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Article

Research on Multidimensional Big Data Assessment and Development Model of Innovation and Entrepreneurship Ability of College Students in Higher Education

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Abstract: Combined with the current situation of innovation and entrepreneurship ability cultivation of college students, this paper establishes the evaluation index system of innovation and entrepreneurship ability of college students, which consists of six secondary ability indicators, namely, goal-setting ability, action-planning ability, decision-making ability, communication and cooperation ability, opportunity-grasping ability, and risk-prevention ability. The evaluation system of college students' innovation and entrepreneurship ability is constructed by the AHP method, and the consistency and credibility of the evaluation system are examined with the sample data. Collect college students' innovation and entrepreneurship behavior data, establish four LGCM models such as intercept model and unconditional linear growth model, and determine the overall trajectory of college students' innovation and entrepreneurship ability development through the comparison of LGCM models. Establish LCGM model to test the heterogeneous development trajectory of college students' innovation and entrepreneurship ability. Combined with the model fitting indexes of the heterogeneous development trajectory of ability, the development of innovation and entrepreneurship ability of college students is divided into four categories, which are low stable group, stable rising group, medium and fast rising group, and high stable rising group. The intercept means of the four development trajectories of college students' innovation and entrepreneurship ability are 17.825, 16.918, 19.003, and 21.536, respectively. Combined with the proportion of the number of people in each category, the development of college students' innovation and entrepreneurship ability is mainly concentrated in the medium and fast rising group.

Keywords: student behavior data; LGCM model; LCGM model; consistency test; innovation and entrepreneurship ability

1. Introduction

Innovation and entrepreneurship is a person's ability of self-survival and self-development in entrepreneurial practice activities. A college student who succeeds in independent entrepreneurship not only will not become the employment burden of the society, but also can increase jobs through independent entrepreneurship to ease the employment pressure of the society and contribute to the harmonious and stable development of the society [1-4]. Through self-employment, college students can connect their interests with their careers and do what they really want to do, which is conducive to college students' survival and rapid realization of self-worth [5-7]. In the era of big data, the development of innovation and entrepreneurship ability plays a very important role in the improvement of students' comprehensive ability, and the assessment of innovation and entrepreneurship ability of big data is of great significance in discovering the deficiencies and better developing this ability [8-11].

Big data is not a simple collection of ponderous data, but a giant data set that discovers new knowledge, creates new value, and improves new abilities by collecting data from different sources and formats and storing and correlating and analyzing these data [12-15]. In the assessment of innovation and entrepreneurship ability of college students, it is mainly based on the qualitative and quantitative

characteristics of the innovation and entrepreneurship ability of college students, grouping and categorizing the multi-dimensional data, so as to understand the intrinsic structure of the individual elements of the innovation and entrepreneurship ability of college students and to provide a detailed description of each trait element [16-20]. At the same time, the innovative entrepreneurial ability of college students is realistically assessed through careful investigation of hierarchical analysis. Based on the assessment of the ability, big data technology can analyze, process and mine the large amount of information rapidly obtained from big data according to the characteristics of students' career interests, career aspirations, cognitive abilities, etc., to provide a more refined and efficient learning and cultivation paths and modes for the development of innovation and entrepreneurship of college talents, and to help students to comprehensively improve their comprehensive quality through the implementation of personalized and precise education [21-25].

This paper analyzes the process of collecting data on innovation and entrepreneurship behavior of college students and pre-processes the collected data on innovation and entrepreneurship behavior of college students. The process of determining the evaluation index system of college students' innovation and entrepreneurship ability is described in three steps. The AHP method is introduced into the evaluation index system of college students' innovation and entrepreneurship ability, and the evaluation system of college students' innovation and entrepreneurship ability is examined by combining the sample data. Multiple LGCM models are established to determine the development trajectory of the overall innovation and entrepreneurship ability of the sample. Based on the LGCM model with free estimation of time scores, the intercept mean and slope mean of college students' innovation and entrepreneurship ability are obtained. Determine the categories of college students' innovative and entrepreneurial ability development and the percentage of the number of people in each category based on the model fitting indicators of the heterogeneous development trajectory of college students' innovative and entrepreneurial ability.

2. Data collection on innovation and entrepreneurial behavior of university students in the era of big data

2.1. Current situation of the development of innovation and entrepreneurship training for university students

The cultivation of innovation and entrepreneurship ability of college students is a systematic and complex educational project, and the teaching concept, teaching method, talent training program, discipline setting, educational practice platform, campus cultural atmosphere and other factors affect the innovation and entrepreneurship ability of college students and the cultivation and enhancement of college students [26-28].

At present, innovation and entrepreneurship education is still in the exploratory stage, and a complete and effective institutionalized and patterned education system that is compatible with social and economic development has not yet been formed. After interviewing teachers, current college students and graduating college students in many universities, it is found that in terms of students' innovation and entrepreneurship, it is highlighted that there is a high willingness to start a business when they are in school. However, the number of people who actually implement innovation and entrepreneurship is low, the technological content of entrepreneurial projects is low, and the survival rate of entrepreneurial projects is low. In terms of teachers' teaching, there is a structural imbalance between theoretical knowledge and practical ability in the innovation and entrepreneurship teacher team. At the same time, teachers' innovation and entrepreneurship education concepts and innovation and entrepreneurship teaching practices have not yet played the expected role in the implementation of the strategy of an innovative country. In terms of social support, the mechanism and environment for encouraging and accommodating innovation are yet to be optimized, and the corresponding laws and regulations are not yet perfect.

2.2. Behavioral Data Collection

In order to accurately analyze the innovative and entrepreneurial behaviors of college students, the data are mainly collected from the students' historical classroom records, regular characteristics of their behaviors in school, personal interest characteristics, consumption, and conversations, photos, and videos in their daily online behaviors. The behavioral data collection process is shown in Figure 1.

