

# Index System and Its Application of Fuzzy Assessment on Undergraduates' Employment Quality

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**Abstract**—Assessment index reflects assessed contents and the choice of assessment method. A scientific assessment index system is in favor of exactly assessing the quality of talent cultivation, as well as guiding the enhancement of the quality. This paper intends to establish an index system of fuzzy assessment of undergraduates' employment quality through the theoretical approach of management science and engineering and apply it into the guidance of undergraduates' employment from Beijing University of Technology.

*Keywords*—index system; fuzzy mathematics; employment quality

## I. INTRODUCTION

In 1999, the implementation of college admission expansion policy has transformed higher education from elite mode to public mode. Confronted with the rapid outspreading of colleges' scales, policy makers have to answer a question: whether the economic demand for highly educated talents and the talent supply from college has reached a balance? An intuitional index for answering this question is the employment situation of college undergraduates. Before college admission expansion in 1999, fresh graduates always had multiple employment choices; however, after the expansion in 1999, especially after 2001, Ministry of Education started to pay attention to undergraduates' employment rate--their first employment rate basically remained at 75% or so, which meant that 25% fresh graduates were unemployable. It is worth noting that in 2008 and 2009, the first employment rate, affected by worldwide financial crisis, fell down below 70% for the first time--it remained at around 68% [1]. Thus, the grim picture for fresh graduates' employment could be seen and key universities, as a result, had to consider the subsequent influence on their own enrollment exerted by the employment rate and employment quality.

## II. LITERATURE REVIEW

In accordance with requirements of college talents' cultivation, A number of experts and scholars of education have established assessment index from various perspectives which can be classified as two categories: one is from the perspective of elements that affects the quality of college talents' cultivation; the other is from the perspective of the cultivation's standards and components.

### A. Quality Elements

In the first category, Ni lijuan has put forward five elements: the correctness of a university's positioning, the normalization of teaching, the importance of practical teaching, the scientificity of teaching assessment and teaching method; in line with an all-round, coordinated, and sustainable talent cultivation quality concept that take people as the foremost [2], Sun Mingbao and Li Xiping have designed first-class indexes—guiding ideas, teaching staff, teaching condition, majors and courses, teaching management, teaching and learning atmosphere, teaching effects, and special projects—to assess talent cultivation quality [3]; Zhang Dejiang assesses talent cultivation quality from seven aspects: the central status of teaching, teachers' devotion, students' right to handle their own study, teaching mode, students' learning status, multi-media teaching effects, and moral education [4].

### B. Standards and Components

In the second category, Zhang Pei has designed seven first-class indexes, each attached by several second-class indexes, to assess the quality of talent cultivation. The seven first-class indexes contain elements composing the quality of talent cultivation, the optimized rationality of designing course system and teaching contents, the basic quality of professional teaching resources, the basic quality of newly-enrolled students, the quality of theoretical teaching, the quality of professional and practical teaching,

the improvement of professional teaching condition, and the all-round quality of graduates[5].Zhang Yunxia, from a strategic perspective, has designed indexes such as a guarantee system of talent cultivation quality, the employment rate of graduates, the salary comparison rate of graduates, the satisfaction rate of graduates, the satisfaction rate of employees, and the cognition degree of talent quality brand, in order to assess the quality of university's talent cultivation[6]; Shi Huamin has put forward the social-need-oriented principle of talent cultivation to build up three assessment indexes: the construction of knowledge structure,the construction of ability structure, and moral education[7]. In addition, Dai Ning and Cai Baping[8], Sun Zeping[9], Zhou Yan[10], and other scholars have also set up assessment indexes from the aspects of composition and contents of university's talent cultivation quality standards.

### C. Further Study

Assessment index reflects assessed contents and the choice of assessment method. A scientific assessment index system is in favor of exactly assessing the quality of talent cultivation, as well as guiding the enhancement of the quality. College talent cultivation should stick to guidelines for college management that take students as the foremost and promote students' all-round development, improve the quality of talent cultivation that lays emphasis on knowledge imparting, ability training, and quality enhancing. Therefore, assessment index needs to focus on knowledge, ability, quality, and other related elements; also it attaches importance on the feasibility of index to design index for assessment.

