Research on Quantitative Evaluation Method of Students' Computer Application Ability

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Abstract. With the advent of the Internet era, the construction of enterprise informatization has put forward higher requirements for the training of college students' computer application ability. The evaluation of students' computer application ability is an important link in the training system of college students' computer application ability. The result of college students' computer application ability evaluation is also an important criterion to judge whether the feedback training mode or the teaching reform is feasible and effective. The traditional evaluation method is mostly based on the qualitative evaluation, which can not realize the objectivity, standardization and accuracy of the evaluation. In this paper, the evaluation element and the capacity factor were defined, the calculation model of the capacity factor and the total ability degree were designed by using the mathematic method, and the properties of the model were analyzed. The method we designed achieves the objective quantitative evaluation of the students' computer application level.

Introduction

Under the background of Industry 4.0 and China made 2025, the enterprise informationization construction not only puts forward higher requirements for students' professional skill level and innovative consciousness, but also places more expectation on students' ability of computer application and adaptability to information working environment[1]. Students' computer application ability [2] refers to the students' cognitive ability of basic concepts and common sense in the field of computer science, as well as to the comprehensive application of common operating systems, common components of office systems, commonly used multimedia software, computer network technology and professional related software.

The evaluation of students' computer application ability is an important link in the training system of college students' computer application ability. The result of college students' computer application ability evaluation is also an important criterion to judge whether the feedback training mode or the teaching reform is feasible and effective. However, this link is often weakened or neglected. With the new curriculum reform, a series of evaluation mechanisms such as the concept, the subject, the content and the method of evaluation have undergone great changes [3]. At present, the traditional evaluation method of students' computer application ability mostly follows the subjective qualitative evaluation method. The quantitative evaluation also does not get rid of the evaluation method based on the single evaluation indicator such as the student examination score or the certificate level, and the main calculation model of weighted summation and average [4].

The main work of this paper is to design the calculation model of the ability factor and the total ability degree by using mathematical method, and to analysis the properties of the method. Thus, the objective and quantitative evaluation of the students' computer application ability is realized. It realizes the objectivity, standardization and accuracy of the evaluation, and the evaluation result can objectively feedback the comprehensive teaching quality data information, so as to solve the problems and drawbacks in teaching reform.
Related Concepts

Evaluation Element

The evaluation element of computer application ability is the basic element of evaluating the students’ ability. The evaluation element can be selected through subjective and objective methods, which can be the objective result of a course or competition, or the subjective evaluation degree of a knowledge point.

Sub-capability

Student computer application ability is a comprehensive ability, composed of various kinds of sub-capability, which mainly can be divided into 6 classes, respectively:
- The cognitive ability of basic concepts and common sense in the computer field
- The operational ability of common operating systems
- The application ability of common components to office software
- The application ability of common multimedia software
- The application ability of computer network technology
- The application ability of professional related software

Ability Factor

The ability factor refers to the degree value of the sub-capability, which is computed by the ability factor calculation model.

Evaluation Process

The quantitative evaluation process of students' computer application ability is as follows:
- The first step: According to the evaluation criteria, evaluation element is selected.
- The second step: According to the evaluation element related to each sub-capability, the different ability factors are calculated by using the ability factor calculation model.
- The third step: According to the ability factor of different sub-capability, the total ability degree value is calculated by using the total ability degree calculation model.

The general evaluation process is shown in Fig. 1.

Figure 1. Student Computer Application Ability Quantitative Evaluation Process.

Ability Factor Calculation Model

The main function of the ability factor calculation model is to calculate the ability factor of the sub-capability according to the corresponding evaluation element.

We use factor analysis method [5] to design this model. Factor analysis is a statistical method used to describe variability among observed, correlated variables in terms of a potentially lower number of unobserved variables called factors. Factor analysis searches for such joint variations in response to unobserved latent variables. The observed variables are modelled as linear
combinations of the potential factors, plus "error" terms. Factor analysis aims to find independent latent variables. The theory behind factor analytic methods is that the information gained about the interdependencies between observed variables can be used later to reduce the set of variables in a dataset.