The figure shows the process of data collection. When collecting data on the innovative and entrepreneurial behavior of college students, it is necessary to follow the above process, and the specific collection process is shown below:

First of all, understand the time and place of students using the one-card swipe card at school, student

consumption, classes, etc., and analyze the differences and gradual changes in the regularity of different students' behavior at school.

The collected data are processed by data integration, data cleaning, data conversion and data statute, etc. Data cleaning is carried out due to the existence of duplicated and invalid data in the original data, and also for the convenience of the subsequent analysis of students' innovative and entrepreneurial behavior.

The cleaned data are deposited into the database, and data mining technology is used to generate behavioral data with reference to the rules of behavioral database for the pre-processed data in the past database, and behavioral data are evaluated to visualize the collected data, which provides certain basic data for the analysis of students' innovative and entrepreneurial behaviors through the collection of basic behavioral data of the students.

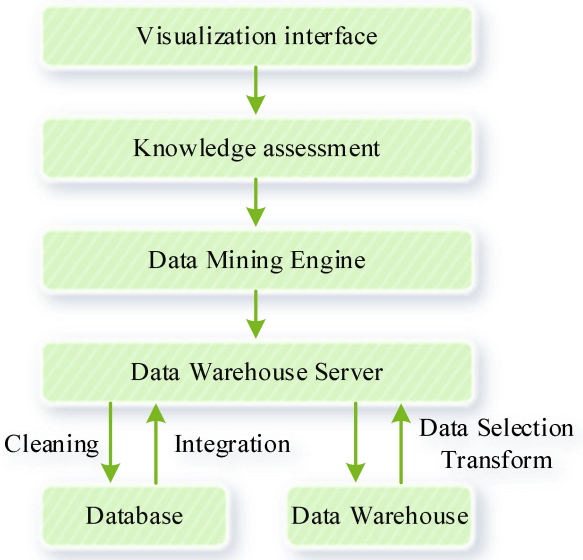

Figure 1. Behavioral data acquisition process.

2.3. Pre-processing of Student Behavior Data

The collected data on innovative and entrepreneurial behaviors of college students were subjected to data cleaning. The process of data cleansing includes dealing with missing values, eliminating noisy data, and eliminating inconsistencies between data (naming, formatting, etc.).

Data integration is the integration of data patterns for data from different data sources, in the process of integration, attention should be paid to the naming and format of each data source, detecting and solving the problem of data value conflicts (attribute values may be different between the source data and data storage rules are different) to correct one by one and deal with the redundant data (an attribute can be obtained from another attribute).

The relevance measure for determining whether an attribute is redundant or not is shown in equation (1):

$$\gamma_{A,B} = \frac{\sum (A-\bar{B})(B-\bar{B})}{(n-1)\sigma_A \sigma_B} \tag{1}$$

where n is the number of tuples, $\bar{A}$ and $\bar{B}$ are the mean values of A, B respectively, and σ_A and σ_B are the standard deviations of the attributes A and B respectively as shown in equations (2), (3):

$$\sigma_A = \sqrt{\frac{\sum (A-\bar{A})^2}{n-1}} \tag{2}$$

$$\sigma_B = \sqrt{\frac{\sum (B - \bar{B})^2}{n-1}} \tag{3}$$

If $\gamma_{A,B} > 0, A, B$ attributes are positively correlated with each other, this means that the value of A increases with B. The larger the value, the higher the probability that one attribute implies the other attribute, and one of the attributes can be deleted as a redundancy item when it is large enough.

If $\gamma_{A,B} < 0, A, B$ attributes are negatively correlated with each other, this means that the value of A decreases as B increases, i.e., one attribute prevents the other from appearing.

If $\gamma_{A,B} = 0, A, B$ are independent of each other, they are not correlated.

If two data properties are independent of each other then the two data properties do not need to be deleted. If the two data attributes are positively correlated then one of the data attributes needs to be deleted. If the data between the two attributes is negatively correlated then keep both the data attributes.

The most common method of transforming data into a form of data storage that is easy for data mining is specification, i.e., scaling the attribute data so that it falls into a specific interval.

(1) Min-max normalization

For a given numerical attribute $A, [\min_A, \max_A]$ is the interval of values before the specification, and $[new\_\min_A, new\_\max_A]$ is the interval of values after the specification. The min-max normalization specifies the value v of A as v' according to the following equation, as shown in Equation (4):

$$v' = \frac{v - \min_A}{\max_A - \min_A}(new\_\max_A - new\_\min_A) + new\_\min_A \tag{4}$$

(2) Zero-one mean specification

For the given numerical attributes $A, \bar{A}, \sigma_A$ are the mean, standard deviation of A, respectively, the zero-one mean specification specifies the value v of A as v' according to the following equation as shown in equation (5):

$$v' = \frac{v - \bar{A}}{\sigma_A} \tag{5}$$

(3) Fractional calibration specification

For a given numerical attribute $A, \max|A|$ is the maximum absolute value of A, and j is the smallest integer that satisfies $\frac{\max_{|A|}}{10^j} < 1$, the fractional calibration specification specifies the value of A, v, as v', according to the following formula, shown in Eq. (6):

$$v' = \frac{v}{10^j} \tag{6}$$

The data statute of college students' innovative and entrepreneurial behavior data and later on their data analysis. The data statute can also be called data approximation or data simplification. The preprocessed college students' innovation and entrepreneurship behavior data is used as the basic data for evaluating the development of college students' innovation and entrepreneurship ability, which assists the subsequent analysis.

3. Establishment of an assessment system for university students' innovation and entrepreneurship capacity

3.1. Process of determining indicators for evaluating innovative and entrepreneurial capabilities

(1) Formulation of evaluation indicators

The formulation of the evaluation indicator system is mainly divided into two steps: one is the dispersion of indicators, and the other is the aggregation of indicators. The dispersion of indicators is based on the connotation of the seven secondary competencies, the operability of evaluation, and the

behavioral performance of the competencies, the decomposition of the secondary competencies, and then the formation of the third-level competency indicators, and the initial establishment of the competency evaluation indicator bank. Aggregation of indicators is a secondary exploration of the indicators in the evaluation indicator library. Delete the tertiary competence indicators that have low correlation with the secondary competence, merge the tertiary competence indicators that have an inclusion relationship with each other, and integrate the tertiary competence indicators that have a cross-relationship with each other, in order to form the tertiary competence indicators that are independent of each other and have a high correlation with the tertiary competence indicators [29].