## III. ESTABLISH ASSESSMENT INDEX SYSTEM OF EMPLOYMENT QUALITY

Quality is the eternal theme and the lifeline of higher education's development. Improving talent cultivation quality is the core issue of higher education's development and the fundamental requirement of enhancing the international competitiveness of China's higher education. So the standards for college talent cultivation quality and the idea of it become a focus of many experts and scholars[11]. This paper intends to establish an index system of fuzzy assessment of undergraduates' employment quality through the theoretical approach of management science and engineering and apply it into the guidance of undergraduates' employment from Beijing University of Technology(BJUT for short). As for the quality of undergraduates' employment, many indexes are

incapable of measuring the complementation degree of the employment. Therefore, this paper, by introducing membership function to set up a membership matrix of assessing the competitiveness of undergraduates' employment, combines conventional qualitative research and quantitative research to translate them into pure quantitative research.

### A. Index Set

In the light of aspects of undergraduate' employment quality, this paper categorizes various elements that influence assessed objects into primary and secondary elements. The element set mentioned above is the index set to be assessed, which can be represented in the same manner as  $U = (u_1, u_2, \dots, u_m)$ . The set, consisting of multiple primary and secondary elements, indicates from which aspects to assess objects. The ultimate goal of this paper's fuzzy assessment system is to feedback through undergraduate' employment and to make comprehensive assessment on the employment quality of undergraduates from different majors( or from different Colleges). For that reason, contributions to general objective made by all basic elements needs to be considered.

In order to assess undergraduates' employment quality scientifically, this paper, on the basis of referring a large amount of literature, puts forward a new set of assessment index system for the quality of undergraduates' employment. This system consists of five first-class indexes: students' satisfaction degree of employees, students' satisfaction degree of employment guidance, preparation of each student's job hunting, teaching contents' practicability, and students' satisfaction degree of teaching. Such a design aims to investigate the teaching and employment guiding of colleges and their Colleges before their undergraduates finish their study, consider these students' subjective initiative during their job hunting, and assess the overall condition of employment quality from employees' perspective.

To exactly and easily collect and assess statistics, this paper classifies each first-class index into several second-class index, as shown in Tab.1. When selecting second-class indexes, this paper should consider if these second-class indexes belong with the first-class indexes' concepts, and concepts of second-class indexes, when the indexes belong to the same first-class index, cannot repeat, which means each second-class index is a clear explanation of their first-class index in certain aspect.

TABLE I. REMARK SET OF ASSESSMENT INDEX OF BJUT UNDERGRADUATES' EMPLOYMENT QUALITY

First-class index	First-class weights	Second-class index	Second-class weights	Ideal	Good	Average	Sub-standard	Disappointing
Students' satisfaction degree of employees	0.198	Salary	0.033	Quite satisfied	Satisfied	Average	Dissatisfied	Quite dissatisfied
		Welfare	0.033	Quite satisfied	Satisfied	Average	Dissatisfied	Quite dissatisfied
		Work environment	0.033	Quite satisfied	Satisfied	Average	Dissatisfied	Quite dissatisfied
		Relationships among colleagues	0.033	Quite satisfied	Satisfied	Average	Dissatisfied	Quite

