

Practical Ability Evaluation System of College Students Based on CMMI and AHP

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ABSTRACT

CMMI is an evaluation standard of software capability maturity usually used at the beginning of software design. Its main function is to guide the process of software development and improvement through the evaluation of software development capability. In this paper, CMMI is used to evaluate the practical ability of college students, so as to improve the current evaluation system of college students' practical ability. This paper applies the CMMI method to the evaluation system of college students' practical ability, analyzes this kind of ability of college students from multiple angles, and determines the practical ability of students as five progressive levels: initial stage, repeatable level, standard level, quantitative management level and optimization level, forming a relatively complete evaluation system of college students' practical ability based on CMMI, and combining with the analytic hierarchy process (AHP) It also provides an objective evaluation model for college students to improve their practical ability.

Keywords: CMMI, College students' practical ability, Evaluation system, Analytic hierarchy process.

1. INTRODUCTION

1.1. Overview of CMMI

CMMI (Capability Maturity Model Integration), namely capability maturity integration model, is a multi-disciplinary and extensible product set [1]. Its primary motivation is to use multi-disciplinary model to manage and improve the integration process of an organization. CMMI constructs a new integrated model framework in the process of improving an organization, so as to eliminate the inconsistency between models, reduce the repeatability of each model, and increase the comprehensibility and transparency, so as to build an automatic and extensible organizational framework [2]. Therefore, it is capable to improve the quality and efficiency of the organization as a whole. For example, the purpose of CMMI application in software development is to help software enterprises manage, control and improve the software development process, so as to ensure that the software can deliver high-quality software products to customers within the time expectation and budget [3]. The method is to continuously strive to build an effective basic model structure of software engineering process, and constantly improve practice management in the process to overcome the problems encountered in software development.

CMMI model describes the process capability of software phase and establishes the grading standard of software process maturity [4-6]. It is divided into five levels, and provides an orderly and progressive improvement standard and direction for software enterprises to evaluate the process capability of developing software, as shown in Figure 1.

CMMI consists of five levels and four processes. Each level corresponds to a set of objectives (except the first level). If the software process reaches the corresponding set of objectives, it indicates that it has achieved the corresponding maturity level and can continue to advance to a higher level. In CMMI evaluation

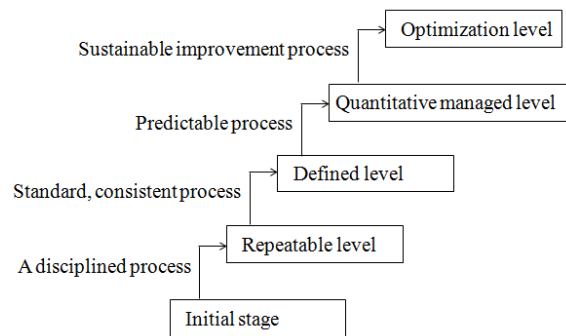


Figure 1 CMMI capability maturity level chart

management system, cross level evaluation is not recommended in principle, and the realization of its low-level objectives is the basis for the realization of the upper level objectives.

CMMI is the basic model for enterprises to implement system engineering production process and the improvement. It emphasizes what to do rather than how to do it. It pays more attention to the key elements in the process, neglecting the secondary factors rather than comprehensiveness. Its process improvement also depends on each stage matter and procedure to realize [7].

1.2. Application of CMMI in Practical Ability Evaluation of College Students

CMMI is proposed on the basis of CMM (Capability Maturity Model Integration). It inherits and develops the excellent characteristics of CMM, draws on the advantages of other models, and integrates new theoretical and practical research results [8]. CMMI is the integration of multiple models based on CMM, which expands the application scope of CMM, and can improve the integrated model of engineering development. CMMI can be used not only in process management, transformation and evaluation of software engineering, but also in systems engineering, human resource management and other fields. This is mainly because many engineering and management fields need to have a level of evaluation and analysis, and it is also expected that each level can reach the corresponding maturity [7, 8].

