Study on Comprehensive Evaluation of University Students in Computer Basic Course Based on AHP

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Abstract. In this paper we take Computer Basic Course as example, study the students' final evaluation. Different from the final exam, by selecting appropriate index and connecting with the AHP method, we construct a hierarchical structure to evaluate students' learning effects. A more comprehensive method and system is constructed, a quantitative result is given to each student. Usual course quiz, EXCEL experiment work, WORD report and PPT report are selected as evaluating index according to teachers' experience, after that, more related index is set in the text according to teachers' experience. The evaluation system is shown in Sect. 2. What we studied in this paper not only provides reference for better evaluating students, but also help teachers with teaching contents, computer subject developing and so on.

Keywords: Evaluation of university students · AHP · Multi-index evaluation · Math-software

1 Introduction

Along with the social development, scientific and technological progress, the Internet technology and Artificial Intelligence are developing rapidly. As compulsory course in the most universities, the Computer Basic Course can help students adapting to further study and work better. In the new intelligence era, the purpose of setting up Computer Basic Course in universities is to broaden students' horizons, and prepare themselves for subsequent courses for necessary knowledge. Furthermore, motivated by the book *Teaching implementation plan for the core computer basic courses in colleges and universities* (2011), students can consciously apply concepts, technology and methods studied from computer lessons into their own majors, even it is helpful for their future job. Actually, this is also a positive result of every stage of education, such as secondary education and university education. Under the circumstances, students are expected to solve problems that may arise in computer applications. In this process, they obtained greater progress and become more professional.

With the development of artificial intelligence and big data technology, it is very necessary to improve computer skills. Therefore, in almost every university, the computer

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basic courses are offered to students with different majors. When students finished their computer courses, the traditional evaluation is final exam at the end of a semester. However, with the development of modern society, the ability of computer operating and practice application is more important, only a final exam cannot meet the requirements of comprehensive evaluation of students' learning effects. Therefore, it is urgent to improve the evaluation method of students' learning effects. Meanwhile, it is necessary to study more reasonable evaluation methods. To evaluate students' learning effects more reasonable and comprehensive, lots of factors and index are needed to consider, such as basic computer knowledge, practical computer application, and so on. Furthermore, more reasonable evaluation methods can help teacher knowing students' learning state. It can also provide reference to selecting excellent students. For these reasons, the evaluation methods can be continuously studied and upgraded.

There are a few results studying the curriculum evaluation. For a long time, original curriculum evaluation is based on the view of managers. Since 1970s, a new evaluation system is developing (Zhong, 2003), the system contains following contents: communication, cooperation, consistent orientation, and the best common interests. Some researchers, such as Zhu (2008), Xu & Liu (2019), Lu *etc.* (2019), Lei (2020), studied the courses evaluation based on students' competency and education certification. The following references consider the course evaluation methods. For example, Wu (2014) studied the Computer Application Basis Course evaluation by use of fuzzy Analytic Hierarchy Process method. Chai *etc.* (2018) studied the online study system evaluation based on Delphi method and AHP method. Wang & Zhu (2019) considered the short WORD report evaluation in *University Computer Basic Course* by AHP. However, to the best of our knowledge, few result mentioned the final evaluation to students in the case of a semester finished. In this paper, we focus on the study of a more comprehensive evaluation method of students with multi-index. we take *Computer Basic Course* as example in this text.

According to online self-teaching experiences under COVID-19, also aiming to evaluate students' learning effects more reasonable and comprehensive, In this paper we consider the following four aspects: Usual Course Quiz, EXCEL Experiment Work, WORD Report and PPT report. Herein, Usual Course Quiz is assigned online by teacher according to the lecture content. EXCEL Experiment Work is assigned for checking students' EXCEL operation. The Word Report and PPT Report submitted by students should reflect their understanding to this course. The other requirements are listed as follows: no limit on the content, no more than 5 pages, free to add animation in PPT, free to combine with your major. These requirements also help students with their learning and innovation ability, increase their enthusiasm. The assignment of four aspects show that we pay more attention to each individual student, which is in line with the thought of quality education instead of score evaluation. Besides the above four aspects, we select more reasonable evaluation index in this paper, give a multi-index evaluation system by use of AHP method. The evaluation result can be quantified, which is convenient to teachers for their subsequent teaching work, such as determining students' score value sequence, understanding students' learning effect and improving teaching contents in the next semester and so on.

