Research on the Performance Assessment of Teaching Cloud Platform Based on Fuzzy Comprehensive Evaluation

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Abstract. Teaching cloud platform is a complex system in which enterprises, teachers, experts, and students participate together. The quality of teaching platform based on cloud computing is directly related to the normal development and effect of teaching work. According to the principle of comprehensive evaluation of an information system, the performance evaluation index system model of teaching cloud platform is first constructed. Then evaluation research with fuzzy comprehensive evaluation method is conducted on the system. Finally, experimental verification on an example is completed.

1. Introduction
With the rapid development of cloud computing technology, many colleges and universities have carried out the construction of teaching platform based on cloud computing. The importance of cloud computing platform in teaching is becoming increasingly prominent [1, 2]. The quality of cloud computing teaching platform is directly related to the normal development and effect of teaching work. Therefore, the evaluation of teaching cloud platforms has become a hot topic. The evaluation index system of teaching cloud platform is designed to correctly evaluate teaching cloud platforms comprehensively to provide decision data support for teaching units or relevant departments. It also can help improve the performance of teaching cloud platforms to generate greater social and economic benefits.

2. Establishment of evaluation index system
Some important characteristics include scientific, systematic, measurable and hierarchical characteristics of an evaluation index system are the keys to effectively evaluate cloud computing platforms [3]. Evaluation indexes should not only be able to scientifically and accurately measure the efficiency of the system, but also have the characteristics of low operational difficulty, convenient implementation and economic feasibility. The first grade index of teaching cloud platform includes teaching indicator, technology indicator, service indicator and other indicator. And each first grade indicator is composed of five second grade indicators. All evaluation indexes of teaching cloud platform are shown in Table 1.

The first grade teaching index focuses on the evaluation of the teaching effect, which is evaluated from the aspects of advanced concept, target accuracy, content accuracy, method effectiveness, and method diversity. Here, advanced concept refers to learning theory, target accuracy refers to the accuracy of teaching objectives, content accuracy is used to evaluate whether the content is suitable for learners' needs. Method effectiveness is used to evaluate the effectiveness of teaching methods,
such as whether teaching focuses, diffuses difficulties, is easy for learners to accept, whether teaching strategies and learning strategies are in place, and whether operational demonstration meets the requirements; Method diversity evaluates whether to provide a variety of teaching and learning tools, good at guidance. The data sources of the evaluation indexes are mainly from demand documents and effect evaluation data.

Table 1  Evaluation indexes of teaching cloud platform

| Grade | Index 1 | Index 2 | Index 3 | Index 4 |
|-------|---------|---------|---------|---------|
| 1st   | U_1: teaching | U_2: technology | U_3: service | U_4: other |
| 2nd   | C_1: advanced concept | C_6: system security | C_11: personalized services | C_16: continuity of application |
|       | C_2: target accuracy | C_7: data security | C_12: value-added services | C_17: platform openness |
|       | C_3: content accuracy | C_8: log review | C_13: storage retrieval efficiency | C_18: service manageability |
|       | C_4: method effectiveness | C_9: application security | C_14: resource migration | C_19: terminal support capability |
|       | C_5: method diversity | C_10: monitoring and event handling | C_15: efficiency and manageability | C_20: workload management |

The first grade technical indicator focuses on the evaluation of platform technology, which is evaluated from the aspects of system security, data security, log review, application security management, monitoring and event processing. Here, system security evaluates cloud operating system kernel security and cloud infrastructure security; data security indicator is used to evaluate the safety and effectiveness of core data management; log review indicator is used to evaluate platform whether to review system log; application security evaluate platform application security management, visitor identity security management; monitoring and event processing evaluates the security monitoring and emergency handling capacity of cloud platform. The index evaluation is mainly based on design document, development document and test document, which are evaluated by experts.

The first grade service indicator focuses on the evaluation of platform services, which is evaluated from the aspects of personalized service, value-added service, storage and retrieval efficiency, resource migration, efficiency and manageability. Here, personalized service evaluates personalized teaching service types; value-added services evaluates the types of services in cloud applications; storage and retrieval efficiency evaluates the cloud storage and retrieval efficiency of database; resource migration evaluates the resource mobility from traditional teaching platform to cloud environment; efficiency and manageability evaluates the efficiency and manageability of cloud platform application services. The index evaluation is mainly based on user satisfaction data, system normal operation rate and application efficiency test.