Currently, the practical ability of college students trained by many colleges and universities is generally weak, which leads to employment difficulties to a certain extent. The cultivation of practical ability of college students has become a common concern [9]. The practical ability of students can be investigated from the aspects of experiment, competition, training, extracurricular practice and internship. If the students' practical ability can be evaluated by stages with the corresponding maturity model, it will be very helpful for teachers or enterprises to get to know students' practical ability level and carry out targeted training and improvement according to the model [10-12]. It is available to design an evaluation system based on CMMI to analyse and evaluate the practical ability of college students

In the evaluation system, the practical ability of college students is divided into five levels:

- Initial stage: weak practical ability.
- Repeatable level: the practical ability is not strong enough.
- Standard level: have certain practical ability.
- Quantitative management level: strong practical ability.
- Optimization level: excellent practical ability.

At each level, the evaluation is carried out from eight factors, namely: professional quality, social practice, various competitions, curriculum design, daily homework, attendance, academic year grade points and professional core courses. The specific classification and evaluation criteria are shown in Table 1.

2. THE HIERARCHICAL ANALYSIS OF COLLEGE STUDENTS' PRACTICAL ABILITY EVALUATION SYSTEM BASED ON CMMI

2.1. Establishment of Hierarchy

Analytic hierarchy process (AHP) is a multi-objective decision analysis method which combines qualitative and quantitative analysis methods [13, 14]. The core idea is to decompose a complex problem into multiple levels and multiple factors, compare the importance of any two (a pair) indicators in each level, and give the management degree or contribution degree of the relationship between them in a quantitative way, so as to establish a judgment matrix [15, 16]. By calculating the maximum eigenvalue of the judgment matrix and its corresponding eigenvector, the importance degree of different determinants, namely weight, is obtained [17-19].

Target level A, college students' practical ability level: it is a comprehensive evaluation of college students' practical ability, which can be evaluated from professional quality, social practice, discipline competition, curriculum design, daily work, attendance, academic year credit points, professional core course scores, etc., shown as Figure 2.

Standard layer B1, professional quality: it refers to the quality and cultivation reflected in the professional aspects of an individual, including professional ethics, professional awareness and professional behaviour habits.

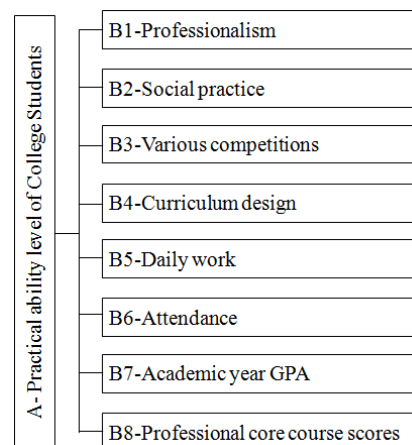


Figure 2 Target level and Standard layer of evaluation system

Table 1. Evaluation system of College Students' practical ability based on CMMI

| project | Initial stage | Repeatable level | Standard level | Quantitative management level | Optimization level | |
|-------------------------|---------------------------------|--|--|--|---|---|
| Practical ability level | Weak practical ability | Have certain practical ability | Strong practical ability | Very strong practical ability | Excellent practical ability | |
| evaluation criterion | Professionalism | Master the basic theory of this major | Master the knowledge structure of this major | Master the typical methods of this major | Master the thinking mind research methods of this major | Use the knowledge to solve practical problems |
| | Social practice | No practical experience | Less practical experience | Rich practical experience | Rich and comprehensive practical experience | Ability to translate experience into practical ability |
| | Various competitions | Rarely take part in competitions | Many competitions, but few awards | Often participate in competitions, get smaller awards | Often participate in competitions and win many prizes | Often participate in the competition, and can be in the top |
| | Curriculum design | Unable to do the course design on time | Course design is not perfect | Complete the course design on time according to the requirements | Complete all course design and make optimization | Complete the course design effectively, and be innovative |
| | Daily work | Complete part of the work | Finish the homework, but not in time | Finish homework on time, but the quality is not high | Finish work with high quality and high efficiency | Do high-quality work, and do additional work |
| | Attendance | Frequent absenteeism | Occasional absence | Not absent, but occasionally late or leave early | No absence, no lateness, no early leave | Take the initiative to go to self-study |
| | Academic year GPA | Less than 2.5 | 2.5—3.0 | 3.0—3.5 | 3.5—4.0 | Above 4.0 |
| | Professional core course scores | Less than 60 points | 60—69 | 70—79 | 80—89 | Above 90 points |

Criterion layer B2, social practice: this is an important index to measure the practical ability of college students. By examining a person's enthusiasm, experience and attitude towards practice, the assessment can be more accurate and efficient.