(2) Revision of evaluation indicators

After the evaluation indicators are formulated, the expert review method is adopted to revise and improve the indicators in the indicator library, and the main steps are indicator scoring, expert discussion, indicator revision, and the final formation of innovation and entrepreneurship ability evaluation indicator system.

(a) Indicator scoring stage.

180 questionnaires were distributed to experts and scholars, teachers, innovation and entrepreneurship, graduate students and undergraduates, and 162 valid questionnaires were recovered, with an effective recovery rate of 90%.

Including: 5 experts and scholars of innovation and entrepreneurship education, educational measurement and evaluation, educational psychology. 6 innovation and entrepreneurship instructors, course teachers. 4 innovation and entrepreneurs, 20 graduate students of education, psychology, management. 145 undergraduate students. The research subjects rated the reasonableness of the indicators based on the operational definition of the indicators with the options of 1-5 (very unreasonable, unreasonable, uncertain, reasonable, and very reasonable), and the last question was an open-ended question in which the rater made other comments and suggestions about the indicator system.

Statistics on the scoring results show that the average scores of all indicators are above 4.0, and the standard deviation between groups of the same level of competence is below 0.7, which indicates that experts, teachers, innovators and entrepreneurs, and students basically share the same view of the indicator system, and basically agree with the indicator system. The open-ended opinions solicited are mainly for the indicator name expression, accepting some of the more concentrated and reasonable suggestions and renaming some of the indicators.

(b) Expert discussion stage. The second-level indicator framework of innovation and entrepreneurship capacity is recognized by experts and scholars, and some of the third-level indicators have problems such as improper naming, cross-cutting connotation of capacity, and unclear operational definition.

(c) Indicator revision stage. The research team synthesized all the suggestions of the experts and further revised the indicators, and finally identified 6 secondary competence indicators and 18 tertiary competence indicators.

(3) Establishment of evaluation indicators

After a series of indicator development work, the team finally established the evaluation index system of innovation and entrepreneurship ability, and the specific indicators and operational definitions are shown in Table 1.

Table 1. Innovation and entrepreneurship ability evaluation index system.

Capacity framework	Ability indicator	Ability classification
Target determination/A	Self-cognition/A1	Attitude ability
	Self-identification/A2	Attitude ability
	Assessment situation/A3	Behavioral ability
	Set target/A4	Behavioral ability
Operational planning/B	Planning/B1	Behavioral ability
	Resource planning/B2	Behavioral ability
	Initiative/B3	Attitude ability
Decision-making ability/C	Adventure/C1	Attitude ability
	Bold decision/C2	Behavioral ability
Communication skills/D	Communication/D1	Behavioral ability
	Teamwork/D2	Behavioral ability
	Conflict resolution/D3	Behavioral ability
Seize the opportunity/E	Discover and evaluate opportunities/E1	Behavioral ability
	Bear the uncertainty/E2	Attitude ability

	Innovative behavior/E3	Behavioral ability
Risk prevention/F	Perceived risk/F1	Behavioral ability
	Reflective learning/F2	Behavioral ability
	Risk management/F3	Behavioral ability

3.2. Constructing an evaluation index system for innovation and entrepreneurship ability

Since the weights comprehensively reflect the importance of each indicator in the evaluation system, the AHP was first used to determine the weights of each indicator of the evaluation system.

3.2.1. Constructing judgment matrices

A two-by-two comparison between the elements of the guideline layer as well as the content layer, i.e., element $i(i=1,2,3,\cdots,n)$ and element $j(j=1,2,3,\cdots,n)$ of the same layer, is finalized to determine the ratio of the two indicators, and a 5 judgment matrix is constructed $\left(\mathbf{X},\mathbf{X}_1,\mathbf{X}_2,\mathbf{X}_3,\mathbf{X}_4\right)$ for the target and guideline layers, i.e.,:

$$\mathbf{X}=\begin{bmatrix} x_{11} & \cdots & x_{1n} \\ \vdots & & \vdots \\ x_{n1} & \cdots & x_{nn} \end{bmatrix} \tag{7}$$

$$\mathbf{X}_1=\mathbf{X}_2=\mathbf{X}_3=\mathbf{X}_4=\begin{bmatrix} x_{11} & \cdots & x_{1j} \\ \vdots & & \vdots \\ x_{i1} & \cdots & x_{ij} \end{bmatrix} \tag{8}$$

where x_{ij} is the importance scale of x_i over x_j. x_{ji} is the importance scale of x_j over x_i and x_{ji} and x_{ij} are inverses of each other.

The scaling method is shown in Table 2. Based on the scoring criteria of the scale method, the expert group compared and scored the importance of the guideline layer (6 categories) and the content layer (18 indicators) two by two, and obtained the corresponding judgment matrix.

Table 2. Scale method.

Scale	Define	Meaning (two elements for a rule)
1	Same importance	Equally important
3	Slightly important	One is slightly more important than the other
5	Significant	One is obvious more important than the other
7	Strong importance	One is intensity more important than the other
9	Extreme importance	One is extreme more important than the other
2, 4, 6, 8	Median of adjacent scale	Means that the adjacent two scale is eclectic
The standard is the inverse	Inverse ratio	/

3.2.2. Finding matrix eigenvectors

In order to confirm whether the weight allocation is reasonable or not, it is also necessary to perform consistency test on the judgment matrix.

(1) Normalization process:

$$\overline{x}_{ij}=\frac{x_{ij}}{\sum_{i=1}^{n}x_{ij}} \qquad i=1,2,3,\cdots,n \tag{9}$$

where $\overline{x}_{ij}$ is the product of the elements of each row of the judgment matrix, and i is the same layer element.

