

Measuring the Maturity Level of the Organization in the Process Software Development Using the CMMI-Dev Method

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Abstrak—Pengaruh besar perkembangan teknologi terhadap banyak aspek kehidupan antara lain terlihat pada perubahan besar pada proses ekonomi, sosial, politik, bahkan dunia pendidikan. Seperti halnya dialami Perguruan Tinggi. XX, organisasi yang bergerak dalam dunia pendidikan. Implementasi produk teknologi informasi seperti aplikasi-aplikasi sudah dilakukan, namun ditemukan bahwa selama masa pengembangan sampai sekarang, Perguruan Tinggi XX belum pernah melakukan pengukuran tingkat kematangan organisasi dalam proses pengembangan perangkat lunak, sehingga organisasi tidak dapat mengetahui seperti apa kinerja sistem, dan seperti apa *feedback* dari *user* diantaranya mahasiswa, dosen, tenaga kependidikan terhadap kinerja sistem yang mereka miliki. Oleh sebab itu perlu dilakukan pengukuran tingkat kematangan organisasi dalam proses pengembangan perangkat lunak menggunakan metode CMMI-Dev. Berdasarkan 22 area proses yang ditawarkan oleh CMMI-Dev, maka dilakukan penyesuaian area proses dengan sistem yang dimiliki, area proses yang dimaksud adalah *Product Integration* (PI) atau Integrasi Produk dan *Validation* (VAL) atau Validasi. Setelah dilakukan Gap Analisis, didapat bahwa tingkat kematangan (*maturity*) 3,5 dengan nilai gap nominal 0,5 dan nilai gap presentasi 50% adalah Gap terendah, maka disimpulkan bahwa tingkat kematangan organisasi saat ini berada pada level 2. Artinya proses telah direncanakan dan dilaksanakan sesuai dengan kebijakan yang ada, sumberdaya manusia yang dipekerjakan sudah terampil dibidangnya dan memiliki sumber daya lain yang memadai. Namun dalam penerapannya masih terdapat domain yang harus diperbaiki dan ditingkatkan agar mencapai level maksimal. Direkomendasikan untuk menerapkan SOP dan selalu mengevaluasi apakah proses telah berperilaku konsisten dan stabil.

Kata Kunci: konsisten dan stabil, CMMI-Dev, SDLC, SOP, *Activity Based coating*

Abstract— The great influence of technological developments on many aspects of life, among others, is seen in major changes in economic, social, and political processes, and even the world of education. As experienced by the College of XX, an organization engaged in the world of education. The implementation of information technology products such as applications has been carried out, but it was found that during the development period until now, the College of XX has never measured the level of organizational maturity in the software development process, so the organization cannot know what system performance is like, and what kind of feedback from users include students, lecturers, education staff on the performance of the system they have. Therefore, it is necessary to measure the level of organizational maturity in the software development process using the CMMI-Dev method. Based on the 22 process areas offered by CMMI-Dev, then adjustments are made to the process area with the system that is owned, the process area in question is Product Integration (PI) or Product Integration and Validation (VAL) or Validation. After conducting the Gap Analysis, it was found that the maturity level (*maturity*) is 3.5 with a nominal gap value of 0.5 and the percentage gap value of 50% is the lowest Gap, it is concluded that the organizational maturity level is currently at level 2. This means that the process has been planned and carried out in accordance with existing policies, and the human resources employed are skilled in their fields and have other adequate resources. However, in its application, there are still domains that must be improved and improved in order to reach the maximum level. It is recommended to implement the SOP and always evaluate whether the process has behaved consistently and stably.

Keywords: consistent and stable; CMMI-Dev; SDLC; SOP; Activity Based Coating

INTRODUCTION

The development of information technology has influenced many aspects of life. Major changes have occurred in economic, social, political processes, as well as in several other aspects of life, including in the world of education. Organizations that have experienced this influence are starting to see changes in their business models from conventional systems to digital ones. The influence of the development of information technology requires organizations to develop reliable software

to support their operations and improve the quality of services to the community (Asmy and Hasugian, 2021). The ability of organizations to apply information technology to business processes will make them superior to others, because of the many advantages and benefits that will be generated (Mahmud, Rachmadi and Saputra, 2018). Some of the advantages and benefits that will be obtained are increased community satisfaction due to reduced service time, ease of access, increased system functionality, and information disclosure, which in turn will encourage growth and accelerate

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the achievement of organizational goals (Widodo and Informatika, no date) (Isa, 2020).

