A predictive modeling study of international novice and skilled Chinese language teachers

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Abstract. Based on competency theory, evaluate and study international Chinese language teachers at different stages of development, establish predictive models of international Chinese language teachers at different stages of development, and analyze their competency characteristics. To establish predictive models of international Chinese language teachers at different development stages based on artificial intelligence-related technologies. First, the research data obtained from the questionnaire survey method are clustered and analyzed by machine learning. Second, models suitable for categorizing international Chinese teachers at different stages of development were selected to explore the competency factors of international Chinese teachers at different stages of development.

Keywords: Chinese as a foreign language; teacher competency characteristics; evaluation

1 Preface

Chinese is one of the fastest growing world languages in the world. Although the field of artificial intelligence is widely used in various sectors of society, it has not yet received widespread attention in the field of international Chinese language education. The advantages of big data processing capability, accuracy and objectivity that artificial intelligence technology possesses are very effective in classifying novice and skilled teachers of international Chinese, and are unmatched by traditional methods. The intervention of artificial intelligence into human resource management has a huge positive effect on improving the quality of human resource management, reducing management costs and promoting management change[1].

This paper aims to answer three questions. First, what are the categories into which the current international Chinese education talents can be categorized? Using unsupervised learning in artificial intelligence-related techniques, natural clusters of talents in the sports industry are established by cluster analysis modeling, cluster labels (labels) are established for each respondent, and then inter-group feature comparisons are performed; second, into which category should a new, participating talent be classified most appropriately? The dataset with new labels in the previous section is used for model development, supervised classification techniques are used to assign

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labels to new candidates in the future, the prediction accuracy among algorithms is compared, and normative analyses are carried out in combination with candidates' individual situations to provide them with suggestions to improve their personal abilities; third, the relationship among major factors is analyzed by the conditional process, which gives relevant theoretical support to the employing organizations to cultivate candidates and to promote the development of high-quality talents for international Chinese language education. Thirdly, it relies on the conditional process to analyze the relationship between the main factors to provide relevant theoretical support for employers to train candidates and promote their development into high-quality talents in international Chinese education. Although the technology related to artificial intelligence is widely used in various industries in society, it has not been generally emphasized in the evaluation of talents in the sports industry. However, it has the advantages of big data processing capability, accuracy, objectivity, etc., which is very effective for talent evaluation and incomparable to traditional methods. The intervention of artificial intelligence in human resource management has a great positive effect on improving the quality of human resource management, reducing management costs and promoting management change.

2 Materials and Methods

2.1 Cluster Analysis of International Chinese Language Teachers at Different Stages of Development

The data for this study were derived from a questionnaire administered to 60 international Chinese language teachers. Each subject answered three questionnaires on work style, work skills, and work values as well as basic personal information. Fifty-six sets of valid questionnaires (persons) were recovered.

The three questionnaires of work style, work skills, and work values were taken from the O*NET job analysis system[2]. This system, developed by the U.S. Department of Labor organization, is one of the more mature job analysis tools and is suitable for all types of occupational assessment in all sectors of society. It integrates various job analysis methods such as questionnaires and expert interviews, reflects both occupational characteristics and jobholder characteristics, and is capable of integrating occupational information and jobholder characteristics organically. It is a widely used job analysis tool in the United States [3].

O*NET Work Style Questionnaire: Work style is a personal characteristic that affects a person's work. The questionnaire investigates 16 styles, and subjects respond on a 5-point scale (unimportant, somewhat important, important, very important, extremely important), and are assigned a score of 1-5 to determine the extent to which each work style is associated with their own job performance.

O*NET Job Skills Questionnaire: Job skills are the abilities a person needs to accomplish a task. The questionnaire examines 35 skills and subjects respond on a 5-point scale (not important, somewhat important, important, very important, extremely important) and are assigned a score of 1-5 to determine the extent to which each job skill is related to their own job performance.

O*NET Work Values Questionnaire: Work values are the orientation of one's thinking at work. This questionnaire investigates 21 perceptions on a 7-point scale (Strongly Disagree, Disagree, Somewhat Disagree, Unsure, Somewhat Agree, Agree, and Strongly Agree), which were assigned corresponding values of 1-7. Subjects evaluated the degree of agreement with each item on this questionnaire.

