles and responsibilities
Excessive workload can lead to lack of team responsibility [LT2] [LT4] [LT15] [LT17], duplication of roles and poorly organized projects [LT9].

13. OB13: Lack of trust
Examples of this obstacle is lack of trust on team to team or team to organizational [LT2] [LT4] [LT5] [LT10] [LT11] [LT13] [LT14] [LT17].

4.2. Top three obstacles based on empirical research
In the previous section, we found 13 obstacles that might occur in improving the software development process. Based on these 13 obstacles, empirical research was conducted by distributing questionnaires to 58 employees at the company. The distribution of the questionnaires was carried out in stages over
one week. At the end of the questionnaire distribution period, 55 valid data were obtained. The results of the questionnaire are described in Table 4 below.

| Code | Total Point | Rank |
|------|-------------|------|
| OB1  | 186         | 3    |
| OB2  | 112         | 1    |
| OB3  | 389         | 6    |
| OB4  | 133         | 2    |
| OB5  | 377         | 5    |
| OB6  | 242         | 4    |
| OB7  | 451         | 9    |
| OB8  | 435         | 7    |
| OB9  | 594         | 13   |
| OB10 | 580         | 12   |
| OB11 | 524         | 10   |
| OB12 | 532         | 11   |
| OB13 | 448         | 8    |

From Table 4, it is known that OB2, OB4 and OB1 have the least total values. This shows that employees choose the three obstacles as the main obstacle. The problem of lack of communication and coordination, politics and organizational culture and large workloads are the three obstacles most felt by employees. Next, recommendations for solutions related to the three obstacles will be given.

4.3. Recommendation of Solution

After knowing the three obstacles that occurred in the company, a solution recommendation was formulated based on literary studies.

4.3.1. Lack of communication and coordination. According to literature, being in the same environment and using effective equipment, such as whiteboards, screens, and LCDs can help improve the effectiveness of communication and coordination [32]. In addition, applying practices in Scrum, such as sprint planning, daily stand-up meetings, sprint reviews, and disciplined sprint retrospectives will help improve communication and coordination between development teams [33]. Then the use of tools in Agile implementation, such as Microsoft Teams, Jira and Trello as a support in the development process is one of the recommended aspects to facilitate communication and coordination [34].

4.3.2. Organizational culture and politics. Organizational culture is an important part of the successful implementation of SPI. Improving organizational culture is one thing that needs to be prioritized. According to the literature, the organizational contribution or organizational culture that needs to be applied so that SPI runs successfully is a commitment to quality rules, has a clear vision, goals, and steps, companies need to be committed to deadlines and goals, supervise development activities, increase participation and the commitment of each employee in the SPI process [35].

4.3.3. Excessive workload. According to the literature, workload problems often occur in companies that have many projects. There are several tools that can be used to aid in flexibility and effective planning such as MS. Project. The use of these support tools can affect the entire software development process and reduce wasted time [36]. In addition, it is necessary to have good documentation from each employee. So, if there are additions, developments, changes to a feature requested by the customer, then the work does not have to be done by the same person [37].
5. Conclusions
Based on the research results, there are 13 obstacles that can occur in improving the software development process. This research also explains the possible cause of obstacles. The 13 obstacles that we can mention lack of communication and coordination, organizational culture and politics and excess workload of employees are the three obstacles that are considered the most influencing process improvement in the company. Recommendations for solutions to these three problems include the use of appropriate supporting tools, application of Scrum practices in the development process, implementing improved organizational culture, and complete documentation by each employee.

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Appendices

APPENDIX A

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| Data | OB1 | OB2 | OB3 | OB4 | OB5 | OB6 | OB7 | OB8 | OB9 | OB10 | OB11 | OB12 | OB13 | Total |
|------|-----|-----|-----|-----|-----|-----|-----|-----|-----|------|------|------|------|-------|
| 1    | 2   | 4   | 6   | 8   | 10  | 12  | 14  | 16  | 18  | 20   | 22   | 24   | 26   | 64    |
| 2    | 4   | 6   | 8   | 10  | 12  | 14  | 16  | 18  | 20  | 22   | 24   | 26   | 28   | 66    |
| 3    | 5   | 4   | 1   | 6   | 7   | 8   | 9   | 10  | 11  | 12   | 13   | 14   | 15   | 70    |
| 4    | 6   | 8   | 10  | 12  | 14  | 16  | 18  | 20  | 22  | 24   | 26   | 28   | 30   | 72    |
| 5    | 7   | 1   | 2   | 3   | 4   | 5   | 6   | 7   | 8   | 9    | 10   | 11   | 12   | 51    |
| 6    | 8   | 10  | 12  | 14  | 16  | 18  | 20  | 22  | 24  | 26   | 28   | 30   | 32   | 54    |
| 7    | 9   | 11  | 13  | 15  | 17  | 19  | 21  | 23  | 25  | 27   | 29   | 31   | 33   | 56    |
| 8    | 10  | 12  | 14  | 16  | 18  | 20  | 22  | 24  | 26  | 28   | 30   | 32   | 34   | 58    |
| 9    | 11  | 13  | 15  | 17  | 19  | 21  | 23  | 25  | 27  | 29   | 31   | 33   | 35   | 60    |
| 10   | 12  | 14  | 16  | 18  | 20  | 22  | 24  | 26  | 28  | 30   | 32   | 34   | 36   | 62    |
| 11   | 13  | 15  | 17  | 19  | 21  | 23  | 25  | 27  | 29  | 31   | 33   | 35   | 37   | 64    |
| 12   | 14  | 16  | 18  | 20  | 22  | 24  | 26  | 28  | 30  | 32   | 34   | 36   | 38   | 66    |

**Table A 1. Summary of Questionnaire**