College of XX is a non-profit organization that has implemented information technology in its business processes and is even integrated with several existing applications within the organization. They consider this very important in an effort to improve the quality, rating and image so that they are included in the superior university cluster which in the end makes it one of the universities that is in great demand by the public. Academic Information System (AIS) is one of the software developed. This system accommodates several features such as functional lecture contracts, viewing the results of lecture evaluations by students, recapitulation of semester learning outcomes, transcripts, monitoring of lecture contracts by academic supervisors, uploading announcements, uploading materials, and lecture scores by lecturers. Plus the ability to integrate with other systems such as Edom (lecturer assessment system) and payment systems.

However, limited resources are an obstacle in improving the software development process, so there are still some system services that are not in line with the expectations of the organization and society. There needs to be a strategy in optimizing the software development process so that software development does not depend on people, but rather on a standardized process (Deswandi and Hudaya, 2020). Therefore, to measure the level of organizational maturity in the software development process, it is necessary to manage information systems using a method. The method used is CMMI-Dev (Capability Maturity Model Integration) For Development. CMMI-Dev can help organizations to improve their performance and capabilities in providing services (Pembimbing *et al.*, 2015) (Wulandari, Herlambang and ..., 2019). CMMI-Dev is a process and behavior model that can help organizations to simplify process improvement and encourage productive and efficient behavior that reduces risk in software, product and service development and is a process improvement approach that provides the essential elements for a more efficient process. effective for the organization (CMMI Institute, 2019) (Al Adawiyah and Ruldeviyani, 2020) (Mewengkang and Djamen, 2016).

In this study, the authors conducted a literature review using journals relevant to the chosen theme, such as I Putu Dedy Sandana and Hari Ginardi in their research entitled Governance of Software Development Dr'eam at PT. PLN (Persero) Bali Distribution With CMMI-Dev. This study describes how to measure how well the process of running a system by using a method, namely CMMI-Dev by comparing the Gap Analysis of the expected Capability to be achieved. The conclusion of the research shows that their system is at the level of maturity (Capability) Level 3 or has a gap of 10%

from the expected level of maturity (Capability) which is at Level 5.

In another study conducted by Arief Deswandi and Barda Hudaya entitled Software Development Audit Using the Capability Maturity Model Integration Level 3 Method, it is explained how to analyze problems and measure the company's maturity level in software development that will be produced. The conclusion of this research shows that there are process areas that do not meet CMMI standards and need to be improved on a priority scale.

Another study conducted by Ikrima Amanda Wulandari, et al. Explains how to analyze the results of the assessment of the Capability level of the application development process of the Department of Communication and Informatics of Malang City. The assessment is carried out on six process areas based on the CMMI product roadmap. The results obtained from the assessment are that there are no process areas that meet all existing practices or are at Level 0 (Incomplete).

Furthermore, in another study conducted by Alfrina Mewengkang and Arje Cerullo Djamen entitled Utilization of Capability Maturity Model Integration (CMMI) to Improve Software Quality (Case Study: Academic Information System, Manado State University explaining how to measure and improve the quality of Academic Information System Software by using CMMI methodology The results of this study indicate that the maturity level of the system is at level 1 or early.

In addition, there are other studies conducted by Ita Permatahari, et al. The title is Application of Capability Maturity Model Integration to Measure Organizational Maturity Levels in the Software Development Process (Case Study: Innovation Center Directorate of Amikom University Yogyakarta. Which explains how to determine the maturity level of the Amikom CMMI Innovation Center division which is focused on level 2 maturity with six processes The results of this study indicate that the software development process at the Amikom Innovation Center is still at level 1 (initial) or not all of the practices in each of the 6 process areas have been implemented.

Based on these references and after measuring how well the system is running by comparing the Gap Analysis with the expected maturity level, it can be concluded that the CMMI-Dev method is able to show the maturity level of a system that is applied at what level. In this case, the meta-analysis is that several studies dedicated to assessing the level of maturity can be carried out using existing artifacts, both from documents and support systems for the development process as a reference for mapping the CMMI-Dev Process Area.