(2) Summing the judgment matrix by row:

$$\tilde{w}_i = \sum_{i=1}^{n} \overline{x}_{ij} \qquad i = 1, 2, 3, \cdots, n \tag{10}$$

where $\tilde{w}_i$ is the judgment matrix content layer weights.

(3) Regularize the weight vector w:

$$w_i = \tilde{w}_i / n \tag{11}$$

$$w = \left[w_1, w_2, \cdots, w_n \right]^T \tag{12}$$

Where w_i is the combined weight of the judgment matrix.

(4) Calculate the maximum characteristic root $\lambda_{\max}$ of the judgment matrix:

$$\lambda_{\max} = \frac{1}{n} \sum_{i=1}^{n} \frac{(Xw)_i}{w_i} \tag{13}$$

3.2.3. Consistency test

Introduce the negative mean CI of the remaining eigenroots other than the largest eigenroot of the judgment matrix as a measure of the deviation of the judgment matrix from consistency. To wit:

$$CI = \frac{\lambda_{\max} - n}{n - 1} \tag{14}$$

To measure the satisfactory consistency of judgment matrices of different orders, it is also necessary to introduce the value of the average stochastic consistency index RI of the judgment matrices. When the order is greater than 2, the ratio of the consistency index CI of the judgment matrix to the average stochastic consistency index RI of the same order is called the stochastic consistency ratio, denoted as CR. That is:

$$CR = \frac{CI}{RI} \tag{15}$$

If $CR < 0.1$, it means the matrix consistency is good and the test passes.

Combined with equations (7)~(15), the importance of each element relative to the overall goal is calculated, and the weight of each index layer in the evaluation system of innovation and entrepreneurship can be finally derived.

4. Trajectory analysis of the development of innovation and entrepreneurship among university students

4.1. Examination of the assessment system of innovation and entrepreneurship ability of college students

4.1.1. Consistency test

Under normal circumstances, it is logically difficult for an expert to judge the level of importance of the six factors in a self-contradictory manner. However, for the sake of rigor, in accordance with the requirements of hierarchical analysis, the scientific consistency of the weights of the first-level indicators is tested first, and then the satisfaction consistency is tested.

It is assumed that the scientific consistency indicator is replaced by CI, and the satisfaction consistency indicator is replaced by CR. According to the matrix theory in linear algebra, when $C_1 = 0$ it proves that the expert has reached perfection in subjective judgment. Given the existence of asymmetry of information, especially the asymmetry of higher-order information is widespread, the conclusion of perfect science is possible in the field of natural sciences. However, it is unrealistic to obtain perfect conclusions in the social sciences, especially when quantitative analysis is introduced into the social sciences. In view of the above problems, the satisfactory consistency index and its calculation method are given, namely $C_R = C_1 / R_1$.

The satisfaction consistency index mentioned above is 0.0345, and since 0.0345 is much smaller than

0.1, the index of this paper about the assessment index of innovation and entrepreneurship ability system of college students has passed the consistency test.

4.1.2. Reliability tests

In order to measure the stability and reliability of the assessment system of innovation and entrepreneurship ability of college students, it is also necessary to test the reliability of this assessment system. In this regard, experts specializing in the assessment of innovation and entrepreneurship ability in the field of education were invited to assess the innovation and entrepreneurship ability of college students in 20 schools randomly selected from 70 higher education institutions, and the basic data were obtained as shown in Figure 2.

From A to F represent goal-setting ability, action planning ability, decision-making ability, communication and cooperation ability, ability to grasp opportunities, and ability to prevent risks, respectively.

Taking the data of the first school as an example, its scores in the six dimensions are Goal Determination Ability=6, Action Planning Ability=5, Decision Making Ability=6, Communication and Cooperation Ability=8, Seizing Opportunities Ability=7, and Preventing Risks Ability=5. The innovation and entrepreneurship ability of the students of this school is in the middle level, and the communication and cooperation ability and the ability of seizing opportunities of the college students are more outstanding.

There are cases when students of individual schools have low scores in goal-setting ability but 9 in decision-making ability. The development of innovation and entrepreneurship ability of college students in the sample schools is not balanced.

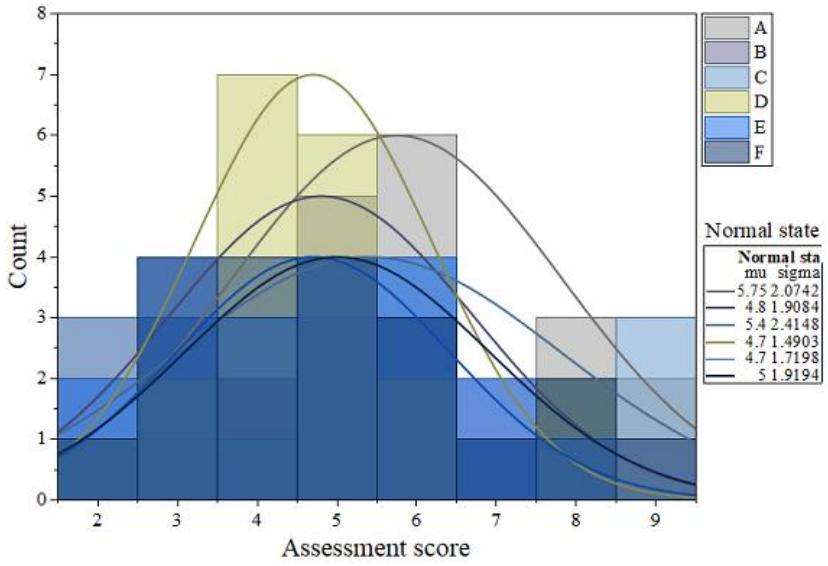

Figure 2. Evaluation results of college students' innovation ability assessment system.

