

Capability Maturity Model for Software Engineering Education *

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Abstract: Good software engineering education plays a vital role to improve the software development ability. In China, many software engineering education institutions have been established in recent years. Current research on the software engineering education is mostly focused on the certain concrete courses and body of knowledge, which lacks the view as an integrated education process. How to evaluate the institutions' education capability and how to help them to improve their capability is a critical issue? This paper describes a model for measuring the maturity of software engineering education processes, which leverages the CMM (Capability Maturity Model) of software process. We call this model SEEDU-CMM (Capability Maturity Model for Software Engineering Education). SEEDU-CMM is used to evaluate the capability of the software engineering education institutions, as well as to provide guide for them to improve their education quality.

Key words: education process; maturity model; education quality

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1 Introduction

Since the end of 2001, the Ministry of Education of P. R. China started the project of pilot software institutes, which initiated the formal software engineering education in China. In that sense, in order to improve the software engineering education quality, it is important to research on the software engineering education that fits the situation of China, as well as the categorization of software engineering and computer science and technology disciplines together with their corresponding parts in the international computing disciplines^[1]. The Software Institute of Nanjing University has done some research in this area, where a rather complete software engineering curriculum is set up based on the teaching practice^[2]. This system provides a solid base to ensure education quality. Meanwhile, its software engineering education quality assurance system is set up to formalize the education and train the high-end software talents^[3]. And the corresponding software system is also implemented to support the quality assurance system policy successfully^[4]. However, the above ecosystem provides a good solution that targets on the case of the Software Institute of Nanjing University, and it cannot be applied directly for improving the software engineering education in general.

In statistics, the need for computer related talents in the China job market is the next to the largest^[5]. Therefore, there are quite a few institutions of software education, such as National Pilot Software Institutes, Software Institutes in universities, and college-level technology institutes. It is most important to provide the evaluation on their education capability, to provide a reference for recruiting companies and government financial support decisions. However, this is quite difficult at the current stage, as there is no generally acceptable standard for the evaluation. On the other hand, these institutions also need a suitable scheme to improve themselves.

It is possible to solve this problem using process model. A typical process includes three parts: process definition or description, process transfer, and process execution. Education is a process, in essence. In this education process, the process definition or description is the education method and curricula, the process transfer is represented as through a certain way to acknowledge all teachers with the education process, method and practice, while the process execution is to ensure teachers perform the education activities according to the defined process and method, which is the building of the education quality assurance system. Every process has input and output. In the process of edu-

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cation, both the input and the output are the object of education, i.e., students. Similar to other processes, the quality of the output depends largely on the quality of the process itself. Therefore, it is essential to research on the improvement of the quality of the education process, to fulfill the goal of improving that of the education.

This paper is divided into three sections. This first section introduces the current research on the education process. The second focuses on the description of an education process maturity framework. That is, based on different levels of maturity, it specifies the major aspects, as well as, typical contents to improve in each level. Also, this section describes the typical ways to apply the maturity framework. The last section discusses further work to detail framework content, to include the best practice within educational area and so on.

2 Current situation

Current software engineering education research mainly focus on the building of the body of knowledge, curricula and education quality assurance system. IEEE and ACM are the famous ones among them. They co-published CCSE (Computing Curriculum Software Engineering) and SWEBOK2004 (Software Engineering Body of Knowledge in 2004^[7, 8]), which is referenced by many research in the software engineering education area.

However, it is still lacking of the systematic research on the education process itself, especially the education process maturity. This prevents the research results as guides to improve the education process and quality.

3 SEEDU-CMM (Capability Maturity Model for Software Engineering Education)

Using the process concept to research on education, the education activity as a whole is regarded as a controllable, measurable and improvable process. With a well defined maturity framework, the aspects of different levels of education process maturity are described, and thus to improve the education process. A typical improving process is [6]:

1) Evaluate the maturity level by comparing with the defined process aspects to understand the current education process status.

2) Decide the direction of improvements through the definition of ideal education vision.

3) Generate the action plan list for improving the education process, for prioritization.

4) Set up the action plan, which is used as the guide to improve education process.

5) Provide required resources to put the improvement into practice.

The framework described in this paper well supports the above education process improvement steps. With this framework, the education institution is able to acknowledge its own status and understand the areas to improve, thus makes the improvement more effective and continuously.

A SEEDU-CMM Framework

Refer to the way to indicate the evolution from immature to mature in the software process capability maturity model, there are five levels of education process maturity recognized: the initial level, the managed level, the defined level, the quantitatively managed level, and the optimizing level. Each level is based on the previous one. The following describes the aspects in each level and the typical improvements for each of them.

Initial level Institutions in this level barely accomplish the desired education, but the process is ad-hoc. There is no basic education flow regulation, or definite education objectives, or detailed education plans, or scoped education content, or pre-defined curricula. The course arrangement lies on the available personnel, but not the actual need. Therefore the education quality mostly relies on the specific instructor, which means there is no guarantee of the quality. Thus the education quality is in an unknown status. For those institutions in this level, the typical improvements they can take are:

- Set up the defined education objectives.
- Establish detailed education plans and enforce them with management.
- Build the curricula based on the knowledge system.
- Set up and enforce the education quality assurance system.

