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Article

Mathematical Analysis and Assessment of the Effectiveness of Personalized Implementation of Ideological and Political Education in Colleges and Universities in a Big Data Environment

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Abstract: The personalized teaching mode is based on individualized needs, and through the support of big data analysis technology, it provides students with more accurate and suitable educational resources to maximize the learning effect. In this paper, we will explore the personalized teaching mode in the field of ideological and political education from the perspective of big data analysis technology, explore the main factors affecting the personalized teaching effect of ideological and political education in colleges and universities by factor analysis method, and construct an evaluation model of the personalized implementation effect of ideological and political education. Using factor analysis and principal component method, the study identifies three common factors affecting the personalized implementation effect of ideological and political education in colleges and universities from 15 indicators, which are: technology integration and platform support efficacy, pedagogical adaptation and personalized experience value, and personalized education goal consensus. Afterwards, a factor score model for assessing the implementation effect of personalized ideological and political education in colleges and universities was constructed based on the regression method: $F = (F_1 * 48.446 + F_2 * 29.985 + F_3 * 16.908) / 95.339$. The evaluation model reduces the cross and redundancy of information, and the evaluation results are scientific and reliable with strong operability and certain value of popularization and application.

Keywords: Factor analysis; Principal component method; Regression method; Personalized implementation effect

1. Introduction

Personalized education is an education that respects the unique value of individual life, explores the potential of individual life, cultivates students' independent personality and unique individuality, and promotes the free and harmonious development of life [1]. In the era of big data, the personalized education model becomes possible for students to become the main body of learning, the duration of learning is not limited, the way of receiving learning advice is not confined, and the learning places are diverse [2-3]. With the enhancement of national power, education investment is increasing day by day, the trend of personalization of contemporary educated people is obvious, and the personalized demand for accepting new knowledge increases, many students not only want to accept knowledge better, but also their own potential to be discovered and developed has become their learning aspirations, and they hope to make more and more comprehensive improvement in all aspects on the basis of accepting common education, which promotes the development of individuality and fairness of education [4-7]. Thought is the precursor of action, and the leading role of personalized civic education for students should not be underestimated.

In the era of big data, technology + education in the context of educational transformation, the traditional education model has been transformed from teacher experience-oriented to student and educational data-oriented [8-9]. And with the in-depth integration of the ideological education of colleges and universities with big data technology, as well as the continuous research and development of big data technology, the ideological education is in a state of rapid development, especially when the big data technology continues to innovate and develop, and a variety of new types of technology in the ideological education, enriching the personalized education of students [10-11]. For example, when carrying out the education of the Civics course of Introduction to the Socialist Theoretical System with Chinese Characteristics, the network platform based on big data technology can be used to plan different learning modes according to the students' individual needs, such as the extension of the Civics knowledge of the students who have already mastered the Civics content of this section, and the enhancement of the education of those who have not mastered the Civics knowledge, so that the significance of the Civics education under the big data is brought into full play by tailoring the education to the needs of the students to satisfy their individualized teaching [12-16]. The implementation effect of personalized ideology and politics is the current education field is more concerned about the problem, but there is a lack of scientific implementation effect assessment system and methods, and with the help of data analysis, to explore the mathematical analysis of the implementation effect of personalized ideological and political education in colleges and universities and assessment methods, to promote the optimization of personalized education, and to become a key topic of the ideological and political education.

This paper explores the effect of the application of big data in the civic education of colleges and universities. The data are factor analyzed by organizing the recovered questionnaires. In the process of factor analysis, the method of principal component factor analysis and maximum orthogonal rotation are mainly used. After the maximum orthogonal rotation of variance to get the factor loading matrix, take the indicators with a loading value greater than 0.3 to stay in the factor matrix. The variance contribution rate of each main factor is calculated to construct the evaluation model of the personalized implementation effect of ideological education. The evaluation of the personalized implementation effect of Civic and Political Education in 15 colleges and universities proves that the model constructed in this paper is operable.