								dissatisfied
		Management level	0.033	Quite satisfied	Satisfied	Average	Dissatisfied	Quite dissatisfied
		Promotion system	0.033	Quite satisfied	Satisfied	Average	Dissatisfied	Quite dissatisfied
Students' satisfaction degree of employment guidance	0.247	University's guidance	0.185	Quite satisfied	Satisfied	Average	Dissatisfied	Quite dissatisfied
		College's guidance	0.062	Quite satisfied	Satisfied	Average	Dissatisfied	Quite dissatisfied
Preparation of each student's job hunting	0.198	Has the student made career plan?	0.101	The student has quite clear plans.	The student has clear plans.	The student has simple plans.	The student plays it by ear.	The student never makes plans.
		How much does the student understand current employment's policies and process?	0.026	The student understands them quite good.	The student understands them.	Average	The student Understands them a little.	The student doesn't understand them at all.
		How much does the student understand and pay attention to employment service website?	0.052	The student quite understands and pays a lot of attention to it.	The student understands and pays attention to it.	Average	The student understands it a little and sometimes pays attention to it.	The student doesn't understand it at all and pays no attention to it.
		How much does the student know about student unions of employment?	0.010	The student knows about them quite good.	The student knows them.	Average	The student knows a little about them.	The student doesn't know about them at all.
		Is the student creditable during job hunting?	0.008	The student sticks to creditability.	The student stick to creditability as much as possible.	It doesn't matter to them.	It depends on different occasion.	It is unnecessary to be creditable.
Teaching contents' practicability	0.198	Knowledge structure	0.007	Quite satisfactory	Satisfactory	Average	Unsatisfactory	Quite unsatisfactory
		Professional knowledge	0.013	Quite satisfactory	Satisfactory	Average	Unsatisfactory	Quite unsatisfactory
		Basic skills	0.026	Quite satisfactory	Satisfactory	Average	Unsatisfactory	Quite unsatisfactory
		Ability to work independently	0.052	Quite satisfactory	Satisfactory	Average	Unsatisfactory	Quite unsatisfactory
		Ability to deal with interpersonal relationship	0.101	Quite satisfactory	Satisfactory	Average	Unsatisfactory	Quite unsatisfactory
Students' satisfaction degree of teaching	0.159	Cultivation of analyzing and solving problems	0.022	Quite good	Good	Average	Bad	Quite bad
		Cultivation of creativity	0.005	Quite good	Good	Average	Bad	Quite bad
		Knowledge broadening	0.005	Quite good	Good	Average	Bad	Quite bad
		Depth and scope of professional knowledge	0.011	Quite good	Good	Average	Bad	Quite bad
		Cultivation of basic skills and manipulative ability	0.041	Quite good	Good	Average	Bad	Quite bad
		Formation of world and life views	0.075	Quite good	Good	Average	Bad	Quite bad

### B. Remark Set

Remark set is represented as Set  $V$ , i.e.  $V = (v_1, v_2, \dots, v_k)$ , in which  $k$  stands for the number of remarks and is actually a division of variable intervals of

assessed objects. This paper divides the quality of undergraduates' employment into five levels: disappointing, sub-standard, average, good, and ideal. Employment quality has been divided into intervals by remark set, but in actual counting, especially in questionnaire investigation, remarks of every index must

be approachable and accord with context. Hence this paper resets remark set of every second-class index, as shown in Tab. 1.

### C. Weight Set

In fuzzy and comprehensive assessment, weight exerts great influence on ultimate results since different weights will obtain utterly different results. Therefore, whether selected weight is fit determines whether model succeeds or fails. Comprehensive assessment should be a fuzzy subset  $\tilde{B} = (b_1, b_2, \dots, b_k) \in \wp(V)$  affiliated with  $V$ , and  $b_h$ , ( $h=1, 2, \dots, k$ ) reflects the low order of  $v_h$  in the sequence of  $h$  in comprehensive assessment, i.e. the membership degree of  $v_h$  to fuzzy set  $\tilde{B}$ , which can be presented as  $\tilde{B}(v_h) = b_h$ . Depending on the weights of each element,  $\tilde{B}$ , the comprehensive assessment, should be  $U$ 's fuzzy subset, which can be presented as

$$W = (w_1, w_2, \dots, w_m) \in \wp(U) \quad \text{and} \quad \sum_{i=1}^m w_i = 1 \quad \text{with} \quad w_i$$

standing for the  $i$ th element's weight. Once the weight  $W$  is given, a comprehensive assessment  $\tilde{B}$  can be obtained correspondingly. This paper, via Analytic Hierarchy Process, AHP for short), collects weight information. AHP can not just ensure the model's systematicness and rationality, but also enables decision makers to take full advantage of their valuable experience and discretion to provide powerful policy support to regulation and decision issues. The setting of the weight set of BJUT undergraduates' employment quality assessment index is also shown in Tab.1.

In line with AHP's process and algorithm, this paper obtains first-class and second-class index weights of undergraduates' employment quality assessment index, which offers weight set for fuzzy assessment in the following text. Those weights show the differences of each index's importance among the whole system so as to reflect imbalanced influences on employment quality caused by colleges' education and students' own preparation. It can be seen from the results that : the weights of six second-class indexes affiliated with first-class index "Students' satisfaction degree of employees" are the same, indicating that the six indexes possess the equal importance; in first-class index "students' satisfaction degree of employment guidance", students' satisfaction degree of university's guidance is as almost as three times as that of College's, manifesting greater influence from university level; in first-class index "preparation of each student's job hunting", the weight of "has the student made career plan" accounts the most, pointing that students' subjectivity effects more employment quality than employment information channels; in first-class index of "Teaching contents' practicability", the weight of "ability to deal with interpersonal relationship" occupies the most percentage,

On the basis of this index system, this paper, referring the establishment procedure of fuzzy and balanced score card model, gets corresponding weight set and fuzzy assessment matrix through investigation and interviews so

as to make comprehensive and fuzzy assessment of first-class category and general goal.

