The Evaluation Model of Psychological Quality for Civil Aviation Student Pilot Based on Fuzzy Comprehensive Evaluation

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Abstract. To establish the civil aviation student pilot psychological quality evaluation model, investigation was carried out about the psychological quality indicator system. This paper analyzed and summarized the relevant research literature, extracting the psychological quality indicators which effect flight training performance. 20 experts identified 4 categories of 21 psychological quality evaluation indicators, and established the civil aviation student pilot psychological quality evaluation indicators system. Using Delphi's analysis, the weight of each indicator was determined. The flight psychological quality evaluation model was constructed using fuzzy comprehensive evaluation method and the corresponding internet -based questionnaires were sent out to 100 student pilots. The evaluation results were compared with their flight training results, verifying the correctness and validity of the model indicators. The evaluation model can play an important role in psychological selection and psychological training for student pilots, which could further reduce the grounded rate and avoid unnecessary losses.

Keywords: civil aviation student pilot psychological quality, psychological quality indicator system, fuzzy comprehensive evaluation, psychological quality evaluation model.

1 Introduction

Flight safety has always been the focus of the civil aviation industry worldwide, and the key factors that affect flight safety is the human factors. Statistics show that flight accidents caused by human factors account for about 75%, and the psychological factors constitute the major part of the human factors. The aviation developed countries and regions in Europe and America have researched and established a set of psychological management system suited to their national pilots' selection, training and evaluation and the number of commercial transport pilots being eliminated because of psychological reasons are far more than physical reasons. Currently in China, flight accidents caused by health reasons have been fewer and fewer due to the pilot's

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selection procedure, regular physical examination, and health assessment. But flying career particularity requires pilots have excellent psychological quality. China's civil aviation don't have uniform requirement about psychological selection and evaluation. Currently companies and civil aviation colleges' selection can only ensure physical examination, there is no uniform practice for psychological evaluation, and even some small companies do not conduct psychological evaluation. Now in China, civil aviation flight training academies have no psychological quality assessment and training systems, also lack of psychological quality continuous monitoring system.

Currently, limited by the amount of CCAR-141 flight training academies, the Chinese airlines annually enroll more than 3,000 student pilots and about two-thirds of them were sent to 32 foreign flight training academies. Subject to the region restrictions, it's difficult to carry out systematic psychological quality monitor. Take Civil Aviation University of China for example, 204 of the 252 total undergraduate student pilots were sent abroad in 2012. The student pilots have to face the risk of being grounded at any time during the theoretical study and flight training process, the grounded rate is around 15%-20%, which give them a lot of psychological pressure and make their flight efficiency decreased, their training progress slower, or even be grounded.

This paper will build a psychological quality evaluation model which could be feasible and convenient for evaluating and monitoring student pilots abroad. Timely guidance and help will be given to those whose is found in adverse psychological state, so that to reduce the grounded rate due to psychological reasons.

2 Civil Aviation Student Pilot Psychological Quality Evaluation Indicator System

Establishing appropriate indicator system is the key to evaluate student pilot psychological quality, related to whether we can fully reflect their real psychological condition, and thus directly affect whether the student pilot needs to be helped to adjust his psychological state for the flight training.

Based on 58 related research literature，227 related evaluation indicators were collected and analyzed, and 79 indicators were kept. An expert group composed of 5 psychology experts, 5 flight theory instructor, 5 flight instructors and 5 outstanding student pilots who have completed flight training identified 4 categories of 21 psychological quality evaluation indicators.

2.1 Psychological State

Foreign aviation training academies usually arrange a lot of flight training mission when the weather and control condition allows in order taking full advantage of the good weather and airspace. Therefore, in many cases, training mission will be extreme imbalance; training time is not fixed or regular, which greatly increased the psychological pressure on student pilots.

Psychological State is the indicator to reflect daily psychological condition of student pilot, which directly affect their behavior. There are six secondary indicators: No Pessimism, No Procrastination, No Depression, No Anxiety, No Sensitive, No Stress, and No Training Burnout.