Criteria level B3, all kinds of competitions: competition is a process of mutual learning and communication, and also a way to train college students' team cooperation ability and study practice [20]. The frequency and achievements of a college student participating in various competitions can reflect the strength of their practical ability.

Criteria level B4, curriculum design: curriculum design is a simple performance of applying theoretical knowledge to solve practical problems, which can also reflect the strength of students' practical ability to a certain extent [21]. In the module of the curriculum design, there are three aspects to investigate: whether it can be done on time, whether it can be completed independently and the quality of the course design.

Standard layer B5, daily work: the completion of daily work is mainly judged from three aspects: whether the work can be submitted on time, whether the work can be completed independently and the quality of the work finished.

Criteria level B6, attendance: People's spiritual strength is very important, a person's psychological age,

his strong will, and his optimistic character can often have an inestimable impact on the person's ability indicators. The attendance situation focuses on whether the students meet the daily education, self-control and willpower. Attendance rate, tardiness rate and early leave rate account for a large proportion of personal attendance.

Criteria level B7, academic year GPA: General point average (GPA) is generally used to measure the quantity and quality of students' learning. The standard of whether students can graduate and get a degree is to obtain the necessary credits and average GPA stipulated by the university. GPA can be understood as the embodiment of the learning quality of each course, reflecting the degree of students' mastery of these courses' knowledge, and the GPA can well measure the learning ability and level of college students.

Standard level B8, professional core course performance: professional core curriculum is the soul of professional curriculum system, which plays a decisive role in realizing the training objectives of applied talents, improving the core competitiveness of majors and supporting the ability cultivation of applied talents. Professional core course performance is an important index to evaluate the professional skills of a college student.

2.2. Construction of Judgment Matrix and Weight Analysis

According to the hierarchical structure of the evaluation system of college students' practical ability, considering the steps of analytic hierarchy process, there are

$$A = \begin{pmatrix} \frac{B1}{B1} & \frac{B1}{B2} & \frac{B1}{B3} & \frac{B1}{B4} & \frac{B1}{B5} & \frac{B1}{B6} & \frac{B1}{B7} & \frac{B1}{B8} \\ \frac{B2}{B1} & \frac{B2}{B2} & \frac{B2}{B3} & \frac{B2}{B4} & \frac{B2}{B5} & \frac{B2}{B6} & \frac{B2}{B7} & \frac{B2}{B8} \\ \frac{B3}{B1} & \frac{B3}{B2} & \frac{B3}{B3} & \frac{B3}{B4} & \frac{B3}{B5} & \frac{B3}{B6} & \frac{B3}{B7} & \frac{B3}{B8} \\ \frac{B4}{B1} & \frac{B4}{B2} & \frac{B4}{B3} & \frac{B4}{B4} & \frac{B4}{B5} & \frac{B4}{B6} & \frac{B4}{B7} & \frac{B4}{B8} \\ \frac{B5}{B1} & \frac{B5}{B2} & \frac{B5}{B3} & \frac{B5}{B4} & \frac{B5}{B5} & \frac{B5}{B6} & \frac{B5}{B7} & \frac{B5}{B8} \\ \frac{B6}{B1} & \frac{B6}{B2} & \frac{B6}{B3} & \frac{B6}{B4} & \frac{B6}{B5} & \frac{B6}{B6} & \frac{B6}{B7} & \frac{B6}{B8} \\ \frac{B7}{B1} & \frac{B7}{B2} & \frac{B7}{B3} & \frac{B7}{B4} & \frac{B7}{B5} & \frac{B7}{B6} & \frac{B7}{B7} & \frac{B7}{B8} \\ \frac{B8}{B1} & \frac{B8}{B2} & \frac{B8}{B3} & \frac{B8}{B4} & \frac{B8}{B5} & \frac{B8}{B6} & \frac{B8}{B7} & \frac{B8}{B8} \end{pmatrix} = \begin{pmatrix} 1 & 1/3 & 3 & 5 & 7 & 7 & 5 & 5 \\ 3 & 1 & 5 & 7 & 9 & 9 & 7 & 7 \\ 1/3 & 1/5 & 1 & 3 & 5 & 5 & 3 & 3 \\ 1/5 & 1/7 & 1/3 & 1 & 3 & 3 & 1 & 1 \\ 1/7 & 1/9 & 1/5 & 1/3 & 1 & 1 & 1/3 & 1/3 \\ 1/7 & 1/9 & 1/5 & 1/3 & 1 & 1 & 1/3 & 1/3 \\ 1/5 & 1/7 & 1/3 & 1 & 3 & 3 & 1 & 1 \\ 1/5 & 1/7 & 1/3 & 1 & 3 & 3 & 1 & 1 \end{pmatrix} \tag{1}$$