2 Multi-index Evaluation System with Hierarchy Structure

Concerned with the quality of students' quiz and reports, we select some relevant index based on teaching experience, and always focus on students' operational ability. At the same time, we build the hierarchy structure contained four layers: layer A, layer B, layer C and layer D. Here, Layer A means target layer, Layer B means the First-criterion layer, Layer C means the Second-criterion layer, and Layer D means evaluation layer. For the sake of simplicity, all the index are listed in Fig. 1, the index contents details are shown in Fig. 1 in the next page.

As shown in Fig. 1, index D_1 in Layer D represents excellent evaluation, index D_2 represents good evaluation, index D_3 represents moderate, index D_4 represents failed. During the following process, we take one student as an example, and completed the evaluation process. Based on the teacher's experience, following fairness principle, we set the score distribution in the First-criterion Layer as Table 1. It seems that the distribution value in Table 1 is not from 1 to 9, which is different from the importance scale value table (Hu&Guo, 2018). But, when we set the corresponding pairwise comparison matrix according to the score distribution, the matrix meets all the requirement. Therefore, the score distribution is different from but connected with the important scale value.

The relevant score distribution are set as weights, as shown in Table 1.

According to the score distribution, we set the following pairwise comparison matrix.

$$A = \begin{bmatrix} 1 & \frac{1}{2} & \frac{7}{4} & \frac{7}{4} \\ 2 & 1 & \frac{7}{2} & \frac{7}{2} \\ \frac{4}{7} & \frac{2}{7} & 1 & 1 \\ \frac{4}{7} & \frac{2}{7} & 1 & 1 \end{bmatrix},$$

By use the math-software MATLAB, we get the following results.

$$\lambda_{max} = 4,$$

the corresponding eigenvector is

$$\xi' = [0.4206 \quad 0.8412 \quad 0.2403 \quad 0.2403]^{\mathrm{T}},$$

after sum normalized, the vector is that

$$\xi = [0.2414 \quad 0.4828 \quad 0.1379 \quad 0.1379]^{\mathrm{T}}.$$

Table 1. Score Distribution in First-criterion Layer.

First-criterion Layer Index	B_1	B_2	B_3	B_4
Index Content	Usual Course Quiz	EXCEL Experiment Work	WORD Report	PPT Report
Score distribution	20	10	35	35

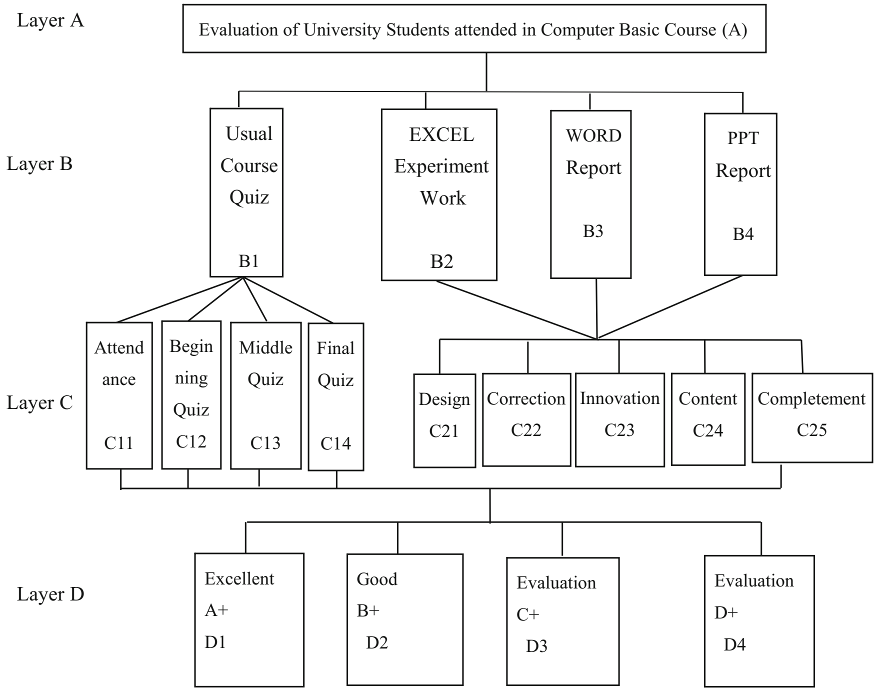

Fig. 1. Students' Course Evaluation Hierarchy Structure.