Clustering is the process of discovering hidden and meaningful groups in a dataset, and is a preprocessing technique for data science algorithms, which reduces the dimensionality and complexity by converting or simplifying n-dimensional attributes into a single categorical attribute, the "cluster ID"[4]. Cluster analysis belongs to the unsupervised learning in machine learning, and the division principle is to minimize the samples within the group and maximize the distance between the groups (outside). In this paper, K-means clustering is used. This is a clustering method based on prototypes (each cluster is represented by a central data object), which aims to distribute all data points to the closest prototypes, forming clusters. However, the limitation of K-means is that it relies on the value of k assigned by the researcher. The reasonableness of the k-value is generally assessed using the lowest average center of mass distance with the Davies-Bouldin index, combined with expertise. Using Rapidminer, the data from the three recovered questionnaires were combined as a DATA set, the data were normalized using the Normalize operator (Z-transformation), and the Clustering (K-means) and Performance (Cluster Distance) operators were connected and embedded to the Loop Parameters operator. the parameter k of Loop Parameters is set to Min=2, Max=7, Steps=10, and the measuretypes are set to Mixed, Numerical, and Bregman Divergences, yielding 18 possible parameter combinations. Following the elbow rule, the inflection point is more pronounced at a k value of 3. In clustering runs with multiple values of k, the metric type with the lowest Davies-Bouldin index can be considered optimal, with the lowest being Bregman Divergences = 2.137 for k = 3.

By filtering out the options of personal information through select attributes and normalizing the data, 2 types of clusters were generated using the clustering (K-means) operator (k=3, max runs=10, measure types=Bregman Divergences), respectively, cluster0=64 and cluster1=18, and the mean scores of the 2 groups on the scale are shown in Fig. 1. Therefore, cluster0 was set as group A and cluster1 as group B. One-way ANOVA test was performed, and Dunnett-t test was selected when equal variance was assumed, and Tamhane's T2 test was selected when equal variance was not assumed.

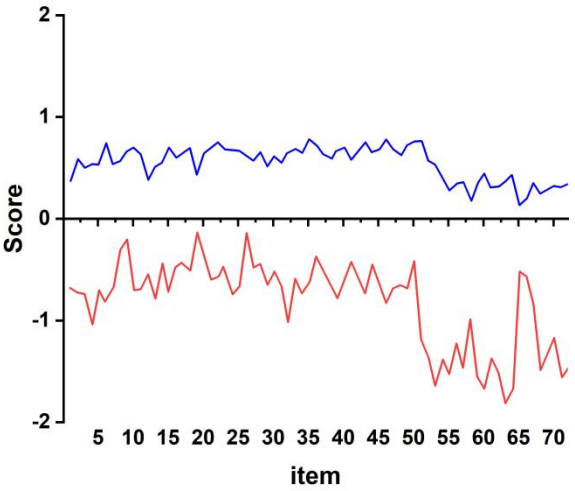

Fig. 1. Score Comparison of Three Groups of Talents in Sports Industry

First, the ANOVA test found that among the 72 items of the scale examined in the three questionnaires combined, only item 65, "Employment security: my current job provides me with a secure employment relationship", did not show any between-group differences - a finding that reflects the social reality. Since the emergence of CKP in 2020, the international Chinese language education sector in China and globally has been directly impacted. In all other questions, there was a significant difference between groups ($p < 0.05$), which was considered suitable for multiple comparisons.

Second, the ANOVA test was conducted on the 71 indicators, and it was found that 39 indicators, including "perseverance", did not meet ANOVA ($p < 0.05$), and Tamhane's T2 test was applied; 32 indicators, including "proactivity", did not meet ANOVA ($p < 0.05$), and 32 indicators were found to meet ANOVA ($p < 0.05$), which was considered suitable for multiple comparisons. indicators met the chi-square ($p > 0.05$), and Dunnett-t test was applied.

In the international Chinese language education industry, it usually contains high-quality talents and general personnel. Combined with the previous section, category A talents need to have very good working skills, excellent working style, and better values, which can be corresponded to high-quality talents; category B talents are close to category A in terms of values that are more difficult to be changed later, but need to be further cultivated in terms of working style and working skills to accumulate experience, which can be corresponded to the average personnel.