The reliability analysis of the above basic data was carried out, and the basic data were obtained showing the reliability coefficient α = 0.835 and standardized α = 0.823. The analysis of the factors affecting the reliability coefficient is shown in Figure 3.

Developing planning and planning resources under the action integration ability and reflective learning and risk management under the risk prevention ability in the development of innovation and entrepreneurship are the main factors affecting the reliability coefficient of this assessment system.

Planning B1 = 0.735 and resource planning B2 = 0.723. Reflective learning F2 = 0.722, risk management F3 = 0.724. It is important to draw the full attention of teachers to the education of creative and entrepreneurial skills.

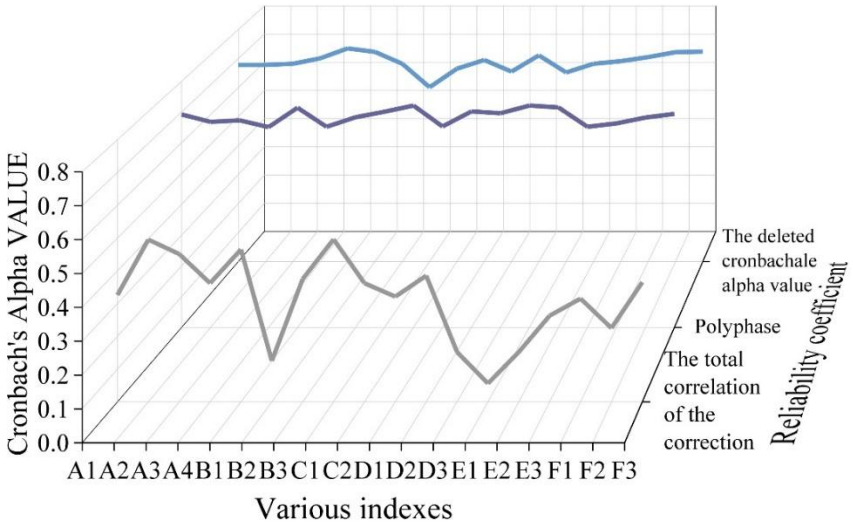

Figure 3. The factor analysis of reliability coefficient.

In order to feedback the information of the assessment system of innovation and entrepreneurship ability of college students to the education and teaching practice, it is also necessary to statistically analyze the correlation between the secondary indicators of the system.

The correlation between the secondary indicators is shown in Fig. 4. A to F represent the goal-setting ability, action planning ability, decision-making ability, communication and cooperation ability, the ability to grasp opportunities, and the ability to prevent risks, respectively.

From the correlation coefficients between the items, it can be found that the highest correlation coefficient between initiative and self-identity is 0.725, followed by the correlation coefficients between conflict resolution and self-identity, and the correlation coefficients between risk management and risk-taking, with the correlation coefficients of 0.668 and 0.665, respectively.The above mentioned correlation coefficients of top three correlation coefficients have a high degree of correlation between two variables, which proves that the internal consistency confidence of the assessment system is high.

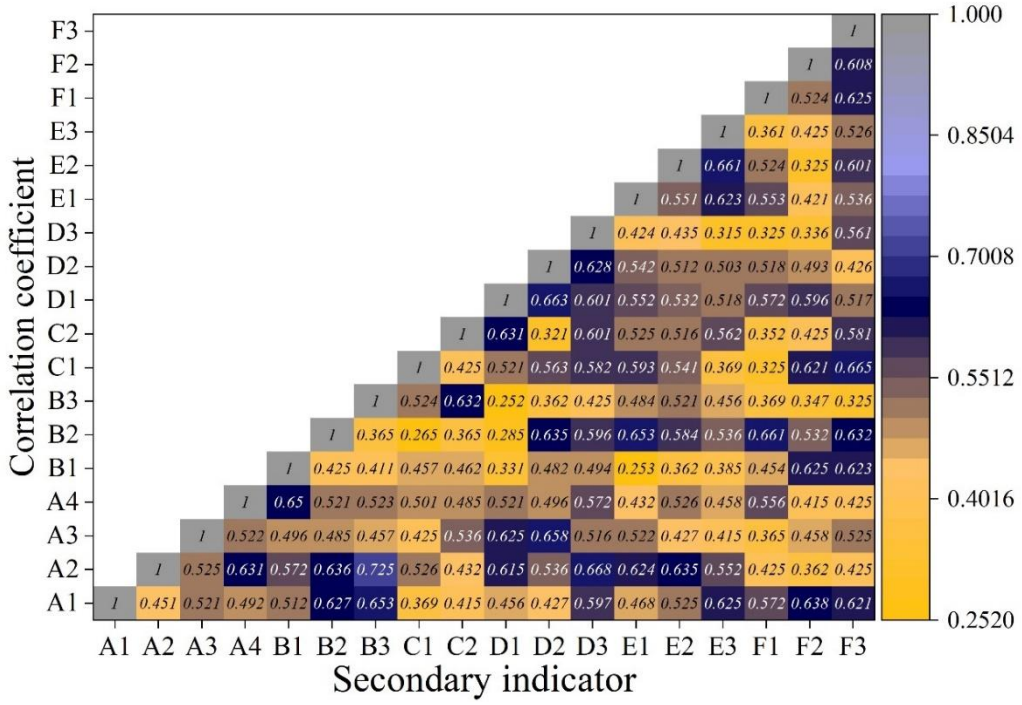

Figure 4. Correlation between secondary indicators.

4.1.3. Validity tests

In this paper, 20 colleges and universities are taken as 20 samples, and then scored by educational experts in the field of innovation and entrepreneurship after obtaining the relevant data on the innovation and entrepreneurship ability of college students in the above sample institutions.The scores of the assessment system of innovation and entrepreneurship ability of college students in the 20 colleges and universities are shown in Fig. 5.

The total average score of innovation and entrepreneurship ability of college students in 20 colleges and universities is 88.1.The theoretical value and actual value of the first college and university are 96 and 92 respectively, with a difference of 4 points, which indicates that the level of innovation and entrepreneurship ability of college students in this college and university is better, and the development is in line with the theoretical planning.