Suppose we have a set of samples and each sample has an observation variable (evaluation element), which has a strong correlation.

\[
\begin{align*}
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\end{align*}
\]

\[
\begin{align*}
&\text{denotes the standardized original variables.}
\end{align*}
\]

\[
\begin{align*}
&\text{denotes the standardized common factors, which are independent and work on each of the original observation variables.}
\end{align*}
\]

\[
\begin{align*}
&\text{denotes the special factors of each original variable, which work on only one original variable. Among common factors, special factors, special factors and all common factors are independent. Each } X_i \text{ can be expressed as a linear combination of } F \text{ and the corresponding special factor } \varepsilon_i. \text{ The model is as follows:}
\end{align*}
\]

\[
\begin{align*}
\left\{ 
X_1 &= \alpha_{11} F_1 + \cdots + \alpha_{1m} F_m + \varepsilon_1 \\
\vdots
X_p &= \alpha_{p1} F_1 + \cdots + \alpha_{pm} F_m + \varepsilon_p 
\right.
\end{align*}
\]

\[
\text{for short } X = AF + \varepsilon
\]

Where:

1. \(A = (a_{ij})_{p \times m}\) denotes the factor loading matrix.
2. \(a_{ij}\) denotes factor loading.

Also we will impose the following assumptions on F:

\[
\begin{align*}
&\text{cov}(F, \varepsilon) = 0; (2) \ E(F) = 0, \text{ cov}(F) = I; (3) \ E(\varepsilon) = 0, \text{ cov}(\varepsilon) = \\
&\begin{pmatrix}
\sigma_{11}^2 & \cdots & 0 \\
\vdots & \ddots & \vdots \\
0 & \cdots & \sigma_{pp}^2
\end{pmatrix}
\end{align*}
\]

The purpose of factor analysis is to replace the high-dimensional variables X with the low-dimension variables F by using the above models, so as to achieve the goal of reducing the dimension, and abstract a small number of common factors to analyze the problems. Finally, the sample is evaluated quantitatively with the factor score.

**Total Ability Degree Calculation Model and Its Properties Analysis**

The main function of the total ability degree calculation model is to derive the total ability degree value according to each ability factor, and the model is as follows:

\[
\begin{align*}
&\alpha_1 + \alpha_2 + \cdots + \alpha_n = \sum_{j=1}^{n} \alpha_j = 1 (0 \leq \alpha_j \leq 1) \\
&T = y_1^{\alpha_1} y_2^{\alpha_2} \cdots y_n^{\alpha_n} = \prod_{j=1}^{n} y_j^{\alpha_j} (0 \leq y_j \leq 1)
\end{align*}
\]

Where:

1. \(T\) denotes the total ability degree calculation function.
2. \(y_i (0 \leq y_i \leq 1)\) denotes the ability factor of Sub-capability i.
3. \(\alpha\) denotes the weight of the ability factor.

Intuitively, this model satisfies the "Cannikin Law", that is, the total ability to achieve a certain value, then must each ability factor need to reach a certain limit of value, otherwise it will not be able to reach the overall capacity value, this can also be visually understood as the ability of each sub-capability as the circuit design of the components in tandem relationship.

The model satisfies the following 5 construction criterions:

1. Monotonicity: The calculation function T is a monotonically increasing function on each ability
factor \(y_i\). That is, the increment of one ability factor's value leads to the increment of the degree value. That means:

\[
\frac{\partial T}{\partial y_i} > 0
\]  

(4) Coherency: The growth rate of \(T\) is a monotonically decreasing function for each ability factor. The coherency describes the changing rate of an ability factor. When raising an ability factor continuously, the acceleration of ability degree value will be slowing down. That means:

\[
\frac{\partial^2 T}{\partial^2 y_i} < 0
\]  

(5) Sensitivity: The sensitivity describes the effect of each ability factor \(y_i\) to \(T\). That means, the sensitivity function should be positive and related to the weight of the ability factor. The function is defined as:

\[
\frac{\partial T}{\partial y_i} \cdot \frac{\Delta T}{\Delta y_i} = \lim_{\Delta y_i \to 0} \frac{T}{y_i}
\]  

(6) Substitutability: The substitutability describes how to adjust these ability factor's values if we want to keep the overall ability degree value. That means:

\[
\frac{d(y_i / y_j)}{d(dy_i / dy_j)} \cdot \frac{dy_i / dy_j}{y_i / y_j} > 0
\]  

(7) Stability: The calculation function \(T\) should be within the same range as the range in which all ability factor's values \(y_i\). That means: if \(\forall i, y_i \in [a, b]\) then \(T \in [a, b]\).

These criterions describe the relationship between the ability factor and the overall ability degree value.

**Summary**

In this paper, the evaluation element and the capacity factor were defined, the calculation model of the capacity factor and the total ability degree were designed by using the mathematics method, and the properties of the model were analyzed. However, with the implementation of the curriculum reform, the capacity factor calculation model designed in this paper is not applicable to all sub-capability degree values. We will continue to modify and improve it in the follow-up work.

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**References**