2.2 Development and comparison of predictive classification models for international Chinese teachers

When a university or an enterprise identifies the need for a position, whether it is an external recruitment or an internal transfer, it seeks to match the best possible candidate with the position; the same principle is followed when it intends to assign a candidate to

a position. In order to improve efficiency and accuracy, eliminate human interference in the early stages and provide a scientific basis for the final decision, machine learning can be introduced to build a classification model.

Classification models achieve the pursuit of predicting the binary or categorical target variable given a set of input variables by learning to predict the generalised relationships between the target variable and all other input attributes of the known data set. In Rapidminer, different predictive classification models were built using mainstream algorithms and information such as prediction accuracy was compared between the models and the results are shown in Table 1. From an overall prediction perspective (i.e. when predicting a class that may fall into one of the categories of novice or skilled teachers), Support Vector Machine (SVM) is more accurate and has less error.

Table 1. Comparison of different algorithms for predictive classification models

Model	Accuracy	Gains	Total time	Training time	Scoring time
Support vector machine	95.8%	45	10s	401s	657ms
Gradient boosted trees	94.2%	43	95s	6s	756ms
Generalized linear model	91.9%	41	6s	10s	673ms
Fast large margin	91.3%	43	9s	574s	1s
Naive bayes	88.0%	39	7s	876s	783ms
Random forest	87.6%	35	17s	2s	2s
Deep learning	82.8%	20	5s	1s	654ms
Decision	70.1%	19	4s	354s	543ms
Logistic regression	54.2%	0	8s	3s	1s

The algorithms were optimized to obtain the maximum prediction accuracy (direction for confidence=maximize, error controlled within 2 SD) for predictive studies of the target categories. Comparison of different algorithms reveals that Generalized Linear Model can achieve 85% prediction accuracy for category A i.e. high quality talent after optimization, while its prediction accuracy for category B talent also reaches 90% (Table 2).

Table 2. Accuracy Comparison of Different Optimized Models

Model	A	B
Generalized Linear Model	85%	90%
Deep Learning	85%	82%
Gradient Boosted Trees	84%	92%
Fast Large Margin	83%	99%
Random Forest	83%	99%
Support Vector Machine	76%	72%
Decision Tree	65%	65%

Predictive research analyzes based on the input-output principle, while normative analysis is when the goal (output) is clear and the optimal values of the parameters (input) are desired. This approach has a practical need, which is reflected in the following: to train a candidate to become a skilled international Chinese language teacher, what areas should he focus on to improve in the context of his personal situation?

First, the important factors predicting high quality talent in the sports industry are shown in Table 3. when all seven points listed reach the desired values, the probability of the subject becoming a skilled teacher will be 84.34%.

Second, for a candidate who has participated in the test and is predicted to become a skilled Chinese teacher, when the values of each of his/her rubrics are known, the model can be analyzed to suggest improvements. For example, the indicators that are relatively difficult to change or have low scores can be set as constants, and the algorithm can be optimized to suggest what values should be achieved for the other indicators that still have the possibility of improvement on the original basis, so as to be able to achieve the goal of becoming a skilled international Chinese language teacher.

Table 3. Important Factors for High-quality Talents in International Chinese Language Education

Important Factors for A	Score	Global Importance10
Adaptability	1.312	23.61%
Active Learning	0.954	15.98%
Selection of equipment	1.712	17.90%
Human Resource Management	1.345	10.76%
Physical Resource Management	1.604	4.89%
Caring for others	1.358	4.67%
Science	1.435	5.08%

3 A Conditional Process Analysis of Factors for International Chinese Language Teachers

3.1 Correlation analysis

Correlations were analyzed between work styles, work skills, work values, and personal information of international Chinese language teachers (Figure 2). The analysis showed that the correlations between work style, skills and values were significant. From the personal information of international Chinese language teachers' work, the number of years of teaching experience (abbreviated as "years of service") was the most correlated and significant with work style, and the highest degree was the most correlated and significant with work values ($p < 0.05$), but no factor was significantly correlated with work skills.