The first grade other indicator focuses on the evaluation of the platform's capability in terms of performance, service and application development. It is evaluated from the aspects of application continuity, platform openness, cloud service manageability, terminal support ability, workload management and so on. Here, application continuity is used to evaluate the security and continuity of cloud application services. Platform openness is applied to evaluating openness of cloud development platform; service manageability evaluates platform cloud application and cloud service manageability; terminal support capability evaluates platform cloud application platform; workload management evaluates the dynamic workload and resource management capabilities of the cloud platform. The evaluation is mainly based on cloud technology, cloud service specification and system test.

3. The process of evaluation

3.1. Establishment of expert group for evaluation

In order to accurately evaluate the teaching cloud platform system, the expert group for evaluation are generally from domain experts, senior managers and users. The evaluation set of the teaching cloud
platform is divided into five levels. The collection of their comments is \( V = \{v_1, v_2, v_3, v_4, v_5\} \). The order from \( v_1 \) to \( v_5 \) is one to five. Level one is the highest and level five is the lowest.

### 3.2. Determine index weight

Fuzzy comprehensive evaluation [4] is used to calculate the index weight. The steps are as follows: a questionnaire is designed according to structural model, and the questionnaire is issued to domain experts in the expert group. Experts are invited to judge the mutual importance of the evaluation index system of teaching cloud platform at all levels.

1. **Construct judgment matrix**
   
   The method first constructs the judgment matrix by pant wise comparison. The scale from 1 to 9 is used to represent the judgment difference. Let \( A \) represent the evaluation objective, \( U \) represent the evaluation index set, \( u_i \) denote the evaluation index. Here, \( u_i \in U, (i=1, 2, ..., n) \), \( u_{ij} \) represents the relative importance of \( u_i \) to \( u_j \) (\( j=1, 2, ..., n \)).

2. **Calculate the order of importance**
   
   The geometric average method is used to find out the eigenvector corresponding to the maximum eigenroot \( \lambda_{\text{max}} \) of the matrix \( U \), and normalize the treatment[5]. The formula is:
   
   \[
   W_i = \frac{\left( \prod_{j=1}^{n} u_{ij} \right)^{\frac{1}{n}}}{\sum_{i=1}^{n} \left( \prod_{j=1}^{n} u_{ij} \right)^{\frac{1}{n}}}.
   \]  
   (1)

   Here, \( i = 1, 2, ..., n, j = 1, 2, ..., n \), and \( W = (W_1, W_2, ..., W_n)^T \) is the eigenvector.

3. **Calculate the ranking of comprehensive weights**
   
   The calculation of total weight distribution can be expressed as:
   
   \[
   W = \sum_{j=1}^{p} WU_j * WC_{ij}, p \in \{1, 2, 3, 4\}
   \]  
   (2)

   Here, \( WU_j \) represents \( U_j \) weight of importance relative to \( A \), \( WC_{ij} \) represents \( C_{ij} \) weight of importance relative to \( U_j \). \( WC_{ij} = 0 \) when \( U_j \) has nothing to do with \( C_{ij} \).

### 3.3. Determine the membership degree of indicators

When domain experts, senior managers and users evaluate a teaching cloud platform together according to the determined comment set, the evaluation result can be represented as:

\[
R = (r_{ij})_{m \times l}
\]  
(3)

In the matrix \( R \), it represents the percentage of number of people evaluating the \( j \)-grade of the \( i \)-th evaluation index in total number of experts, i.e. \( r_{ij} = d_{ij} / D \). \( d_{ij} \) represents the number of people who have assessed the \( i \)-th evaluation index with the \( j \)-th rating. \( D \) represents the total number of expert groups, \( m \) represents the number of indicators, and \( l \) represents the number of assessment grades.

### 3.4. Calculate valuation

After the membership matrix \( R \) is obtained, \( S = W * R \) can be used to calculate the evaluation value. If the evaluation set is quantified, the comprehensive evaluation value can be calculated by:

\[
P = V * S^T
\]  
(4)

### 4. Experiment and result analysis

The following is a concrete example to illustrate how to evaluate a teaching cloud platform. The evaluation structure model was shown in Table 1, and fuzzy comprehensive evaluation method is used to evaluate the teaching cloud platform [5].