2.2 Basic Ability

Before flight training student pilots need study theoretical knowledge first and pass various theoretical exams in country where they are trained. Most training academies have strict limits for the number of make-up, if cannot pass the exam within the specified time and limits, the student pilot will be suspended or even permanent grounded, resulting in some psychological pressure on them.

Basic Ability is the indicator to reflect if the student's ability is competent for study, which directly affect student's learning efficiency. There are four secondary indicators: Making Decision, Judgment and Reasoning, Communication and Coordination, Quantitative Relationship.

2.3 Smooth Flight

Every flight is a test. To ensure a smooth flight a good personality is an important factor affecting the state of the pilot work.

Smooth Flight is the indicator to reflect whether student pilot could stably display personal ability. There are six secondary indicators: Rigorous, Systematic, Self-discipline, Responsibility, Teamwork, and Emotional Stability.

2.4 Crisis Response

In flight training, student pilots are likely to encounter some unexpected events, which test if they can maintain calm and objective attitude to withstand the psychological pressure, and decisively solve the problem.

Crisis Response is the indicator to reflect if student pilots can handle crisis situations. There are five secondary indicators: Strong-willed, Affordability, Objective and Rational, Aggressive, Decisive.

3 Evaluation Model Based on Fuzzy Comprehensive Evaluation

Fuzzy comprehensive evaluation method is based on the theory of fuzzy mathematics and on the basis of fuzzy relations with their synthetic operations, with the help of function in fuzzy theory to express the state of the factors. It is a combination of qualitative and quantitative evaluation methods to solve a variety of factors on the material being evaluated. It is particularly suitable for comprehensive evaluation of the project that lots of indicators are difficult to quantify. The steps of fuzzy comprehensive evaluation method are as follows:

- Determine the factors U of psychological quality evaluation of distribution network. Each of these factors is represented by a single review. Supposing there are m reviews, and they constitute a reviews of discourse U .

$$U = \{u_1, u_2, ..., u_i, ..., u_m\} \tag{1}$$

i = (1, 2, …, m), u_i is one of the review.

- Establish the quality level V of the reviews. In accordance with the degree of pros and cons, divide u_i into n levels, that is the level of discourse V .

$$V = \{v_1, v_2, ...v_j, ... v_n\} \tag{2}$$

j = (1, 2, …, n), v_j is one of the levels.

- Establish affiliation and obtain fuzzy evaluation matrix R. Every u_i has a membership for every v_j . Usually the score of the evaluation factors are given by experts. Then the fuzzy evaluation matrix R is:

$$\mathrm{R} = \begin{pmatrix} r_{11} & r_{12} & \cdots & r_{1n} \\ r_{21} & r_{22} & \cdots & r_{2n} \\ \vdots & \vdots & \ddots & \vdots \\ r_{m1} & r_{m2} & \cdots & r_{mn} \end{pmatrix} \quad 0 \le r_{ij} \le 1 \tag{3}$$

$R_i = (r_{i1}, r_{i2}, \ldots r_{ij}, \ldots, r_{in})$ is one of the fuzzy evaluation vectors.

- Indicators of different weights may lead to different evaluation results. The traditional methods to determine the weight is expert assignment method, using the expert investigation method to determine the subjective weight A .

$$A = (a_1, a_2, \cdots, a_n) \qquad \sum_{i=1}^{n} a_i = 1 \tag{4}$$

a_i is the weight which given by experts.

- According to the weights of all evaluation factors make the fuzzy comprehensive evaluation.

$$\mathrm{B} = \mathrm{A} \circ \mathrm{R} = (a_1, a_2, \cdots, a_m) \begin{pmatrix} r_{11} & r_{12} & \cdots & r_{1n} \\ r_{21} & r_{22} & \cdots & r_{2n} \\ \vdots & \vdots & \ddots & \vdots \\ r_{m1} & r_{m2} & \cdots & r_{mn} \end{pmatrix} = (b_1, b_2, \cdots, b_n) \quad (5)$$

Fuzzy vector B = (b_1, b_2, …, b_n) is the needed result.