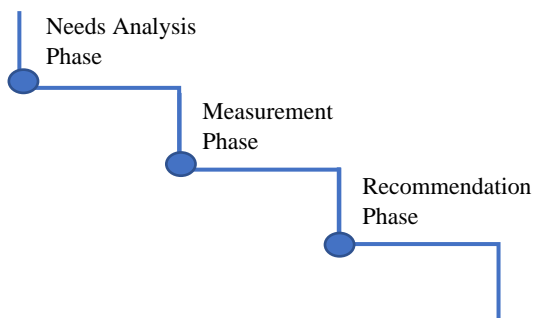
The purpose of this study was to measure the level of organizational maturity in the software development process using the CMMI-Dev method.

While the expected results of these measurements are at what level of maturity the organization is in the software development process that is being implemented by the organization. This will be used as a guideline for preparing plans and actions in an effort to improve the quality of the system and determine the level of maturity in the next system and improvements to the current system.

RESEARCH METHODOLOGY

1. Research Stages

The research phase is carried out in 3 phases, namely the needs analysis phase, measurement and analysis, and the recommendation phase (Himawan, 2021).



Source: (Himawan, 2021)

Figure 1. Research Stages

Phase 1 (needs analysis phase), in this phase a needs analysis of the object of research is carried out regarding what the organization needs in the subsequent development process of the software they have.

Phase 2 (measurement and analysis phase), in this phase the measurement of the state of the organization is carried out which is then analyzed using CMMI by ensuring that the needs analysis process has been completed. Within the CMMI-Dev (Capability Maturity Model Integration) for Development, there are 22 Process Areas, which focus on organizational development activities. CMMI-Dev is a reference model that includes activities in developing products and services in various industries. [(CMMI Institute, 2019) (Mewengkang and Djamen, 2016) (Made Sugi Ardana and Suharjito, 2017). This data was obtained from interviews and discussions with responsible parties in order to find out the existing problems and obtain information related to the system development process in the organization.

To measure the maturity level of the software development process, 100% of the respondents from the population were 6 people. Measurements were carried out using a questionnaire adapted to the CMMI rules. Each indicator is provided with 5 answer choices, which are applied with a Likert scale ranging from 1 to 5.

Table 1. List of questions used in the questionnaire

Num ber	Statement	SD	DA	JA	A	SA
1	There are already other tools or software used to help the SQA (Software Quality Assurance) process					
2	The institution has certain development standards in developing software					
3	The institution has implemented an SQA (Software Quality Assurance) process to test software quality					
4	There are no obstacles that occur along the way of making software from design, production, software testing process, until a software is published or used by users.					
5	There are no complaints from users regarding the software developed					

Source: (Sinaga, Samsinar and Afriany, 2021)

SD = Strongly Disagree

DA = Don't Agree

JA = Just Agree

A = Agree

SA = Strongly Agree

Phase 3 (recommendation phase), this is the phase of providing recommendations needed for further software development to move up to a better level

in accordance with CMMI standards. The recommendations given must of course be based on the results of the analysis of phase 1 and phase 2. (Pembimbing *et al.*, 2015)

2. Measurement with CMMI

CMMI-Dev (Capability Maturity Model Integration for Development) is an organization's process improvement training and assessment program (Software Engineering Institute, 2010)(Artha, 2014). Managed by CMMI Institute which is a

subsidiary of ISACA, developed at Carnegie Mellon University (CMU). CMU claims CMMI can be used to guide process improvement across projects, divisions, or entire organizations. CMMI defines maturity levels for the following processes: Initial, Managed, Defined, Quantitatively Managed and Optimized. CMMI is structured based on three concepts, namely Process Area (PA), Goals, and Practices. CMMI consists of 22 Process Areas. (Software Engineering Institute, 2010).

Table 2. *Process Area, Categories, and Maturity Levels*(Software Engineering Institute, 2010)