According to the calculation method of matrix eigenvalue, eigenvector, inhibitory index CI and consistency ratio Cr, the maximum eigenvalue $\lambda = 8.3109$, and the eigenvector corresponding to the maximum eigenvalue $\omega = (0.4717, 0.8183, 0.2533, 0.1134, 0.0511, 0.0511, 0.1134, 0.1134)$ τ is obtained [22]. The consistency index CI = 0.0444, the evaluation consistency index RI = 1.41, the consistency ratio CR = 0.031 < 0.1, the consistency check passed.

(2) Criterion layer B1 - factor layer C matrix and weight analysis

Criterion layer B1-Judgment matrix of factor layer C is:

$$B1 = \begin{pmatrix} \frac{C1}{C1} & \frac{C1}{C2} & \frac{C1}{C3} & \frac{C1}{C4} \\ \frac{C2}{C1} & \frac{C2}{C2} & \frac{C2}{C3} & \frac{C2}{C4} \\ \frac{C3}{C1} & \frac{C3}{C2} & \frac{C3}{C3} & \frac{C3}{C4} \\ \frac{C4}{C1} & \frac{C4}{C2} & \frac{C4}{C3} & \frac{C4}{C4} \end{pmatrix} = \begin{pmatrix} 1 & 1 & 1 & 1 \\ 1 & 1 & 1 & 1 \\ 1 & 1 & 1 & 1 \\ 1 & 1 & 1 & 1 \end{pmatrix} \tag{2}$$

Considering the calculation method of matrix eigenvalue, eigenvector, consistency index CI and consistency ratio Cr, the maximum eigenvalue $\lambda = 4.0000$, and the corresponding eigenvector $\omega = (0.5000, 0.5000, 0.5000)$ τ can be achieved. The consistency index CI = 0, the evaluation consistency index RI = 0.90, the consistency ratio CR = 0 < 0.1, and the consistency check passed.

(3) Criterion layer B2 - factor layer C matrix and weight analysis

Criterion layer B2, Judgment matrix of factor layer C refers to:

nine relation matrixes in the hierarchical relationship of the evaluation system of college students' practical ability

(1) A-layer criteria and target weight matrix analysis

Target layer - Criteria layer judgment matrix:

$$B2 = \begin{pmatrix} \frac{C5}{C5} & \frac{C5}{C6} & \frac{C5}{C7} & \frac{C5}{C8} \\ \frac{C6}{C5} & \frac{C6}{C6} & \frac{C6}{C7} & \frac{C6}{C8} \\ \frac{C7}{C5} & \frac{C7}{C6} & \frac{C7}{C7} & \frac{C7}{C8} \\ \frac{C8}{C5} & \frac{C8}{C6} & \frac{C8}{C7} & \frac{C8}{C8} \end{pmatrix} = \begin{pmatrix} 1 & 1 & 2 & 2 \\ 1 & 1 & 2 & 2 \\ 1/2 & 1/2 & 1 & 1 \\ 1/2 & 1/2 & 1 & 1 \end{pmatrix} \tag{3}$$