## IV. ALGORITHM PROCESS OF FUZZY ASSESSMENT

Fuzzy and comprehensive assessment is an effective multi-factor decision method to comprehensively assess objects affected by multiple factors, so this method can also be claimed as fuzzy and comprehensive decision or fuzzy multiple decision.

Fuzzy and comprehensive assessment can usually be separated into two steps: the first step is make single factor assessment, and the second step is to make comprehensive assessment of overall factors. The benefits of this simple mathematic model is easy to master and can exactly assess complicated problems of multi factors and multi levels. Thus, it is irreplaceable by other mathematic branches and models. Also it can assess objects one by one and has the only value to them, free from influences of the set in which objects are. The specific procedures of fuzzy hierarchy analyst model is as follows.

### A. Construct Fuzzy Assessment Matrix

Each factor  $u_i$  is counted as an assessment  $f(u_i)$ , so it can be regarded as fuzzy mapping  $\tilde{f}$  from  $U$  to  $V$ .

$$f : U \rightarrow \wp(V) \quad (1)$$

$$u_i \mapsto \tilde{f}(u_i) \in \wp(V) \quad (2)$$

From  $\tilde{f}$ , an induced fuzzy linear transformation  $\tilde{T}_f$  from  $U$  to  $V$  can be regarded as the mathematic model of the comprehensive assessment  $\tilde{B}$  resulted from weight  $A$ .

Consequently, fuzzy mapping  $\tilde{f}$  can induce fuzzy relation  $\tilde{R}_f \in \wp(U \times V)$ , i.e.  $\tilde{R}_f(u_i, v_h) = \tilde{f}(u_i)(v_h) = r_{ih}$ , among which  $\tilde{R}_f$  can be represented as fuzzy matrix  $\tilde{R} \in \mu_{m \times k}$ :

$$\tilde{R} = \begin{bmatrix} r_{11} & r_{12} & \cdots & r_{1k} \\ r_{21} & r_{22} & \cdots & r_{2k} \\ \vdots & \ddots & \cdots & \vdots \\ r_{m1} & r_{m2} & \cdots & r_{mk} \end{bmatrix} \quad (3)$$

$\tilde{R}$  is called as single-factor assessment matrix, among which  $r_{ih}$  means starting from factor  $x_i$  and this assessed object can be counted as membership degree of  $v_h$ . To put it specifically,  $r_{ih}$  stands for the frequency distribution of the  $i$ th factor  $x_i$  in the  $h$ th assessment  $v_h$ , and the frequency distribution is generally normalized to

meet the demand of  $\sum_{h=1}^k r_{ih} = 1$ . As such, matrix  $\tilde{R}$  itself doesn't have dimension so particular processing is unnecessary.

### B. Calculate the Value of Fuzzy and Comprehensive Assessment

fuzzy relation  $\tilde{R}_f$  can induce fuzzy linear transformation  $\tilde{T}_f$  from  $U$  to  $V$ . Thus,  $(U, V, \tilde{R})$  compose a fuzzy and comprehensive assessment model.

In order to consider each index's influence on students' job-searching competitiveness, this paper applies weighted average model to weight  $W$  and fuzzy matrix  $\tilde{R}$  to make synthetic algorithm, which means calculating via model  $M(\cdot, +)$ . The comprehensive assessment formula is:

$$\tilde{B} = W \cdot \tilde{R} \quad (4)$$

The function of this formula is like the function of converter, as shown in Fig.1:

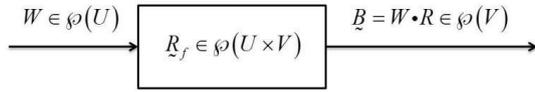


Figure 1. Figure 1. The matrix converting of fuzzy assessment's membership degree

When a weight  $W \in \varphi(U)$  is input, and a comprehensive assessment will be output:

$$\tilde{B} = W \bullet \tilde{R} \in \varphi(V) \quad (5)$$

When  $\sum_{h=1}^k b_h \neq 1$  is normalized,  $\bar{B} = (\bar{b}_1, \bar{b}_2, \dots, \bar{b}_k)$  can

be obtained if  $\bar{b}_h = b_h / \sum_{h=1}^k b_h$  is set.