Managed level Institutions in this level has the basic aspects of management, not only the basic teaching activities. There are relative complete body of

knowledge system and curricula built on top of course level or related course module^[2]. Also the defined education objectives are set up accordingly. Detailed education plans are established to fulfill the education objectives, and they are managed and tracked during the actual education activities. Therefore, the education plans can be performed and thus the education objectives are achieved. There are corresponding education quality assurance mechanism and education process information measurement, analysis, storage and share mechanism. Thus, it can adjust the course or course module according to the industry requirement. For those institutions in this level, the major aspects of the education process management are that the courses or the course modules lack the unified integration. Therefore, the typical improvements for them are:

- Build and maintain discipline level body of knowledge system and curricula
- Build and maintain discipline level complete education plans
- Build and maintain discipline level education process, define the course mandatory and elective activities accordingly
- Build the feedback mechanism on the discipline level to actively respond to the industry needs

Defined level. Institutions in this level have built complete body of knowledge system and curricula. Also with corresponding mechanism to ensure the effective and reasonable course setup, the courses will cover the whole knowledge system as much as possible, while avoiding the overlap of the same knowledge points in different courses^[4]. On the top of this, the mandatory education activities and contents are defined concerning the specialty of different courses. Thus, instructors are able to arrange their course content and teaching plans, and the education quality assurance mechanism is built tending toward perfection to track and manage the education activities. With this feedback mechanism, the model can actively respond to the industry need. However, this response is not ad hoc, but should be coordinated on the discipline level. That is, a maintenance team is formed for building knowledge system, curricula and quality assurance system on the discipline level, and evaluating the education process status regularly or by incident driven, to improve the education process. For those institutions falling into this level, the man-

agement is not data centered but quality control centered. Therefore, the typical improvements for them are:

- Set up and maintain quantified objectives in the discipline level to characterize the education process performance
- Build mechanism in the quality assurance system to ensure the quantified objectives are fulfilled

Quantitatively managed level. In this level, institutions have set up the quantitative objectives, such as course coverage, teaching time, grade distribution, and deviation range, for characterizing the education process performance. With these quantitative objectives, detailed education plans and the corresponding quality assurance mechanism are built to fulfill them. The deviation between the education plans and the actual process can be identified and reduced accordingly. The quantitative model is able to analyze statistically on the data collected during the education process, while the analyzing results will guide the education process in the future, thus the process is more stable along with time. For the institutions in this level, they have adequate procedural data collection and focused on stabilizing the education process. However, it lacks the adjustment and improvement for the education process itself. So the typical improvements for them are:

- Build and maintain root cause analysis and prevention mechanism
- Build and maintain the import mechanism for new education methodologies and education processes

Optimizing level. Institutions in this level have built the risk cause analysis and prevention mechanisms. There is the dedicated team to discuss regularly on the problems occurred during the education process, and to solve these problems from source so that the same problem does not re-occur. In addition, it sets up the criteria to manage the import of new education process and methodology. In general, the new process or methodology will be experimented in a small range to collect enough data for analysis, and then fully import the effective new process or methodology. For these institutions, persistent optimization on the education process is habitual, and the education quality is improved continuously.

B Application of the SEEDU-CMM framework

The SEEDU-CMM model describes the evolution

of the education process from immature to mature. There are two approaches to apply it:

- Build the corresponding education process evaluation system based on the framework. The system is used to evaluate the level of a certain education institution by comparing to the typical aspects defined in each maturity level. This evaluation result makes it clear to the institution about its pros and cons, and serves as the starting point to improve.

- It provides the guide to improve the education process. As the framework provides the route to the education process maturity, any institution can leverage the evaluation results, and design the suitable improvement plans by referring to the maturity goal.

4 Future work

The above stated framework captures the typical aspects of the education process in each maturity level, which is enough to meet the goal of process evaluation and improvement. However, there is some further work ahead.

Detailing of the SEEDU-CMM framework content: there is work on the definition of process sections that are related with the education process, referring to the method for organizing the process section in CMMI. Combined with the best practices in the education area, this work will enrich the framework content and make it easier to apply.

Design of evaluation survey: One of the important usages of this framework is to evaluate the education process. In order to assist the evaluation, it is worthwhile to organize a well-designed survey to help judge the process aspects.

Application in other education areas: Most the current statements are focused on the software engineer-

ing education area, and it is because of its uniqueness. However, it is both challenging and significant to investigate its extensibility to other education areas.

5 Conclusion

The quality of the education process itself is as important, and thus deserves attention, as the perfection of software engineering body of knowledge system, curricula and quality assurance system. The capability maturity framework presented in this paper can be used as the evaluation system, to help institutions understand their own status. It can also be used as the guide to help them improve the education process, therefore to improve the education level and quality.

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