In the data of 20 colleges and universities, the maximum difference between the theoretical value and the actual value is 13, which indicates that the actual level of innovation and entrepreneurship ability of the students in this school is low, and it is necessary to adjust the measures in time to improve the development of innovation and entrepreneurship ability of the students.

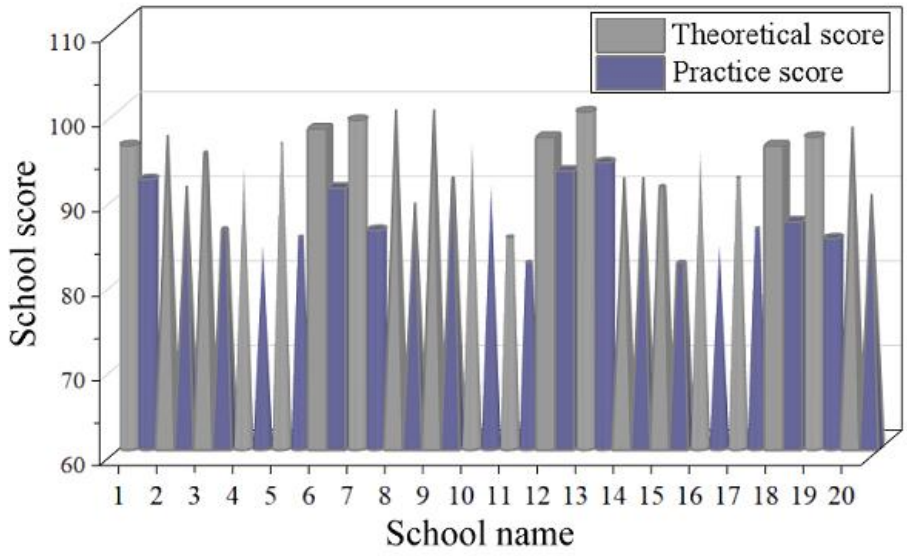

Figure 5. Student innovation and entrepreneurship assessment of 20 universities.

Pearson correlation test was conducted using SPSS, and the results of content validity test (correlation) are shown in Table 3. The significance (two-sided) between practical scores and theoretical scores is 0.000, and the covariance is 32.251.The validity coefficient of the assessment system of college students' innovation and entrepreneurship ability is 0.817, which fully verifies the scientificity of the assessment system of college students' innovation and entrepreneurship ability constructed in this paper.

Table 3. Content validity test results (correlation).

Project	Categories	Practice score	Theoretical score
Practice score	Pearson correlation	1	0.817**
	Significance (double side)		0.000
	The sum of the square and the cross product	655.664	683.014
	Covariance	30.199	32.251
	N	20	20
Theoretical score	Pearson correlation	0.817**	1
	Significance (double side)	0.000	
	The sum of the square and the cross product	683.014	661.030
	Covariance	32.251	35.000
	N	20	20

4.2. Trajectory of innovation and entrepreneurship among university students

In order to test the general development trajectory of innovation and entrepreneurship ability of college students in a university, the unconditional latent variable growth curve model (LGCM) of innovation and entrepreneurship ability is established by combining the data of innovation and entrepreneurship behavior of college students collected in the previous section.

(1) The fit of different models for the general development trajectory of innovation and entrepreneurship ability

Four LGCM models, namely, intercept model, unconditional linear growth model, unconditional quadratic growth model, and time score free estimation model, are compared to determine the development trajectory of the sample's general innovation and entrepreneurship ability. The fit of different models for the general development trajectory of innovation and entrepreneurship capabilities is shown in Table 4.

The results show that the time score free estimation model has the best fit index, AIC=30123.12, BIC=30214.58, CFI=0.967, TLI=0.867, RMSEA=0.101, SRMR=0.034.

Table 4. The fitting degree of different models of innovative entrepreneurial ability.

	AIC	BIC	$\chi^2(df)$	CFI	TLI	RMSEA	SRMR
I	30124.52	30634.78	52.13	0.922	0.824	0.181	0.075
Linearity I+S	30523.04	30542.61	86.54	0.814	0.764	0.135	0.066
I+S+Q	30409.01	30415.92	80.97	0.836	0.121	0.368	0.062
Time free estimation I+S	30123.12	30214.58	34.65	0.967	0.867	0.101	0.034

(2) Model fit indices

Two latent variables are defined through repeated measures of the observed indices, representing the latent intercept factor α and the latent slope factor β. There are two parameters, mean and variance, for each of α and β, by which the LGCM describes inter- and intra-group differences.

Specifically, the mean of the intercept factor indicates the average initial state of the development trend of college students' innovative entrepreneurial ability, and the variance of the intercept factor indicates the size of the inter-individual differences in the initial state of the development trend of college students' innovative entrepreneurial ability. The mean of the slope factor indicates the average growth rate of the development trend of college students' innovation and entrepreneurship ability between time points, and the variance of the slope factor indicates the size of the inter-individual differences in the growth rate of the development trend of college students' innovation and entrepreneurship ability.

The fitted indices with intercepts and slopes of the latent variable growth curve model for the free estimation of the time score of college students' innovation and entrepreneurship ability are shown in Table 5.

The results show that the mean value of the intercept of college students' innovation and entrepreneurship ability in the LGCM with free estimation of time scores is 20.521 ($p<0.001$), and the variance is 3.859 ($p<0.001$), which indicates that the mean value of the initial state of the trajectory of the college students' innovation and entrepreneurship ability development is 20.521, and that there is a significant inter-individual difference. The mean value of the slope of innovation and entrepreneurship ability of college students is 3.004.

Table 5. Model fitting index and intercept and slope.