It is shown that the Second-criterion Layer C is divided into two independent parts from Fig. 1 which indicates the students' course evaluation hierarchy structure. In sequel, for convenience of calculating, we go on our evaluation process in two parts separately in the Second-criterion Layer C.

Firstly, for the first part set of $\{C_{11}, C_{12}, C_{13}, C_{14}\}$, we only need to consider the value to index B_1 in Layer B. We directly give the matrix and relevant results as follows:

$$A1 = \begin{bmatrix} 1 & 1 & \frac{3}{2} & \frac{3}{2} \\ 1 & 1 & \frac{3}{2} & \frac{3}{2} \\ \frac{2}{3} & \frac{2}{3} & 1 & 1 \\ \frac{2}{3} & \frac{2}{3} & 1 & 1 \end{bmatrix},$$

$\lambda_{max} = 4,$

$$\xi_1^{'} = [0.5883 \quad 0.5883 \quad 0.3922 \quad 0.3922]^T,$$

$$\xi_1 = [0.0.3000 \quad 0.3000 \quad 0.2000 \quad 0.2000]^T.$$

Similarly, for the other part set of $\{C_{21}, C_{22}, C_{23}, C_{24}, C_{25}\}$, we need to consider the set to the other index $B_2, B_3,$ *and* B_4 in Layer B, all the matrices and vectors are listed as follows.

$$A2 = \begin{bmatrix} 1 & \frac{3}{2} & \frac{1}{2} & \frac{1}{2} & \frac{3}{2} \\ \frac{2}{3} & 1 & \frac{1}{3} & \frac{1}{3} & 1 \\ 2 & 3 & 1 & 1 & 3 \\ 2 & 3 & 1 & 1 & 3 \\ \frac{2}{3} & 1 & \frac{1}{3} & \frac{1}{3} & 1 \end{bmatrix},$$

$\lambda_{max} = 5,$
$\xi_2' = [0.3180 \quad 0.2120 \quad 0.6360 \quad 0.6360 \quad 0.2120]$
$\xi_2 = [0.1579 \quad 0.1053 \quad 0.3158 \quad 0.3158 \quad 0.1053]^{\mathrm{T}}.$

$$A3 = \begin{bmatrix} 1 & \frac{2}{15} & \frac{2}{3} & \frac{4}{15} & \frac{4}{15} \\ \frac{15}{2} & 1 & 5 & 2 & 2 \\ \frac{3}{2} & \frac{1}{5} & 1 & \frac{2}{5} & \frac{2}{5} \\ \frac{15}{4} & \frac{1}{2} & \frac{5}{2} & 1 & 1 \\ \frac{15}{4} & \frac{1}{2} & \frac{5}{2} & 1 & 1 \end{bmatrix},$$

$\lambda_{max} = 5,$
$\xi_3' = [0.1068 \quad 0.8012 \quad 0.1602 \quad 0.4006 \quad 0.4006]^{\mathrm{T}},$
$\xi_3 = [0.0571 \quad 0.4286 \quad 0.0857 \quad 0.2143 \quad 0.2143]^{\mathrm{T}}.$

$$A4 = \begin{bmatrix} 1 & \frac{1}{5} & \frac{3}{2} & \frac{3}{10} & \frac{1}{2} \\ 5 & 1 & \frac{15}{2} & \frac{3}{2} & \frac{5}{2} \\ \frac{2}{3} & \frac{2}{15} & 1 & \frac{1}{5} & \frac{1}{3} \\ \frac{10}{3} & \frac{2}{3} & 5 & 1 & \frac{5}{3} \\ 2 & \frac{2}{5} & 3 & \frac{3}{5} & 1 \end{bmatrix},$$

$$\lambda_{max} = 5,$$

$\xi_4' = [0.1551 \quad 0.7756 \quad 0.1034 \quad 0.5171 \quad 0.3103]^{\mathrm{T}},$
$\xi_4 = [0.0833 \quad 0.4167 \quad 0.0556 \quad 0.2778 \quad 0.1667]^{\mathrm{T}}.$

After finishing these work, now we need to consider the Layer D. For convenience, we list the distribution directly in Table 2.