2. The application of big data in the civic education of colleges and universities

In recent years, big data technology has been developing rapidly and has been widely used in many fields such as social governance, industrial manufacturing and business operation. In this context, ideological and political educators in colleges and universities will face a new mission brought by technological change. The intervention of big data technology provides technical support for personalized ideological and political education in colleges and universities [17]. Big data can be divided into categories for the personality of the education object “portrait”, and then improve the targeting and accuracy of ideological and political education, and enhance the level of ideological and political education in colleges and universities.

2.1. Accurate grasp of students' personality traits

The comprehensiveness of data collection helps to accurately grasp the individual characteristics of the educational object. In the traditional teaching of ideological and political theory courses, the homogenized and standardized teaching process is prone to ignore the uniqueness of the education object. The emergence of big data technology has made it possible for colleges and universities to record the data of each student's social contacts, leisure and entertainment, life shopping, study and training, enabling colleges and universities to analyze and explore the uniqueness of different educational objects in terms of their study, life and social life. The volume of the above data is astonishing, but with the technical support of big data, the data can be transmitted and flowed in real time and quickly, becoming an important reference for improving the quality of theoretical teaching of Civics and Political Science courses, and presenting unique application value and advantages. On the basis of comprehensive data collection, big data “portraits” the individuality of education targets in different categories, and teachers of ideological and political courses can then grasp students' personality characteristics in a concise and visualized way to improve management inside and outside the classroom and accurately implement teaching strategies.

2.2. Analysis of the dynamics of students' thoughts and behaviors

The analysis of massive data helps to strengthen the immediate monitoring of students' ideological dynamics. Big data technology can capture, circulate and feedback the dynamic information of students

in real time, so that teachers can discover certain personality characteristics of the target of education in time, and then adjust and improve teaching strategies in a targeted manner. Student groups in higher education are characterized by rapid cognitive development and change. In the absence of technical means of support, the grasp of the dynamics of student thinking and behavior is more through the "qualitative" judgment, it is difficult to combine with scientific "quantitative" research methods for in-depth analysis. Big data technology can effectively solve the problem of difficult data collection. Big data technology can effectively accumulate, track and quantitatively analyze the information of students' thoughts and behaviors, and then through the construction of a scientific analysis model of the interface between thoughts and behaviors, discover the connection between thoughts and behaviors of different individuals, so as to accurately grasp the dynamics of the whole target group's thoughts and capture the key information contained therein, and to effectively explore the real value hidden in the huge amount of data information.

2.3. Personalized Recommendation of Educational Resources

Big data technology helps drive the implementation of human-centered on-demand learning in ideological and political courses. The integration of ideological and political education with big data technology has promoted the full excavation and utilization of various ideological and political education resources, and a large number of high-quality educational resources have been integrated into the cloud to realize sharing and form learning channels outside the classroom. Students can choose all kinds of online learning channels supporting the ideological and political courses according to their own learning characteristics and personal preferences, and make full use of online course resources such as open courses, MOOC, boutique courses, microcourses and so on. The application of educational resource sharing under the support of big data expands the freedom of learning in time and space, and students can obtain high-quality course resources anytime and anywhere by using cell phone APP or PC website. At the same time, a set of educational resources personalized recommendation system established with the technical support of big data can more accurately identify students' interest in learning, and help different groups of students to find learning content that is interesting and suitable for their own characteristics.

3. Methods of mathematical analysis and assessment of the effectiveness of personalized implementation

The application of big data technology creates new opportunities for the development of personalized ideological and political education. In this paper, we will extract the main factors of big data technology to promote the personalization of ideological and political education in colleges and universities based on factor analysis [18], and construct a model for assessing the implementation effect of personalization of ideological and political education.