Process Area	Category	Maturity Level
Maturity Level 2 - Managed		
Configuration Management (CM)	Support	2
Measurement and Analysis (MA)	Support	2
Project Monitoring and Control (PMC)	Project Management	2
Project Planning (PP)	Project Management	2
Process and Product Quality Assurance (PPQA)	Support	2
Requirements Management (REQM)	Project Management	2
Supplier Agreement Management (SAM)	Project Management	2
Maturity Level 3 - Defined		
Decision Analysis and Resolution (DAR)	Support	3
Decision Analysis and Resolution (DAR)	Project Management	3
Measurement and Analysis (MA)	Process Management	3
Organizational Process Focus (OPF)	Process Management	3
Organizational Training (OT)	Process Management	3
Product Integration (PI)	Engineering	3
Requirements Development (RD)	Engineering	3
Risk Management (RSKM)	Project Management	3
Technical Solution (TS)	Engineering	3
Validation (VAL)	Engineering	3
Verification (VER)	Engineering	3
Maturity Level 4 - Quantitatively Managed		
Organizational Process Performance (OPP)	Process Management	4
Quantitative Project Management (QPM)	Project Management	4
Maturity Level 5 - Optimizing		
Causal Analysis and Resolution (CAR)	Support	5
Organizational Performance Management (OPM)	Process Management	5

Source: (CMMI Institute, 2019)

Maturity Level 1 – Initalized

At level 1, the process is usually ad-hoc and disorganized. In this case, the institution does not provide a stable environment to support a software development process. The success achieved by an institution at this level is highly dependent on the competence of the people in that institution. Although capable of producing a well-functioning

system, it usually costs more than budget and time that doesn't match the schedule it should have. This level has several characteristics such as the following: (Al Adawiyah and Ruldeviyani, 2020)(Handoyo, Umar and Riadi, 2019)

- a. There is an excessive tendency to rely on an individual in the process

- b. Ignoring the process that should be done at a critical moment
- c. Lack of project management
- d. No quality assurance
- e. No documentation

Maturity Level 2 –Managed

At this level 2, when the implementation of a project is usually a process that has been planned and carried out in accordance with existing policies, the human resources employed are people who are skilled in their fields and have other adequate resources to produce output in accordance with what has been determined. The characteristics of this level are as follows:

- a. Software quality has started to depend on the process not on its human resources
- b. There is project management
- c. There is quality assurance even though it's still simple
- d. There is documentation
- e. There is a simple configuration management software
- f. Very vulnerable to changes in organizational structure

Maturity Level 3 –Defined

At this level 3, a process must be described with a standard, procedure and method. The difference with the previous level is that at this level the process is usually set more strictly. The process clearly has objectives, inputs, entry criteria, activities, roles, measures, verification steps, outputs and exit criteria. The characteristics at this level are as follows:

- a. Implement SDLC (system development life cycle)
- b. Already have a commitment to follow
- c. Process and product quality is still within estimates
- d. Do not apply Activity Based coating

Maturity Level 4 – Quantitatively Managed

At this level 4, an organization has achieved all the specific and generic goals found at levels 2, 3 and 4. The processes that occur can be controlled. This level has the following characteristics:

- a. There is already Activity Based Costing
- b. The software and project quality assessment process is quantitative
- c. There is a waste of costs to collect data because the data collection process is still carried out manually

Maturity Level 5 – Optimizing

At level 5, an organization has achieved all the specific and generic goals found at levels 2, 3, 4 and level 5. Maturity Level 5, focuses on continuous process improvement through technological innovation. The characteristics at this level are as follows:

- a. Data collection has been done automatically

- b. There is a very good feedback mechanism
- c. There is an increase in the quality of Human Resources and an increase in the quality of the process

Of the 22 process areas offered by CMMI-Dev, it is possible to make adjustments to the process areas related to the system contained in XX College, the process area in question is Product Integration (PI) or Product Integration and Validation (VAL) or Validation.

RESULTS AND DISCUSSION

3. Data Collection and Analysis Process

Some of the reasons that form the basis of the need to carry out measurements of organizational maturity levels in the software development process are: (Software Engineering Institute, 2010):

- a. To know the direction and purpose of an organization
- b. To find out the resources related to the system you have
- c. To find out what the organization lacks in developing software

The following rules summarize the methods for measuring process maturity, namely:

- a. To reach maturity level 2, all process areas assigned to maturity level 2 must reach capability level 2 or 3.
- b. To reach maturity level 3, all process areas assigned to maturity at levels 2 and 3 must reach capability level 3
- c. To reach maturity level 4, all process areas assigned to maturity at levels 2, 3, and 4 must reach capability level 3.
- d. To reach maturity level 5, all process areas must reach capability level 3

The level of capability (capability) applies to improve the process of organizational progress in the field of individual processes. These levels are a means to be able to gradually improve the corresponding process. For example, there are four levels of capability (capability) numbered 0 to 3, the maturity level applies to process improvement in organizational achievement in various process areas. It is a means of improving the process according to a given set of process areas such as maturity level. Furthermore, 5 levels of maturity (maturity) are numbered 1 to 5. The following table 2 shows that there are four levels of ability with five levels of maturity. Note that there are two level names that are the same in both representations (ie, Managed and Defined).