In the light of the calculation method of matrix eigenvalue, eigenvector, consistency index CI and consistency ratio Cr, the maximum eigenvalue $\lambda = 4.0000$, and the corresponding eigenvector $\omega = (0.6325, 0.6325, 0.3162, 0.3162)$ τ is then obtained. The consistency index CI = 0, the evaluation consistency index RI = 0.90, the consistency ratio CR = 0 < 0.1, the consistency check passed.

(4) Criterion layer B3 - factor layer C matrix and weight analysis

Judgment matrix of criterion layer B3 factor layer C is shown as:

$$B3 = \begin{pmatrix} \frac{C9}{C9} & \frac{C9}{C10} & \frac{C9}{C11} \\ \frac{C10}{C9} & \frac{C10}{C10} & \frac{C10}{C11} \\ \frac{C11}{C9} & \frac{C11}{C10} & \frac{C11}{C11} \end{pmatrix} = \begin{pmatrix} 1 & 1 & 4 \\ 1 & 1 & 4 \\ 1/4 & 1/4 & 1 \end{pmatrix} \tag{4}$$

In accordance with the calculation method of matrix eigenvalue, eigenvector, consistency index CI and consistency ratio Cr, the maximum eigenvalue $\lambda = 3.0000$ and the corresponding eigenvector $\omega = (0.6963, 0.6963, 0.1741)$ τ can be obtained. The consistency index CI = 0, the evaluation consistency index RI = 0.58, the con-

sistency ratio $CR = 0 < 0.1$, the consistency check passed.

(5) Criterion layer B4 - factor layer C matrix and weight analysis

Criterion layer B4 - judgment matrix of factor layer C is:

$$B4 = \begin{pmatrix} \frac{c12}{c12} & \frac{c12}{c13} & \frac{c12}{c14} \\ \frac{c13}{c12} & \frac{c13}{c13} & \frac{c13}{c14} \\ \frac{c14}{c12} & \frac{c14}{c13} & \frac{c14}{c14} \end{pmatrix} = \begin{pmatrix} 1 & 1 & 1/3 \\ 1 & 1 & 1/3 \\ 3 & 3 & 1 \end{pmatrix} \quad (5)$$

In line with the calculation method of matrix eigenvalue, eigenvector, consistency index CI and consistency ratio Cr, the maximum eigenvalue $\lambda = 3.0000$ and the corresponding eigenvector $\omega = (0.3015, 0.3015, 0.9045)$ τ can be got. The consistency index $CI = 0$, the evaluation consistency index $RI = 0.58$, the consistency ratio $CR = 0 < 0.1$, the consistency check passed.

(6) Criterion layer B5 - factor layer C matrix and weight analysis

Criterion layer B5 - judgment matrix of factor layer C refers to:

$$B5 = \begin{pmatrix} \frac{c15}{c15} & \frac{c15}{c16} & \frac{c15}{c17} \\ \frac{c16}{c15} & \frac{c16}{c16} & \frac{c16}{c17} \\ \frac{c17}{c15} & \frac{c17}{c16} & \frac{c17}{c17} \end{pmatrix} = \begin{pmatrix} 1 & 1 & 1/3 \\ 1 & 1 & 1/3 \\ 3 & 3 & 1 \end{pmatrix} \quad (6)$$

Using the calculation method of matrix eigenvalue, eigenvector, consistency index CI and consistency ratio Cr, the maximum eigenvalue $\lambda = 3.0000$ and the corresponding eigenvector $\omega = (0.3015, 0.3015, 0.9045)$ τ is able to be got. The consistency index $CI = 0$, the evaluation consistency index $RI = 0.58$, the consistency ratio $CR = 0 < 0.1$, the consistency check passed.