3.1. Factor analysis model

Let $X=\left(x_{ij}\right)_{n\times p}$ be the sample observation matrix consisting of p evaluation indicator variables and n sample points:

$$X=\begin{bmatrix} x_{11} & x_{12} & \cdots & x_{1p} \\ x_{21} & x_{22} & \cdots & x_{2p} \\ \vdots & & & \vdots \\ x_{n1} & x_{n2} & \cdots & x_{np} \end{bmatrix} \tag{1}$$

Remember:

$$X_{\mathrm{i}}=\left(x_{i1},x_{i2}\cdots,x_{ip}\right) \tag{2}$$

Then:

$$X=\begin{bmatrix} X_1 \\ X_2 \\ \vdots \\ X_n \end{bmatrix} \tag{3}$$

where x_{ij} is the value of the i th indicator at the j th sample point.

For convenience the dimensionless data matrix of the original data $X=\left(x_{ij}\right)_{n\times p}$ is still denoted by $X=\left(x_{ij}\right)_{n\times p}$ with $f_1,f_2,\cdots,f_m(m\bullet p)$ denote the m factor variables, i.e., the common factors, respectively, then the factor analysis model is:

$$X=Af+\varepsilon \tag{4}$$

where: $A=\left(a_{ij}\right)_{p\times n}$ is the matrix of coefficients to be estimated, known as the factor loading array, $a_{ij}(i=1,\cdots,p;j=1,\cdots,m)$ is known as the loading of the i variable on the j factor (referred to as the factor loading), and $\varepsilon_i(i=1,\cdots,m)$ is called the special factor of X_i, which are satisfied between them:

(1) $\mathrm{COV}(f,\varepsilon)=0$, i.e., the common and special factors are uncorrelated.

(2) $D_\varepsilon=D(\varepsilon)=diag\left(\sigma^2{}_1,\sigma^2{}_2,\cdots,\sigma^2{}_p\right)$, i.e., the The special factors are uncorrelated and the variances are not required to be equal.

(3) $D_f=D(f)=I_m$, i.e., the individual common factors are uncorrelated and have variance 1.

3.2. Factor analysis steps

The steps of the commonly used factor analysis for comprehensive evaluation are as follows:

(1) Standardize the original data array $X_{n\times p}$ and calculate the covariance array of standardized indicators, i.e., the correlation coefficient matrix R.

(2) Find the eigenvalues $\lambda_1\text{开}\lambda_2\text{开}\lambda_3\text{开}\cdots\text{开}\lambda_p$ of the matrix of correlation coefficients R, and the corresponding eigenvectors, eigenvalue contribution rates, and cumulative contribution rates.

(3) Determine the number of common factors according to the contribution rate of the eigenvalues and the cumulative contribution rate, and establish the factor model.

(4) Calculate the factor loading matrix.

(5) Rotate and transform the factor loading matrix to simplify the structure and make the significance of the public factors clearer.

(6) Construct the comprehensive evaluation model and implement the comprehensive evaluation analysis. The comprehensive evaluation model is $F=\sum_i \omega_i f_i$ is the public factor, and $\omega=\lambda_i\Big/\sum_{k=1}^{p}\lambda_k$ is the contribution rate of this public factor.

4. Factors affecting the effectiveness of personalized implementation and evaluation

4.1. Questionnaire design and survey respondents

The questionnaire content of this paper is designed for 15 colleges and universities that apply big data technology for ideological and political education. Students evaluate the effect of personalized implementation of ideological and political education in their schools' colleges and universities based on the following 13 questions:

T1: My school has established a big platform that integrates data on teaching affairs, academic affairs, logistics, etc.

T2: The school can use big data technology to accurately identify my academic difficulties and provide early warning or assistance.

T3: The school can recommend personalized teaching resources to me based on my reading habits or school interests.

T4: Civics teachers are able to skillfully use online teaching platforms or data analysis tools to teach.

T5: Civics teachers are able to adjust the content and pace of teaching in a timely manner based on classroom feedback.

T6: I think the application of big data technology makes the learning content of the Civics class more

in line with my personal needs and interests.

T7: Big data-enabled Civics education makes it easier for me to understand complex Civics knowledge.

T8: The setting of personalized learning paths improves my engagement and learning initiative in Civics and Political Science classes.