Table 2. Distribution weight from layer D to layer C.

	C11	C12	C13	C14	C21	C22	C23	C24	C25
D1	1	1	1	1	2	1	2	2	2
D2	2	2	2	2	2	2	3	2	2
D3	4	3	3	4	4	3	6	3	3
D4	6	4	4	4	6	4	8	3	3

According to Table 2, the corresponding matrices are listed as follows. The concrete matrices $C\text{i},\ \text{i} = 1, 2, \cdots, 9$ are shown below.

$$C1 = \begin{bmatrix} 1 & 2 & 4 & 6 \\ \frac{1}{2} & 1 & 2 & 3 \\ \frac{1}{4} & \frac{1}{2} & 1 & \frac{3}{2} \\ \frac{1}{6} & \frac{1}{3} & \frac{2}{3} & 1 \end{bmatrix}, C2 = \begin{bmatrix} 1 & 2 & 3 & 4 \\ \frac{1}{2} & 1 & \frac{3}{2} & 2 \\ \frac{1}{3} & \frac{2}{3} & 1 & \frac{4}{3} \\ \frac{1}{4} & \frac{1}{2} & \frac{3}{4} & 1 \end{bmatrix},$$

$$C3 = \begin{bmatrix} 1 & 2 & 3 & 4 \\ \frac{1}{2} & 1 & \frac{3}{2} & 2 \\ \frac{1}{3} & \frac{2}{3} & 1 & \frac{4}{3} \\ \frac{1}{4} & \frac{1}{2} & \frac{3}{4} & 1 \end{bmatrix}, C4 = \begin{bmatrix} 1 & 2 & 4 & 5 \\ \frac{1}{2} & 1 & 2 & \frac{5}{2} \\ \frac{1}{4} & \frac{1}{2} & 1 & \frac{5}{4} \\ \frac{1}{5} & \frac{2}{5} & \frac{4}{5} & 1 \end{bmatrix},$$

$$C5 = \begin{bmatrix} 1 & 1 & 2 & 3 \\ 1 & 1 & 2 & 3 \\ \frac{1}{2} & \frac{1}{2} & 1 & \frac{2}{3} \\ \frac{1}{3} & \frac{1}{3} & \frac{2}{3} & 1 \end{bmatrix}, C6 = \begin{bmatrix} 1 & 2 & 3 & 4 \\ \frac{1}{2} & 1 & \frac{3}{2} & 2 \\ \frac{1}{3} & \frac{2}{3} & 1 & \frac{4}{3} \\ \frac{1}{4} & \frac{1}{2} & \frac{3}{4} & 1 \end{bmatrix},$$

$$C7 = \begin{bmatrix} 1 & \frac{3}{2} & 3 & 4 \\ \frac{2}{3} & 1 & 2 & \frac{8}{3} \\ \frac{1}{3} & \frac{1}{2} & 1 & \frac{4}{3} \\ \frac{1}{4} & \frac{3}{8} & \frac{3}{4} & 1 \end{bmatrix}, C8 = \begin{bmatrix} 1 & 1 & \frac{3}{2} & \frac{3}{2} \\ 1 & 1 & \frac{3}{2} & \frac{3}{2} \\ \frac{2}{3} & \frac{2}{3} & 1 & 1 \\ \frac{2}{3} & \frac{2}{3} & 1 & 1 \end{bmatrix},$$

$$C9 = \begin{bmatrix} 1 & 1 & \frac{3}{2} & \frac{3}{2} \\ 1 & 1 & \frac{3}{2} & \frac{3}{2} \\ \frac{2}{3} & \frac{2}{3} & 1 & 1 \\ \frac{2}{3} & \frac{2}{3} & 1 & 1 \end{bmatrix}.$$