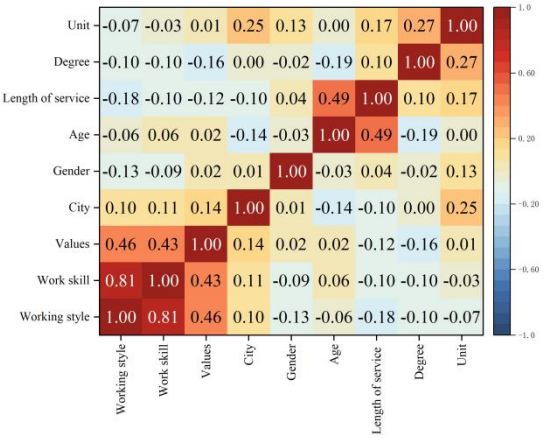

Fig. 2. Correlation Coefficient Analysis

3.2 Theoretical assumption

If the indirect effect of the independent variable X on the dependent variable Y through the variable M varies as a result of a change in the moderator variable W, the relationship from X to Y can be called a Conditional Process. The focus of conditional process research is to quantify the geometry of the effect of X on Y through one or more mediators. According to the classic "iceberg" model of competency, in the process of building a candidate into a skilled international Chinese language teacher, job skills are the most likely to be improved through acquired learning and development; followed by work style, and teamwork has a great influence on individuals. In different work teams, one's work style will be affected and change. Thirdly, work values, which are formed in a long period of time, influence one's choices when facing problems. Subtle changes in values can affect work styles, which in turn have an impact on the acquisition and improvement of work skills. As a person's working hours increase, his or her work habits become entrenched and difficult to change.

Based on the above, this paper proposes the hypothesis that work values have an effect on job skills through work style and that this effect is moderated by length of service.

4 Findings

Standardize work style, skills, and values data ($Z = \frac{X - \overline{X}}{\sigma}$). Referring to the research paradigm of Wen Zhonglin and Ye Baojuan , the first step of the study should be to test whether the direct effect of X on Y is moderated by W. The first step

of the study should be to test whether the direct effect of X on Y is moderated by W. The regression equation for the moderation test is:

$$Y = i_y + b_1 X + b_2 W + b_3 XW + e_y \quad (1)$$

Hayes pointed out that in moderation,1 significant or not determines whether the effect of X on Y is dependent on W [111]. After controlling for the variables of gender, age, highest degree, city affiliation, and unit affiliation, the β of ,= -0.017, and the 95% confidence interval [-0.1385, 0.1045] contains 0, which suggests that the direct relationship between the job values and job skills of international Chinese language teachers is not moderated by years of work experience.

The second step is the mediation test with moderation. To test whether the mediating effect of international Chinese teachers' work values affecting work skills through work styles is moderated by years of working experience, the regression equation of the test is:

$$Y = i_y + c'X + b_1 M + b_2 W + b_3 MW + e_y \quad (2)$$

$$M = i_M + aX + e_M$$

Hayes points out that newer research focuses on the model as a whole, testing whether the weight of the moderating variable (ab_3) in the function expressing the indirect effect is zero. He refers to this weight as the Index of Moderated Mediation, which reflects the magnitude of the influence of the moderating variable across the entire path of mediation. When using this approach to measure whether an indirect effect is moderated, it does not matter whether the interaction of the path that defines the indirect effect is significant [5]. In many tests, the indicator may not be significant even if the interaction term is significant, which raises the standard of the test. Gender, age, highest degree, city affiliation, and affiliation were analyzed as control variables, and the results are shown in Table 4.

Table 4. Model Coefficients for the Conditional Process Model

	M(Working Style)				Y(Working Skill)			
		coeff.	SE	P		coeff.	SE	p
X(Working Values)	a	0.432	0.068	0.000	c'	0.070	0.053	0.192
M(Working Style)		—	—	—	b_1	1.122	0.172	0.000
W(Length of Service)		—	—	—	b_2	-0.009	0.031	0.769
MW		—	—	—	b_3	-0.082	0.044	0.064

Constant	i_M	0.487	0.33	0.142	i_y	-0.348	0.23	0.132
		R2=0.241				R2=0.676		
		F(6,154)=8.144，p<0.001				F(9,151)=35.088，p<0.001		
		MW △R2=0.0074				F(1,151)=3.470 p=0.064		
		Index=-0.035				BootSE=0.018		
		95%CI[-0.072,-0.002]						