T9: I am concerned that personalized recommendations may lead me to be exposed to information and opinions that become homogeneous.

T10: The school has a professional technical support team for the big data application of Civic and Political Education.

T11: The school's data management platform runs stably, and data between different systems can be shared and integrated effectively.

T12: School leaders emphasize and support the exploration and application of new technologies such as big data in ideological education.

T13: The existing assessment methods can effectively assess my personalized growth in the Civics class.

The questionnaire was measured using a five-point Likert scale (1=strongly disagree to 5=strongly agree).

A total of 500 questionnaires were distributed and 486 questionnaires were returned, of which 480 were valid, with an effective recovery rate of 96%.

4.2. Indicator item analysis and validity analysis

(1) Item Analysis

The purpose of item analysis of the raw data is to examine whether the 13 questions designed in the questionnaire accurately measure the respondents' objective views on the questions asked and to delete the questions that did not reach a significant level. The results of the sample independent t-test obtained by collating and examining the test value of each indicator, the 95% confidence interval of the 13 questions did not contain 0. Accordingly, it can be concluded that each question has a good degree of discrimination and all of them can test the degree of reflection of the respondents on the question asked.

(2) Validity analysis

The 13 questions were examined for validity based on the Alpha value, and it was concluded that Alpha = 0.8659, according to the theory of the vast majority of sociological researchers, this Alpha value is quite good between 0.7 and 0.8. The validity value of the 13 questions listed in this questionnaire is 0.8659, indicating that all the indicators are valid.

4.3. Analysis of Factors Influencing the Effectiveness of Personalization Implementation

According to the returned questionnaires, the data on the sub-indicators of the personalized implementation effect of Civic Education were obtained by calculating the mean value of the scores of each indicator of the colleges and universities, and the results of the calculations are shown in Table 1.The range of the scores of each indicator of the 15 colleges and universities covered the range of 1 to 5 points.

Table 1. The data of the individualized implementation of the education.

	T1	T2	T3	T4	T5	T6	T7	T8	T9	T10	T11	T12	T13
1	3	4	1	5	3	3	5	4	1	4	1	4	4
2	4	1	2	5	4	1	2	2	2	2	3	2	3
3	5	2	2	5	1	1	2	5	2	3	4	3	2
4	3	4	5	4	4	4	4	2	3	2	5	5	4
5	1	1	1	1	2	1	3	5	4	5	4	5	1
6	3	4	2	3	3	3	2	4	5	4	3	3	5
7	3	1	5	3	3	5	4	4	3	4	4	4	2
8	3	1	3	3	4	5	5	4	2	4	5	4	4
9	1	4	3	3	5	4	2	3	4	1	1	1	1

10	5	3	5	2	5	5	2	4	4	4	4	3	4
11	3	3	4	4	5	3	4	2	4	4	5	3	2
12	2	2	1	2	3	3	4	2	4	4	2	4	3
13	3	4	5	5	2	3	3	4	4	5	5	5	5
14	4	4	3	5	3	3	4	2	3	3	2	3	2
15	4	2	4	3	3	3	4	3	2	4	3	3	5

Because of the consistent scale between the data, there is no need for standardization, and the original data were analyzed and sorted out by principal component and factor analysis in SAS software, and the results are as follows:

(1) Calculate the correlation coefficient matrix of the original data

The correlation matrix R of the original variables is shown in Figure 1. From this correlation matrix, it can be seen that between these 13 indicators, there is a certain correlation, that is, it shows that there is an overlap in the information reflected in the indicators, and it is necessary to re-extract the factors.