The difference is that there is or is no maturity level 0; no level 4 and 5 abilities; and at level 1, the

names used for capability level 1 and maturity level 1 are different.

Table 3. Comparison of Ability Level and Maturity Level

Level	Representation of Sustainability Level	Gradual Maturity Level Representation
Level 0	<i>Incomplete</i>	
Level 1	<i>Performed</i>	<i>Initial</i>
Level 2	<i>Managed</i>	<i>Managed</i>
Level 3	<i>Defined</i>	<i>Defined</i>
Level 4		<i>Quantitatively Managed</i>
Level 5		<i>Optimizing</i>

Source: (CMMI Institute, 2019)

2. Determination of RACI

RACI (Responsibility, Accountability, Consult, and Informed), each section will be explained as follows: (Permatahati, Winarno and Kurniawan, 2020)(Information *et al.*, 2019)(Samsinar, Sinaga and Afriany, 2021)

- R (Responsible), is the part that performs an activity or is responsible for completing an activity.
- A (Accountable), is the party who has the authority to decide a policy and direct the implementation of activities.
- C (Consulted), is a party that contributes to an activity that becomes a place of consultation in the implementation of activities
- I (Informed), is a party who needs to know the results of a policy that will be given information regarding the implementation of activities.

Based on the organizational structure of college of XX, it is known that the parties who will be responsible for the success of the above activities can be seen in the table below:

Table 4. Process Area

<i>Functional Organization</i>	<i>Functional RACI</i>	<i>Description</i>
<i>Head Of IT Development</i>	<i>Accountable</i>	The party responsible for the system development process
<i>Head Of IT Operation / Administrasion</i>	<i>Consulted</i>	The party responsible for monitoring or

<i>Bisnis Executive (Bidang Pendidikan)</i>	<i>Informed</i>	controlling the running of the system The party who is always asked for his opinion about the running of the system
<i>Bisnis Executive (Bidang keuangan, sarana dan prasarana)</i>	<i>Accountable</i>	The party responsible for all processes of determining planning and development, both in the field of assets and technology in the organization
<i>Pelaksana (Administration of finance)</i>	<i>Responsible</i>	Parties who use and operate
<i>Pelaksana (Administration of Akademik)</i>	<i>Responsible</i>	Parties who use and operate

Source: (CMMI Institute, 2019)

Based on the 22 process areas offered by CMMI-Dev as shown in Table 2, it is possible to make adjustments to the process areas related to the system contained in College of XX, the process area in question is Product Integration (PI) or Product Integration and Validation (VAL) or Validation. Adjustments to this process area are very compatible with the existing systems in the organization where the SIAKAD Product Integration process area has the ability to integrate with other software in the organization. As for the process area in Validation (Val) it is also stated that it is also appropriate because SIAKAD and existing applications offer, and fulfill the use of the organization, or in its application in accordance with the expectations of the organization.

3. GAP Analysis

The sampling method is carried out by determining all members of the population as samples, this is often done if the population is small, less than 30 people. (Achmad Sani, 2010)

The following is a Gap Analysis of the Product Integration and Validation process areas, as contained in table 4 and table 5:

Table 5. Gap Analysis Product Integration

Statement	Responden					Score	Maturity Value	Minimal	Hope	Gap
	1	2	3	4	5					
1		1	3	2		19	3,2	3	4	0.8
2		2	2	2		18	3,0	3	4	1.0
3		1	4	1		18	3,0	3	4	1,0
4		1	3	2		19	3,2	3	4	0.8
5			4	2		20	3,3	3	4	0.7

Source: (Frangky, 2022)

From the PI Analysis Gap table, it can be seen that there are 5 statements with a Likert scale of 1-5, the respondents are 6 people where in statement 1 there is 1 respondent who chooses range 2, 3 people choose range 3 and 2 people choose range 4, so on until statement 5. In the table it can also be seen the

number of scores obtained from the number of respondents multiplied by the range of respondents' answers, while the gap value is the difference between the maturity value and the expected value (expected column).