4 The Evaluation Model of Psychological Quality for Civil Aviation Student Pilot

- Corresponding factor set and sub factors sets are as follows and shown in Table 1.

Table 1. Indicator System of Civil Aviation Student Pilot Psychological Quality Evaluation of Distribution Network

	Factor Set	Sub Factors Sets
Psychological Quality U	Psychological State U_1	No Procrastination u_{11}
		No Depression u_{12}
		No Anxiety u_{13}
		No Sensitive u_{14}
		No Stress u_{15}
		No Training Burnout u_{16}
	Basic Ability U_2	Making Decision u_{21}
		Judgment and Reasoning u_{22}
		Judgment and Reasoning u_{23}
		Quantitative Relationship u_{24}
	Smooth Flight U_3	Rigorous u_{31}
		Systematic u_{32}
		Self-discipline u_{33}
		Responsibility u_{34}
		Teamwork u_{35}
		Emotional Stability u_{36}
	Crisis Response U_4	Strong-willed u_{41}
		Affordability u_{42}
		Objective and Rational u_{43}
		Aggressive u_{44}
		Decisive u_{45}

- According to the psychological quality which possibly is contributed by each factor, we divide the psychological quality level into five levels, namely:

$$V = \{V_1, V_2, V_3, V_4 V_5\} = \{excellent, good, average, fair, poor\} \quad (6)$$

- The weights given by experts are as follows:

  A = (0.3, 0.2, 0.3, 0.2); A_1 = (0.2, 0.2, 0.1, 0.1, 0.2, 0.2); A_2 = (0.25, 0.25, 0.3, 0.2); A_3= (0.1, 0.2, 0.2, 0.2, 0.15, 0.15); A_4= (0.2, 0.2, 0.2, 0.2, 0.2).

- The fuzzy evaluation matrix's establishment uses the expert investigation method. The content which is going to appraise will be designed into the judge advice questionnaire table by the analysis staffs and use letters to distribute to 20 experts. According to their experience experts make clear judgments about the contents by an anonymous way. Depend on the percentage that some appraisal occupies all experts' appraisal number as the determination psychological factor degree of the psychological factors to establish psychological quality evaluation matrix.

Table 2. Civil Aviation Student Pilots Psychological Quality Fuzzy Evaluation Matrix

	V_1	V_2	V_3	V_4	V_5
u_{11}	0.2	0.15	0.5	0.15	0
u_{12}	0.2	0.5	0.2	0.1	0
u_{13}	0.1	0.4	0.2	0.2	0.1
u_{14}	0.2	0.3	0.4	0.05	0.05
u_{15}	0.2	0.2	0.4	0.1	0.1
u_{16}	0.3	0.45	0.2	0.05	0
u_{21}	0.3	0.5	0.15	0.05	0
u_{22}	0.2	0.2	0.4	0.1	0.1
u_{23}	0.4	0.4	0.1	0.1	0
u_{24}	0.1	0.3	0.3	0.2	0.1

	V_1	V_2	V_3	V_4	V_5
u_{31}	0.1	0.25	0.5	0.1	0.05
u_{32}	0.2	0.3	0.4	0.1	0
u_{33}	0.2	0.3	0.35	0.15	0
u_{34}	0.1	0.3	0.4	0.1	0.1
u_{35}	0.1	0.3	0.3	0.2	0.1
u_{36}	0.1	0.4	0.4	0.1	0
u_{41}	0.3	0.4	0.2	0.1	0
u_{42}	0.1	0.4	0.3	0.1	0.1
u_{43}	0.2	0.3	0.25	0.15	0.1
u_{44}	0.1	0.3	0.3	0.2	0.1
u_{45}	0.2	0.35	0.35	0.1	0