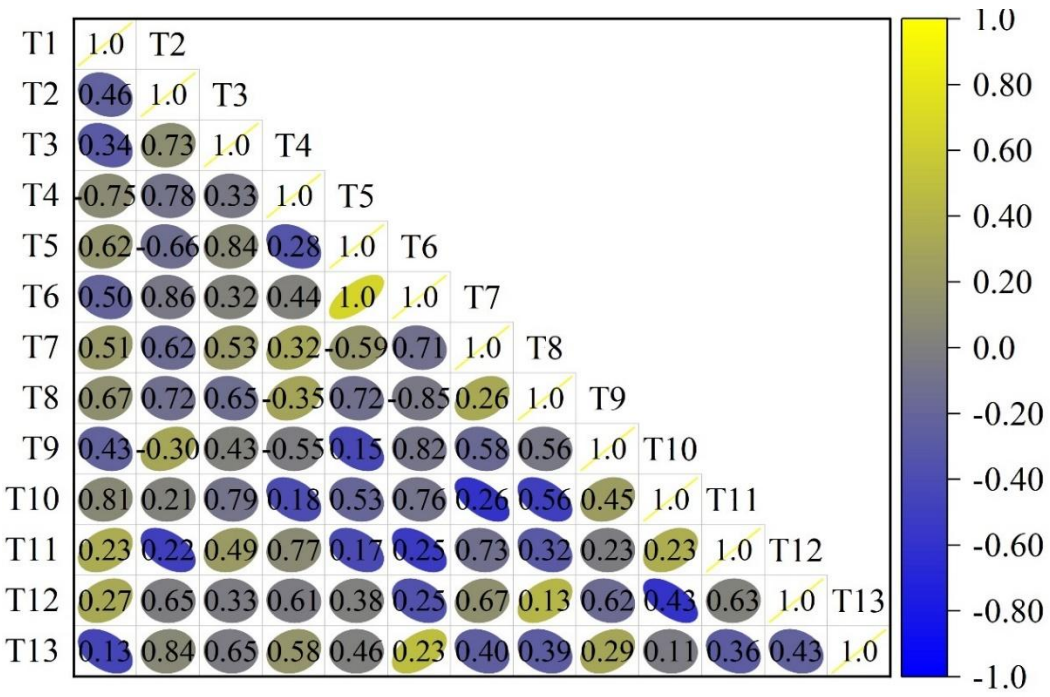

Figure 1. The correlation matrix of the original variable.

(2) Selection of appropriate factors

The cumulative contribution rate refers to the amount of information accumulated by the relevant common factors to reflect the original indicators. The eigenvalues, cumulative contribution rate among the indicators are shown in Table 2. According to the principle of extracting eigenvalues greater than 1, three factors meet the principle, and the cumulative contribution rate of the first three factors is 95.339, which means that the variance explained by the first three common factors accounts for 95.3% of the total variance.

Table 2. The variance of the common factors of each component before rotation.

Component	Initial Eigenvalues			Extraction sums Squared Loadings			Rotation Sums of Squared Loadings		
1	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	6.298	48.446	48.446	6.298	48.446	48.446	6.053	46.562	46.562

2	3.898	29.985	78.431	3.898	29.985	78.431	3.694	28.415	74.977
3	2.198	16.908	95.339	2.198	16.908	95.339	2.647	20.362	95.339
4	0.606	4.662	100						
5	6E-6	0	100						
6	8.5E-7	0	100						
7	6.1E-6	0	100						
8	1.4E-6	0	100						
9	4E-8	0	100						
10	6.3E-7	0	100						
11	4.1E-8	0	100						
12	6.4E-5	0	100						
13	5.2E-5	0	100						

(3) Calculate factor loading moments

The purpose of establishing the factor analysis model is not only to find out the main factors, but more importantly to know the meaning of each main factor. However, with the above method to find out the common factor solution, the typical representative variables of each principal factor are not very prominent, which is easy to make the significance of the factor ambiguous, and not easy to analyze the actual problem, so it is necessary to improve the factor extraction method. In this paper, the principal component method [19] is used to extract the factors, using the variance maximum rotation method converged after three iterations, the results of the factor extraction after rotation are shown in Table 3. The rotated loading factors have been obviously polarized.

The first factor covers question items 1, 2, 3 and 11. This indicates that a powerful data platform, stable technical support and accurate algorithmic recommendation ability are the underlying foundation and key technical guarantee for realizing personalized Civic Education. Therefore, the factor is named: technology integration and platform support effectiveness.