Table 6. Gap Analysis Validation

Statemen	Responden					Score	Maturity Value	Minimal	Hope	Gap
	1	2	3	4	5					
1		2	2	2		18	3,0	3	4	1.7
2			4	2		20	3,3	3	4	0.7
3			3	3		21	3,5	3	4	0.5
4		1	2	3		20	3,3	3	4	0.7
5			2	4		22	3,7	3	4	0.3

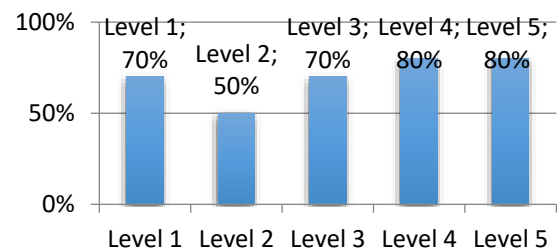
Source: (Frangky, 2022)

As in table 5 in the Gap Analysis Validation table 6, it can be seen that there are 5 statements with a Likert scale of 1-5, the respondents are 6 people where in statement 1 there are 2 respondents who choose range 2, 2 people choose range 3 and 2 people choose range 4, then so until statement 5. In the table it can also be seen the number of scores obtained from the number of respondents multiplied by the range of respondents' answers, while the gap value is the difference between the maturity value and the expected value (expected column). The following is the Gap Analysis of each Maturity level of Level 1, Level 2, Level 3, Level 4, and Level 5, as contained in table 6 below:

Table 7. Gap Analysis of Each Maturity Level

Level	Nilai Maturity	Harapan	Gap Nominal	Gap Presentase
Level 1	3,3	4	0,7	70%
Level 2	3,5	4	0,5	50%
Level 3	3,3	4	0,7	70%
Level 4	3,2	4	0,8	80%
Level 5	3,2	4	0,8	80%

Source: (Frangky, 2022)



Source: (Frangky, 2022)

Figure 2. Gap Analysis of Each Maturity

Based on table 6 and figure 2 above, it can be seen that the gap level of Maturity or Maturity Level at each level is level 1 has a gap rate of 70%, level 2 has a gap level of 50%, level 3 has a gap level of 70%, 4 has a gap rate of 80% and level 5 has a gap rate of 80%. From the value of the gap, it can be seen that the lowest level of inequality is at level 2, which is 50%, therefore it can be concluded that the level of organizational maturity is currently at level 2.

4. Giving Recommendations

After conducting a GAP analysis and getting the gap value in each maturity level, the following are general recommendations that are compiled based on the condition of the maturity level of the software development process maturity level at College of XX:

a. On Organization

1. The organization must ensure whether the process behaves in a consistent and stable manner
2. Identify all aspects of the process that can be improved in accordance with the existing SOP (Standard Operating Procedure)
3. Implement SDLC (system development life cycle)
4. Applying Activity Based coating
5. Carry out the data collection process automatically
6. Have an excellent feedback mechanism
7. Improve the quality of Human Resources and improve the quality of processes
8. Carry out project management

b. While the recommendations on the existing system

1. Ensure that software must depend on processes not on human resources
2. Organizations to implement quality assurance
3. Make good documentation
4. Perform software configuration with good management
5. Improve the management of SIAKAD and applications that are integrated with the system
6. Ensure continuous maintenance or system improvement
7. Ensure the integration of SIAKAD with existing applications runs as expected

CONCLUSION

The conclusion that can be formulated in this study, based on the results of the analysis of the maturity level of the software development process using the CMMI-Dev method, where the maturity level value is 3.5 with a nominal gap value of 0.5 and a presentation gap value of 50% is the lowest gap. . So it is concluded that college of xx. In carrying out a project, usually the process has been planned and carried out in accordance with existing policies, the human resources employed are people who are skilled in their fields and have other adequate resources to produce output in accordance with what has been determined to have been implemented. However, in its application there are still domains that must be improved and improved in order to reach the maximum level.

This conclusion is in accordance with the information obtained during interviews, that during the development period until now, College of XX has never measured the level of organizational maturity in the software development process, which causes the organization not to know what the performance or performance of the system is, and what kind of feedback. from users including students, lecturers, education staff on the performance of the system they have. Therefore, it

is important for organizations to evaluate and carry out all the recommendations that have been made, so that the software developed or even those that will be developed in the future have the quality in accordance with the organization's expectations. So that the level of organizational maturity in the software development process can be increased to a higher level.

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