Model fitting index					Cocorrelation
$\chi^2(df)$	CFI	TLI	SRMR	RMSEA	
8.562	0.946	0.921	0.068	0.077	
Mean		Variance		/	
Intercept	Slope	Intercept	Slope	/	
20.521***	3.004***	3.859***	0.412*	/	-0.547***

(3) Indicators of model fitting

The above results indicate that the random effects (including the variance estimates of the intercept factor and slope factor) of the LGCM model for the free estimation of the time scores of college students' innovation and entrepreneurship ability are significant (ps <0.05). Then the unconditional latent

variable category curve model (LCGM) was further developed to test the heterogeneous development trajectory of college students' innovation and entrepreneurship ability.

The model fitting indexes of the heterogeneous development trajectory of innovation and entrepreneurship ability of college students are shown in Table 6.

The LCGM of category 1-5 is established respectively, and the best category model is determined according to the indexes of AIC, BIC, a BIC, and entropy value. It can be seen that from the 1-category model to the 5-category model, the information indexes AIC, BIC, aBIC continue to decline.

The entropy value of the 4-category model is 0.735, and the LMRT value and BLRT value reach the significant level ($p<0.01$), indicating that the 4-category model is better than the 3-category model. And when it comes to the 5-category model, the LMRT value is not significant ($p>0.05$), indicating that there is no significant difference between the 4-category model and the 5-category model. According to the principle of model simplicity, the 4-category model was finally chosen as the optimal model.

Table 6. The model of the development trajectory of innovative entrepreneurial ability.

	K	AIC	BIC	aBIC	Entropy	LMRT	BLRT	Class probability
1	10	30505.11	30421.96	30401.85	/	<0.001	<0.001	/
2	13	30312.15	30337.05	30358.62	0.774	>0.05	<0.001	19.9%/80.1%
3	15	30272.24	30241.59	30225.15	0.769	<0.01	<0.001	7.6%/9.8%/82.6%
4	19	30196.20	30112.48	30152.05	0.735	<0.001	<0.001	5.9%/6.4%/17.3%/70.4%
5	20	30185.07	30085.95	300102.85	0.709	>0.05	<0.001	3.2%/4.1%/6%/15.7%/71%

(4) Heterogeneous development trajectories of college students' innovation and entrepreneurship ability

Carve out the development trajectory of 4 categories of college students' innovation and entrepreneurship ability. The 4 trajectory categories are named as low stable group, stable rising group, medium fast rising group and high stable rising group. The initial level of college students' innovation and entrepreneurship ability in the low stability group is the lowest, showing a low upward development trend, and the final development level is also the lowest. The innovation and entrepreneurship ability of college students in the stable rising group shows a steady upward trend. The initial level of innovation and entrepreneurship ability of college students in the medium fast rising group is in the middle, but the development speed of this group is the fastest, and the final development level is in the middle-high. The initial level of college students' innovation and entrepreneurship ability in the high stable rising group is the highest, showing a stable rising development trend, and the final development level is also the highest.

The parameter estimates and standard errors M(SE) of the growth factors of the four-category model are shown in Table 7.

The mean value of the intercept for the low stable group is 17.825 (SE=0.652, $p<0.001$) and the mean value of the slope is 0.901 (SE=0.317, $p<0.01$), and the number of people in this group accounts for 5.9% of the total number of people.

The stable ascending group had a mean intercept value of 16.918 (SE=0.204, $p<0.001$) and a mean slope value of 3.515 (SE=0.201, $p<0.001$), and this group accounted for 6.4% of the total.

The number of people in the medium rapid rise group and high stable rise group accounted for 70.4% and 17.3% of the total number of people, respectively.

Table 7. Three types of model growth factor parameter estimation and standard error.

	Number (N)	Intercept (I)	Slope(S)
Low stable group	5.9%	17.825(0.652)***	0.901(0.317)***
Stable ascending group	6.4%	16.918(0.204)***	3.515(0.201)***
Rapid ascending group	70.4%	19.003(0.253)***	3.207(0.186)***
High stable ascending group	17.3%	21.536(0.672)***	1.672(0.357)***

5. Conclusion

This paper applies the collected data of innovation and entrepreneurship behavior of college students to the evaluation system of innovation and entrepreneurship ability, and verifies the rationality of the index system by combining with the consistency test. The unconditional latent variable growth curve model of college students' innovation and entrepreneurship ability is constructed to analyze the general development trajectory of college students' innovation and entrepreneurship ability.

(1) The results of the satisfaction consistency index of the six indicator factors of goal setting ability,

action planning ability, decision-making ability, communication and cooperation ability, grasping opportunity ability and risk prevention ability are 0.0345, with the reliability coefficient α of 0.835 and the validity coefficient of 0.817, which indicates that the assessment indexes of the college students' innovation and entrepreneurship ability system constructed in this paper passed the consistency test and are scientific and reasonable.

(2) The fit index of the time score free estimation model is better than the intercept model, unconditional linear growth model, and unconditional quadratic growth model, with RMSEA and SRMR of 0.101 and 0.034, respectively.

The model fitting indexes that consider the heterogeneous development trajectories of college students' innovation and entrepreneurship abilities are divided into the categories of college students' innovation and entrepreneurship ability development trajectories. The percentages of the number of people in the four categories are low stable group (5.9%), stable rising group (6.4%), medium fast rising group (70.4%), and high stable rising group (17.3%). The development of innovation and entrepreneurship ability of college students in this university centrally shows a medium and fast rising trend, with a good development trend.