For the separate mediation effect analysis of X-M-Y, the effect value total=0.417, 95% confidence interval [0.272, 0.562], and 95% confidence interval [0.231, 0.487] do not contain 0, which indicates that the total effect and the indirect effect are significant, and the effect size of the indirect effect reaches 84.96%. 95% confidence interval [-0.043, 0.168] contains 0, indicating that the direct effect of work values on work skills is not significant and is fully mediated.Hayes pointed out that the validation of the direct effect of X → Y in modern mediation analysis is not a prerequisite for testing its indirect relationship, because there are many cases in which X is not directly related to Y [113].

A pairwise comparison shows that the effect size of the indirect effect decreases by 0.043 for each unit increase in years of service (1.230) (Figure 3). The effect of work style on job skills is 0.404 when the length of service is 2.311, while the value of this effect decreases to 0.317 when the length of service reaches 4.4770, which is a difference of 2 units of effect size.

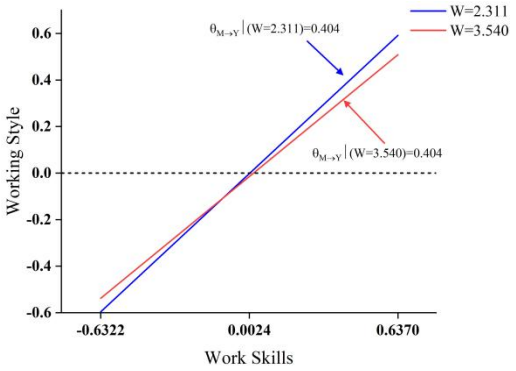

Fig. 3. The Moderation of the Effect of Work Style on Skills by Different Length of Service

In summary, the model was used to make normative analysis to make training suggestions for relevant candidates, which led to the theoretical support of the development path of novice international Chinese language teachers to skilled teachers, and the effective path could be as follows: establish better work values, and bring a positive effect on the improvement of work skills through the mediating path of establishing a more scientific, efficient, and team-responsive work style. Since this mediating effect is negatively moderated by the number of years working in international Chinese language education, it should be initiated as early and as soon as possible in the development of reserve personnel. As teachers' years of work

experience increase, progress in the later stages will be smaller than in the earlier stages.

5 Conclusion

This study investigates international Chinese language teachers based on three questionnaires on work style, work skills, and work values from the O*NET job analysis system, as well as the subjects' basic personal information.

First of all, the international Chinese teachers were clustered into two groups using the K-means method of machine learning cluster analysis, and the specific characteristics of their work styles, work skills, and work values and the characteristics of the "groups" were compared separately. It was found that group A, which corresponded to the skilled international Chinese teachers, generally possessed very good work skills, excellent work styles, and good values. They were significantly different from Group B in all three aspects, with a significant advantage in work style and skills, but a reduced advantage in values.

Second, using Classification of machine learning, we compared and filtered the models that were suitable for predictive classification of international Chinese language teachers at different stages of development. From the perspective of overall prediction (i.e., when predicting that the talents may belong to one of the AB categories), Support Vector Machine is more accurate with less error; Generalized Linear Model can reach 85% accuracy for the prediction of A category, i.e., high-quality talents, and 90% accuracy for the prediction of B category talents. The important factors for predicting international Chinese language teachers at different stages of their careers are summarized. When all seven points listed reach the ideal value, the probability of the subject becoming a high-quality talent will reach 84.34%. For a teacher who has participated in the test and is predicted to be a Category B teacher, when the values of his/her various rubrics are known, individualized suggestions for improvement can be made through the model analysis, i.e., a normative analysis in which the goal (output) is clearly defined and the optimal values of the parameters (inputs) are desired. Third, the conditional process analysis found that work values mediated the positive influence on work skills through work style, which was negatively moderated by the number of years engaged in teaching Chinese. Therefore, when cultivating reserve talents, it should be started as early as possible and as soon as possible. As the number of years of work experience of the talents increases, the progress in the later stage will be smaller than that in the earlier stage.

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