- Establish the fuzzy relation matrix for the single factor fuzzy evaluation as follows:

$$B_1 = A_1 \circ R_1 = (0.2,0.2,0.1,0.1,0.2,0.2) \circ \begin{pmatrix} 0.2 & 0.15 & 0.5 & 0.15 & 0 \\ 0.2 & 0.5 & 0.2 & 0.1 & 0 \\ 0.1 & 0.4 & 0.2 & 0.2 & 0.1 \\ 0.2 & 0.3 & 0.4 & 0.05 & 0.05 \\ 0.2 & 0.2 & 0.4 & 0.1 & 0.1 \\ 0.3 & 0.45 & 0.2 & 0.05 & 0 \end{pmatrix}$$

$$B_1 = (0.21, 0.33, 0.32, 0.105, 0.035)$$

$$B_2 = A_2 \circ R_2 = (0.265, 0.355, 0.2275, 0.1075, 0.045)$$

$$B_3 = A_3 \circ R_3 = (0.14, 0.31, 0.385, 0.125, 0.04)$$

$$B_4 = A_4 \circ R_4 = (0.18, 0.35, 0.28, 0.13, 0.06)$$

- According to the weights of all evaluation factors make the fuzzy comprehensive evaluation.

$$B = A \circ R = (0.3, 0.2, 0.3, 0.2) \begin{pmatrix} 0.21 & 0.33 & 0.32 & 0.105 & 0.035 \\ 0.265 & 0.355 & 0.2275 & 0.1075 & 0.045 \\ 0.14 & 0.31 & 0.385 & 0.125 & 0.04 \\ 0.18 & 0.35 & 0.28 & 0.13 & 0.06 \end{pmatrix}$$

$$B = (0.1940, 0.333, 0.313, 0.1165, 0.0435)$$

- According to the maximum degree of membership principle, take the evaluating indicator which the maximum membership degree B in the calculation correspond. Namely, it is the final evaluating consequence. With the formula expressed as:

$$V_b = \left\{ V_l \middle| V_l \to \max_{i=1}^{n} (b_i) \right\} \tag{7}$$

$$V = \{V_2\} = \{good\}$$

So the student pilot's psychological quality is good.

5 Conclusions and Prospects

5.1 Conclusions

According to the indicator system of civil aviation student pilot psychological quality evaluation, the evaluation factor sets, evaluation criteria sets, membership function and objective weight sets were established, and then a comprehensive fuzzy evaluation for the psychological quality of one student pilot was conducted, by using the principle of maximum method. The result matches the training performance of him.

An internet-based questionnaire of psychological quality test for student pilots had been developed according to the psychological quality evaluation model. The questionnaire, including total 274 questions, taking about 90 minutes, could be taken worldwide by using username and password on the website. The test report would be submitted to the experts and the analyst result would be sent to the individual taken the test.

After 100 student pilots being tested, the comparison of their results in the test and their routinely training performance (fast, normal, slow, facing grounded, grounded) showed that a positive relationship between the two results. The student pilots who got better evaluation in the test were more incline to make better performance in the training courses.

The average grounded rate of student pilots is 15% to 20%. The ground rate of student pilots who scored average and above in the psychological quality evaluation was 10.26% which is much lower than the 33.51% ground rate of the ones who scored worse than average in the evaluation. To sum up, the test results show the validity of the evaluation index system and model.

5.2 Prospects

The research results showed that the psychological quality evaluation model had reflected psychological quality of student pilots which infect their flying performance. Therefore this evaluation model could play an important role in psychological selection and psychological training for student pilots, by reducing ground rate and avoiding unnecessary losses.

In this research a civil aviation student pilot psychological quality evaluation model had been set up based on fuzzy comprehensive evaluation. However, the evaluation indicator system remains to be improved as no specific indicators of the research were in-depth analysis of ambiguity and the system validity is only qualitative analyzed without deeply quantitative detection of evaluation questionnaires and performance.

Seeking cooperation with international experts, to understand the needs of civil aviation student pilots' psychological quality, this research focused on finding new training methods of pilots' psychological quality, in order to improve the effect of pilots' psychological quality training. Establishment of the psychological quality archives of student pilots is crucial in continuing evaluation and instruction in the training process. Detailed records of pilots' psychological quality, not only greatly improve the psychological quality of the pilot, but could also provide a strong basis for flight training, and reduce ground ratio due to psychological causes.

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