In light with fuzzy distribution's principle, each assessment index specifically reflects assessed objects' distribution status. Therefore, to avoid the loss of assessed information, score set  $F = (f_1, f_2, \dots, f_k)$  is introduced and it is column vector with the value of  $k$  equaling that of assessment set.  $f_h$  represents the score of the  $h$  th assessment. With 100 as the full remarks, through arithmetic scoring this paper can get  $F = (20, 40, 60, 80, 100)$ . And with membership degree matrix multiplying score set, this paper can get the comprehensive score of fuzzy assessment, as presented via

the formula  $Z = \bar{B} \square F$  with  $Z$  standing for the fuzzy assessment score of undergraduates' employment quality.

## V. EMPIRICAL ANALYSIS

### A. Data Source

In order to empirically analyze fuzzy assessment of employment quality via the index system this paper has built, the author, with assistance from BUT employment service center, organized a survey on employment condition of this university's graduates of 2015. 1755 effective questionnaires have been return, among which 1104 questionnaires come from undergraduates, taking up 37.31% of the total 2959 undergraduates.

### B. Data Collation

The assessment set defines five statuses of employment quality and each index has its own presenting way according to specific context, as shown in the questionnaire. However, to meet the demands of fuzzy and comprehensive assessment, data, when in collation, should be classified into the five statuses, of which membership degree matrix needs to be determined by degree proportion. Two problems should be noted for the sake of reliability: the first one is that the number of interviewees needs to be enough, and only in this situation can the degree proportion verge on membership degree; and the second one is that interviewees must have a quite good understanding about assessed objects, some assessed objects of professional fields in particular. For this paper, the number of interviewees is enough and every one of them are direct carriers of employment quality.

### C. Assessment Results

According to index system and fuzzy assessment algorithm, this paper gets the employment quality statistics of 2015 undergraduates from 16 colleges in BJUT, which are presented through membership degree matrix and comprehensive scores, as shown in Tab.2.

TABLE II. FUZZY ASSESSMENT OF BJUT UNDERGRADUATES' EMPLOYMENT QUALITY ASSESSMENT INDEX SYSTEM

College	Ideal 100	Good 80	Average 60	Sub-standard 40	Disappointing 20	Score
College of Material	0.13	0.49	0.30	0.07	0.02	72.88
College of Electric Control	0.24	0.49	0.23	0.03	0.00	78.94
College of Environment and Energy	0.16	0.47	0.30	0.04	0.02	74.21
College of Mechanical and Electrical Technology	0.18	0.52	0.27	0.03	0.00	76.79
College of Computing	0.20	0.55	0.22	0.02	0.00	78.61
College of Civil Engineering	0.17	0.57	0.23	0.02	0.01	77.37
College of Architectural Planning	0.23	0.44	0.29	0.03	0.00	77.32
College of Transportation	0.05	0.55	0.32	0.08	0.00	71.06
College of Economics and Management	0.18	0.52	0.27	0.03	0.01	76.54
College of Humanities	0.19	0.57	0.21	0.03	0.01	78.01
College of Software	0.21	0.49	0.25	0.05	0.00	76.81
College of Life Science	0.22	0.47	0.24	0.05	0.01	76.80

College of Experiment	0.17	0.48	0.31	0.04	0.01	75.07
College of Mathematics and Physics	0.16	0.48	0.27	0.05	0.03	73.87
College of Foreign Languages and Literature	0.17	0.45	0.33	0.05	0.00	74.88
College of Arts	0.18	0.44	0.34	0.04	0.01	74.91

The fuzzy assessment score shows that the top three colleges of employment quality are College of Electric Control (78.94), College of Computing (78.61), and College of Humanities (78.01). Viewed from membership degree matrix, the top three colleges in ideal status are College of Electric Control (24%), College of Architectural Planning (23%), and College of Life Science (22%). In conclusion, the advantage of this assessment method lies in not only representing an assessed object's status with one final result, but also offering more perspectives to observe their features to avoid holding a part as the whole. The assessed results of BJUT can be a reference for the university's administration departments to adjust employment service, and they can also be the foundation of performance appraisal. In further study, the assessed results will get more in-depth analysis.

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