The second factor covers items 4, 5, 6, 7, and 8, which reveals that teachers' effective use of technology, tailoring the content to individual needs, and enhancing students' sense of participation are the most direct dimensions of students' perception of personalized Civics education. Therefore, this factor was named: value of instructional adaptation and personalized experience.

The third factor covers items 9, 10, 12, and 13, which suggests that while pursuing personalized education, we must avoid potential risks, and that a clear consensus on the goals is necessary to ensure the sustainable development of personalized education. Therefore, this factor is named: personalized education goal consensus.

Table 3. The results of the rotation factor extraction.

	Component		
	1	2	3
T1	0.963	0.063	0.066
T2	0.955	0.085	0.012
T3	0.863	-0.634	0.114
T4	-0.063	0.921	-0.635
T5	-0.523	0.863	-0.412
T6	0.085	0.944	-0.563
T7	-0.542	0.957	-0.566
T8	-0.325	0.824	-0.568
T9	-0.569	-0.041	0.963

T10	0.042	-0.163	0.974
T11	0.921	-0.047	0.012
T12	0.054	-0.196	0.841
T13	0.213	-0.132	0.853

In summary, the effect of personalized implementation of ideological and political education in colleges and universities in the big data environment is mainly affected by three factors, namely, technology integration and platform support efficacy, pedagogical adaptation and personalized experiential value, and personalized education goal consensus.

4.4. Evaluation of the Effectiveness of Personalized Implementation of Civic Education

The previous article variableized the 13 relevant indicators into three unrelated new composite indicators. These three new indicators are then used to evaluate the effect of personalized implementation of Civic Education, which not only simplifies the evaluation system, but also reduces the crossover and redundancy of information.

The factor score coefficients are further estimated by regression method [20] as shown in Table 4. According to the factor score coefficients, the original index values are substituted into the factor score model to obtain the main factor score Fi (i = 1, 2, 3). Then the weight of the variance contribution rate of each main factor to its cumulative variance contribution rate is used as the weight to calculate the score of personalized implementation effect of Civic Education in each university, i.e.:

$$F = (F_1 * 48.446 + F_2 * 29.985 + F_3 * 16.908) / 95.339 \quad (5)$$

Table 4. Factor score coefficient.

	Factor 1	Factor 2	Factor 3
T1	0.5718	0.6494	0.1912
T2	0.3913	-0.1397	0.6132
T3	-0.5874	-0.7548	-0.9932
T4	-0.1774	0.4053	0.7408
T5	-0.881	-0.2289	-0.7775
T6	0.758	-0.4304	-0.502
T7	0.7132	-0.0838	-0.6864
T8	0.8417	-0.8964	-0.0776
T9	0.7728	-0.4853	0.6083
T10	0.1989	0.8926	0.5861
T11	0.9234	-0.4237	0.0191
T12	0.8969	-0.1056	-0.5492
T13	0.3608	-0.6957	0.4938

According to the factor score model to assess the effect of personalized implementation of Civic Education in 15 universities, the comprehensive evaluation results are shown in Table 5. Where F_1, F_2, F_3 are the main factors before the exclusion of indicators, and F is its corresponding comprehensive score of teaching effect. The ranking of the comprehensive score F is [10, 12, 11, 3, 15, 8, 6, 5, 13, 2, 4, 14, 1, 9, 7], and the ranking of the raw average score is [9, 15, 11, 3, 12, 7, 6, 4, 14, 2, 5, 13, 1, 10, 8], which is not much different from the original score, which suggests that the above factor model can be used to assess the effect of personalized implementation of the Civic and Political Education in colleges and universities. Effectiveness.

Colleges and universities with top scores on the first factor also have top scores on the composite score, so if schools want to improve the effect of personalized implementation of Civic and Political

Education, they have to work hard on the aspects of T1, T2, T3 and T11.