1. **Calculate weights**
In order to determine the index weights, 7 domain experts were invited to evaluate. Fuzzy comprehensive evaluation method was used to conduct consistency test according to the constructed judgment matrix. After meeting the requirements, the judgment matrix $C$ of 7 experts was synthesized by geometric average method to obtain the comprehensive judgment matrix and the weight values calculated are:

$$U = (0.291, 0.273, 0.231, 0.205)$$

$$C = \left( \begin{array}{cccc}
0.081 & 0.042 & 0.081 & 0.063 & 0.024 & 0.075 & 0.081 & 0.045 & 0.035 & 0.037 & 0.052 & 0.033 & 0.025 & 0.061 & 0.060 & 0.065 & 0.032 & 0.041 & 0.022 & 0.045
\end{array} \right)$$

(2) **Determine fuzzy membership degree**

A group of 3 domain experts, 3 senior managers and 5 users were invited to evaluate the information system. According to the comment set, the evaluation result membership degree matrix $R(normalized)$ is expressed as follows:

$$v_1 = (0.5360, 0.4370, 0.0000, 0.0000, 0.0000, 0.1160, 0.0650, 0.5440, 0.4500, 0.1880, 0.0000, 0.0000, 0.2030, 0.3730, 0.0000, 0.0000, 0.0000, 0.1690, 0.554)$$

$$v_2 = (0.2960, 0.0330, 0.5260, 0.0470, 0.0830, 0.3060, 0.6150, 0.0600, 0.4870, 0.2820, 0.6470, 0.5480, 0.4080, 0.0530, 0.2920, 0.4010, 0.2810, 0.7190, 0.5460, 0.422)$$

$$v_3 = 0.1680, 0.5300, 0.2330, 0.5260, 0.2400, 0.4730, 0.5810, 0.3960, 0.0630, 0.2630, 0.0150, 0.0720, 0.7440, 0.3360, 0.0190, 0.0890, 0.2080, 0.2850, 0.024)$$

$$v_4 = (0.0000, 0.0000, 0.2410, 0.4270, 0.6770, 0.0000, 0.1390, 0.0000, 0.0000, 0.0000, 0.0900, 0.4370, 0.5210, 0.0000, 0.0000, 0.0000, 0.5800, 0.6300, 0.0730, 0.0000, 0.0000, 0.0000, 0.0000)$$

$$v_5 = (0.0000, 0.0000, 0.0000, 0.0000, 0.1050, 0.0000, 0.0000, 0.0000, 0.0000, 0.0000, 0.0000, 0.0000, 0.0000, 0.0000, 0.0000, 0.0000, 0.0000, 0.0000, 0.0000, 0.0000, 0.0000, 0.0000, 0.0000, 0.0000, 0.0000)$$

(3) **Calculate the comprehensive evaluation value**

The result comprehensive evaluation value can be described as $S$ and $P$.

$$S = W_C^a * R = (0.214, 0.231, 0.314, 0.167, 0.075)$$

$$P = V * S_T = (5, 4, 3, 2, 1) * (0.214, 0.231, 0.314, 0.167, 0.075) = 3.342$$

From the result, it can be seen that the probability of teaching platform belongs to the "first-grade" membership is 0.214, the second-grade membership is 0.231, the third-grade membership is 0.314, the fourth-grade membership is 0.167, and the fifth-grade membership is 0.075. The quantified value is 3.342, so it should be rated "Grade 3".

5. **Conclusion**

Teaching cloud platform evaluation is a dynamic process, and its indicators may change with the platform products and evaluation time. Therefore, it is necessary to adjust the indicators and weights. The evaluation index system model proposed in this paper is conducive to understanding the establishment of evaluation model and comprehensive evaluation calculation, so it has certain practical significance. One of the difficulties in the evaluation of teaching cloud platform is the construction of judgment matrix, which is given by experienced decision makers and domain experts. Although fuzzy comprehensive evaluation method can be used to evaluate software systems accurately, it requires that the test sample must be large enough, otherwise the conclusion is easy to be biased.

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