References

1. Guo, J., Khatibi, A., & Tham, J. (2024). The Role of Innovation And Entrepreneurship Education In Promoting The Growth Of Students In Higher Vocational Colleges. Library of Progress-Library Science, Information Technology & Computer, 44(3).
2. Li, W. (2021, May). The influence of the integration of innovation and entrepreneurship education and professional education on the employment ability of vocational college students. In 2021 2nd International Conference on Computers, Information Processing and Advanced Education (pp. 314-318).
3. Paladino, A. (2022). Innovation or entrepreneurship: Which comes first? Exploring the implications for higher education. Journal of product innovation management, 39(4), 478-484.
4. Sart, G. (2013). Effects of technology transfer offices on capacity building in creativity, innovation and entrepreneurship. The European Journal of Social & Behavioural Sciences.
5. Chen, S., Tan, X., Shen, W., Liu, R., & Chen, Y. (2025). College student entrepreneurs: individual differences, innovation-oriented behaviors and financial performance. Management Decision.
6. Gao, H., Qiu, Z., Liu, Z., Huang, L., & San, Y. (2016, July). Research and practice on college students' innovation and entrepreneurship education. In International Conference of Young Computer Scientists, Engineers and Educators (pp. 36-44). Singapore: Springer Singapore.
7. Bao, Z., Teng, H., Peng, J., Jin, D., & Liu, X. (2017, December). The Influencing factors and Countermeasures of College Students' Innovation and Entrepreneurship Ability from the Perspective of College Students and Teachers. In 2017 7th International Conference on Mechatronics, Computer and Education Informationization (MCEI 2017) (pp. 237-240). Atlantis Press.
8. Lei, J., Hock, O. Y., & Asif, M. K. (2020). The influence of entrepreneurship education on innovation capability among Chinese undergraduate students in COVID-19 pandemic era: a framework of analysis. Solid State Technology, 63(6), 2279-2296.
9. Edwards-Schachter, M., García-Granero, A., Sánchez-Barrioluengo, M., Quesada-Pineda, H., & Amara, N. (2015). Disentangling competences: Interrelationships on creativity, innovation and entrepreneurship. Thinking skills and creativity, 16, 27-39.
10. Ayoub, H., & Achkouty, N. (2021). Entrepreneurship and Social Innovation in Big Data Era: A Particular Focus on the Internet of Things. In Big Data for Entrepreneurship and Sustainable Development (pp. 1-20). CRC Press.
11. Ylijoki, O., Sirkiä, J., Porras, J., & Harmaakorpi, V. (2018). Innovation capabilities as a mediator between big data and business model. Journal of Enterprise Transformation, 8(3-4), 165-182.
12. Purcell, B. (2013). The emergence of" big data" technology and analytics. Journal of Technology research, 4, 1.
13. De Mauro, A., Greco, M., & Grimaldi, M. (2015, February). What is big data? A consensual definition and a review of key research topics. In AIP conference proceedings (Vol. 1644, No. 1, pp. 97-104). American Institute of Physics.
14. Singh, N., Lai, K. H., Vejvar, M., & Cheng, T. C. E. (2019). Big data technology: challenges, prospects, and realities. IEEE Engineering Management Review, 47(1), 58-66.
15. Kaisler, S., Armour, F., Espinosa, J. A., & Money, W. (2013, January). Big data: Issues and challenges moving forward. In 2013 46th Hawaii international conference on system sciences (pp. 995-1004). IEEE.
16. Zhao, D., & Liang, H. W. (2021). Design of innovation and entrepreneurship effect evaluation system for college students based on MOA model. In IoT and Big Data Technologies for Health Care (pp. 183-198). Cham: Springer International Publishing.
17. Liu, J., & Li, T. (2025, August). Evaluation College Students' Innovation and Entrepreneurship Ability Using MLP-Based Neural Network Model. In 2025 Third International Conference on Networks, Multimedia and Information Technology (NMITCON) (pp. 1-7). IEEE.

18. Luo, Y., & Yang, H. (2024, August). Construction of Evaluation Model for College Students' Innovation and Entrepreneurship Ability Under the Background of Digital Economy. In International Conference on Computational Vision and Robotics (pp. 311-324). Cham: Springer Nature Switzerland.
19. Xue, S. (2025). An evaluation method of innovation and entrepreneurship ability of college students based on implicit knowledge mining. International Journal of Business Intelligence and Data Mining, 26(1-2), 174-189.
20. Yaşar, E., Demir, M., & Cobanoglu, C. (2025). Big data analytic capabilities, intrapreneurship, and service innovation behaviors: a moderated mediation model. The Service Industries Journal, 45(9-10), 819-843.
21. Wang, L., Wang, R., Yuan, K., & Hu, F. (2021). Research on the Improvement of College Students' Capability of Innovation. JOURNAL OF SIMULATION, 9(1), 77.
22. Shi, K. (2018, December). Research on the Cultivation of College Students' Innovation and Entrepreneurship Based on Technological Innovation Platform. In 2018 8th International Conference on Management, Education and Information (MEICI 2018) (pp. 274-278). Atlantis Press.
23. Xie, Q. (2024). Big data analysis and information sharing for innovation and entrepreneurship education. Scalable Computing: Practice and Experience, 25(6), 5518-5527.
24. Peng, Y. (2023). Leveraging Big Data Technology for Enhanced University Education Management: A Path Analysis with Focus on Commercialization and Innovation Strategies. Journal of Commercial Biotechnology, 28(2).
25. Sutrisno, S., Kuraesin, A. D., Siminto, S., Irawansyah, I., & Ausat, A. M. A. (2023). The role of information technology in driving innovation and entrepreneurial business growth. Jurnal Minfo Polgan, 12(1), 586-597.
26. Shuai Yue & Yifan Zhou. (2025). Exploring the Challenges and Countermeasures of Cultivating College Students' Innovation and Entrepreneurship Abilities in the New Era. Management,8(2).
27. Jun Zhao,Lelai Shi,Zimu Li & Jiaqi Yang. (2025). Research on Enhancing Innovation and Entrepreneurship Capabilities of Finance and Economics Students Based on Dual-Innovation Mentors and Disciplinary Competitions. Frontiers in Educational Research,8(5).
28. Hailing Wei,Ailing Ding & Zhiqiang Gao. (2024). The application of project management methodology in the training of college students' innovation and entrepreneurship ability under sustainable education. Systems and Soft Computing,6,200073-200073.
29. Fanyao Zheng,Xiaoqin Jin,Huimin Huo,Yu Tian & He Li. (2025). A new method for constructing an environmental risk analysis and assessment index system for hazardous waste. Results in Engineering,27,106986-106986.