Colleges and universities according to their own ranking on the main factors, they can clearly understand their strengths and weaknesses, so that they can carry out targeted teaching in the future, to improve the effect of personalized implementation of Civic and Political Education to provide a scientific basis. For example, although the second factor score of the first university is ranked second, which is more advanced than the second factor score of the 13th university ranked first, the first factor score of the first university is ranked very backward, thus the comprehensive score is ranked ninth, which is far behind the 13th university. This indicates that the 1st university should focus on improving the effectiveness of technology integration and platform support when utilizing big data technology for Civics teaching in the future.

Table 5. Comprehensive evaluation results.

School	F_1	Rank	F_2	Rank	F_3	Rank	F	Rank	Original average score	Rank
1	2.25	6	4	2	3.25	5	2.98	10	3.23	9
2	2.5	5	2.8	8	2.25	8	2.55	12	2.54	15
3	3.25	3	2.8	8	2.5	7	2.98	11	2.85	11
4	4.25	1	3.6	4	3.5	4	3.91	3	3.77	3
5	1.75	7	2.4	9	3.75	3	2.31	15	2.66	12
6	3	4	3	7	4.25	2	3.22	8	3.38	7
7	3.25	3	3.8	3	3.25	5	3.42	6	3.46	6
8	3	4	4.2	1	3.5	4	3.47	5	3.62	4
9	2.25	6	3.4	5	1.75	9	2.52	13	2.54	14
10	4.25	1	3.6	4	3.75	3	3.96	2	3.85	2
11	3.75	2	3.6	4	3.25	5	3.61	4	3.54	5
12	1.75	7	2.8	8	3.75	3	2.43	14	2.77	13
13	4.25	1	3.4	5	4.75	1	4.07	1	4.08	1
14	3.25	3	3.4	5	2.75	6	3.21	9	3.15	10
15	3.25	3	3.2	6	3.5	4	3.28	7	3.31	8

5. Outlook of personalized teaching based on big data analysis

With the rapid development of information technology and the application of big data analysis technology, more technologies will be applied to the field of education in the future. For example, virtual reality technology, artificial intelligence technology, etc., these technologies will better achieve the goals and requirements of personalized education. Virtual reality technology allows students to experience learning through virtual reality scenes, immersive learning content, helping students better understand and master knowledge. For example, when learning history, students can use VR technology to travel through history and personally feel the process of historical events, so as to improve students' interest in and understanding of history. In addition, VR technology can also help students better practice practical skills, such as simulation experiments in the field of medicine or engineering, students can be safer and more stable experimental operations.

Artificial intelligence technology can predict the problems students may encounter in learning based on their trajectories and behaviors, and provide appropriate interventions and assistance. For example, when learning a language, AI technology can provide students with more precise error correction and grammar strategy suggestions based on the frequency and occurrence of their grammatical errors. At the same time, artificial intelligence technology can also help teachers better understand the learning status and potential of students, and through the analysis of student learning data, provide more humane and accurate learning suggestions and teaching programs to improve students' learning results.

Virtual reality technology and artificial intelligence technology and other information technology can better achieve the goals and requirements of personalized education, providing students with a better learning experience and teachers with better teaching methods and tools. In the future, with the

continuous innovation and development of information technology, personalized education will become more popular and in-depth, bringing strong impetus and support to the development of education.

6. Conclusion

The study used factor analysis and principal component method to extract the main factors affecting the personalized implementation effect of ideological and political education in colleges and universities, and constructed a factor score model through regression method to assess the personalized implementation effect. After factor analysis, in the big data environment, technology integration and platform support effectiveness, teaching adaptation and personalized experience value, and personalized education goal consensus are the main factors affecting the personalized implementation effect of ideological and political education in colleges and universities. Colleges and universities can rely on $F = (F_1 * 48.446 + F_2 * 29.985 + F_3 * 16.908) / 95.339$ to understand the personalized implementation of ideological and political education in order to adjust the teaching mode in time. In the future, technologies such as virtual reality technology and artificial intelligence technology will better achieve the goals and requirements of personalized education.

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