(7) Criterion layer B6 - factor layer C matrix and weight analysis

The judgment matrix of criterion layer B6 - factor layer C is:

$$B6 = \begin{pmatrix} \frac{c18}{c18} & \frac{c18}{c19} & \frac{c18}{c20} \\ \frac{c19}{c18} & \frac{c19}{c19} & \frac{c19}{c20} \\ \frac{c20}{c18} & \frac{c20}{c19} & \frac{c20}{c20} \end{pmatrix} = \begin{pmatrix} 1 & 6 & 6 \\ 1/6 & 1 & 1 \\ 1/6 & 1 & 1 \end{pmatrix} \quad (7)$$

Through the calculation method of matrix eigenvalue, eigenvector, consistency index CI and consistency ratio Cr, the maximum eigenvalue $\lambda = 3.0000$ and the corresponding eigenvector $\omega = (0.9733, 0.1622, 0.1622)$ τ can be obtained. The consistency index $CI = 0$, the evaluation consistency index $RI = 0.58$, the consistency ratio $CR = 0 < 0.1$, the consistency check passed.

(8) Criteria layer B7 - factor layer C matrix and weight analysis

At this time, the factor layer only contains one element, CI and RI are 0 at the same time, and the consistency check is passed.

(9) Criterion layer B8 - factor layer C matrix and weight analysis

At this time, the factor layer only contains one element, CI and RI are 0 at the same time, and the consistency check is passed.

3. HIERARCHY FACTOR WEIGHT OF EVALUATION SYSTEM

Table 2 shows the weight table of hierarchical factors of College Students' practical ability evaluation system based on CMMI.

By means of the analytic hierarchy process of the evaluation system of College Students' practical ability based on CMMI, it is available to find out the key factors affecting the practical ability of college students, and find out the obstacles in the development process of College Students' practical ability [23]. On this basis, we can build a scientific and perfect evaluation system of College Students' practical ability. Through the evaluation system, we can guide the practice of college students, so as to improve the practical ability of college students.

4. CONCLUSION

The practical ability of college students is an important indicator of training objectives, and its objectivity, accuracy and scientificity are often affected by too many subjective descriptions. The establishment of an automatic, objective, scientific and complete evaluation system is helpful to evaluate the practical ability of college students timely and accurately, and guide them to improve their practical ability.

This paper studies some ideas and methods of CMMI evaluation system in the process management and control. According to current evaluation methods and experience of universities, this paper constructs the process management and improvement evaluation index system of College Students' practical ability training. On this basis, the analytic hierarchy process (AHP) is used to analyse and calculate the index weight in the evaluation system of College Students' practical ability. It is found that the CMMI system and analytic hierarchy process can avoid the defects of using descriptive qualitative evaluation and analysis of College Students' practical ability, and get relatively objective, accurate and scientific evaluation indicators and evaluation process and results, so as to provide more useful guidance for the cultivation and development of College Students' practical ability.

Table 2. Hierarchy factor weight of evaluation system

| Criterion layer | Weight of criterion layer | Factor layer | Weight of factor layer |
|---------------------------------|---------------------------|------------------------------|------------------------|
| Professionalism | 0.2 | Professional achievements | 0.05 |
| | | Professional operation | 0.05 |
| | | Professional knowledge | 0.05 |
| | | Professional academic | 0.05 |
| social practice | 0.25 | Practice enthusiasm | 0.075 |
| | | Frequency of practice | 0.075 |
| | | Practice mentality | 0.05 |
| | | Practical attitude | 0.05 |
| Various competitions | 0.15 | Competition frequency | 0.06 |
| | | Awards | 0.06 |
| | | Competition ranking | 0.03 |
| curriculum design | 0.1 | Curriculum design efficiency | 0.03 |
| | | Curriculum design ability | 0.03 |
| | | Curriculum design quality | 0.04 |
| Daily work | 0.05 | Work efficiency | 0.015 |
| | | Answering ability | 0.015 |
| | | Homework quality | 0.02 |
| Attendance | 0.05 | Absence rate | 0.03 |
| | | Late rate | 0.01 |
| | | Early leave rate | 0.01 |
| Academic year GPA | 0.1 | grade point | 0.1 |
| Professional core course scores | 0.1 | Core course scores | 0.1 |

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