By using Matlab software, the corresponding results are calculated easily.
With C1, the corresponding values and vector are $\lambda_{max} = 4$, $\text{n} = 4$, and

$$\eta_1 = [0.5317 \quad 0.2659 \quad 0.1138 \quad 0.0886]^{\text{T}}.$$

For C2, the corresponding values and vector are
$\lambda_{max} = 4, n = 4,$ and
$\eta_2 = [0.4800 \quad 0.2400 \quad 0.1600 \quad 0.1200]^{\text{T}}.$
For C3,
$\lambda_{max} 4, n = 4,$ and
$\eta_3 = [0.4800 \quad 0.2400 \quad 0.1600 \quad 0.1200]^{\text{T}}.$
$\lambda_{\text{max}} = 4, \text{n} = 4, \eta_2 = \eta_3 = \eta_6 = [0.48000.24000.16000.1200]^{\text{T}}$ For C4,
$\lambda_{max} = 4, \text{n} = 4,$ and
$\eta_4 = [0.5128 \quad 0.2564 \quad 0.1282 \quad 0.1026]^{\text{T}}.$
For C5,
$\lambda_{max} = 4, \text{n} = 4,$ and
$\eta_5 = [0.3529 \quad 0.3529 \quad 0.1765 \quad 0.1176]^{\text{T}}.$
For C6,
$\lambda_{max} 4, n = 4,$ and

$\eta_6 = [0.4800 \quad 0.2400 \quad 0.1600 \quad 0.1200]^{\mathrm{T}}$.
For C7,
$\lambda_{max} = 4,\ \mathrm{n} = 4$, and
$\eta_7 = [0.4444 \quad 0.2963 \quad 0.1481 \quad 0.1111]^{\mathrm{T}}$.
For C8,

$$\lambda_{max} = 4, n = 4, \text{ and}$$

$\eta_9 = [0.3000 \quad 0.3000 \quad 0.2000 \quad 0.2000]^{\mathrm{T}}$. Finally, for C9,

$$\lambda_{max} = 4, n = 4, \text{ and}$$

$\eta_9 = [0.3000 \quad 0.3000 \quad 0.2000 \quad 0.2000]^{\mathrm{T}}$.

For the result pair of each matrix, we need to calculate the consistency index(C.I.). We cite the formula as follows (Hu&Guo, 2018).

$C.I. = (\lambda_{max} - n)/(n - 1)$, and

$$C.R. = C.I./R.I.$$

The concerned average random consistency index(R.I.) are 0.89(n = 4) and 1.12 (n = 5)(Hu&Guo, 2018). Direct calculation showed that all the corresponding consistency index(C.I.) and consistency ratio(C.R.) are 0, which means that all the pairwise comparison matrices in this paper meet consistency requirements well.

At last, the evaluation vector β is calculated by the following formula:

$$\beta = \begin{pmatrix} \eta_1 & \eta_2 & \eta_3 & \eta_4 & \eta_5 & \eta_6 & \eta_7 & \eta_8 & \eta_9 \end{pmatrix} \cdot \begin{pmatrix} \xi_1 & 0 & 0 & 0 \\ 0 & \xi_2 & \xi_3 & \xi_4 \end{pmatrix} \cdot \xi$$

$$= [0.4088 \quad 0.2826 \quad 0.1676 \quad 0.1410]^{\mathrm{T}}.$$

From β value, along with the index in evaluation Layer D, we assert that the evaluation of this student is judged excellent on the computer course. Following this process, to each student, the corresponding value can be given. After finished all the students' evaluation, the values can be sorted in ascending order, we can call it a score sequence. From the sequence, we can determine a mapping to a score interval so as to give a concrete score finally, which shows a more reasonable score.

3 Conclusions

In this paper, students' learning evaluation is studied based on the teacher's own teaching practice. The evaluation method is proposed by AHP and score distribution. The method can help teachers with individual study, set different goal to different students. Students can also benefit from the evaluation method, they become more interested in studying, study knowledge more active, all of these improve their computer level. At the same time, it can also provide teachers for their try in teaching content, teaching scheme, teaching mode, etc.

The evaluation method in this paper also accords with the study mode in the modern society. Today, we more focus on students' computer learning ability instead of pure score from final exam. However, the index we selected are limited. In the future, we will explore more index, find feasible evaluation method or combine with other methods. We will consider more aspects as well, such as group evaluation, self-evaluation and so on.

The method and evaluation system can also be applied to other computer courses, such as program language C, C + +, C#, etc. This will also be our future study direction, with exploring more evaluating contents and methods, and with the hope to provide reference to computer courses in universities.

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The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper. There are no conflicts of interests.

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