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Computing-based Innovation and Entrepreneurship Education Curriculum Design and Its Practical Research in Cultivating Innovative Abilities

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ABSTRACT

In-depth investigation of the combination of innovation and entrepreneurship education and computing technology is of great theoretical and practical significance for the continuous promotion of innovation and entrepreneurship education in colleges and universities. In this paper, after clarifying the three elements of environment, subject and behavior in the design of innovation and entrepreneurship education courses, we design an innovative teaching model for innovation and entrepreneurship education courses based on computing technology and digital learning environment, and adopt similarity metrics and questionnaires to count the frequency of students' on-line learning behaviors and the level of cultivation of their innovative spirit and ability respectively. The results of teaching practice show that the practice of innovation and entrepreneurship education courses based on computing has a facilitating effect on the cultivation of students' innovative spirit and ability. The Spearman correlation coefficients of the learning behaviors in the online teaching platform of innovation and entrepreneurship education courses and the dimensions of innovation spirit and ability show medium-high correlation (r>0.3), and its regression model can effectively explain more than 60% of the variance of innovation spirit and ability. The research in this paper provides an effective reference for the innovative development and practice of innovation and entrepreneurship education programs, and lays the foundation for promoting more effective and innovative development of dual innovation education in colleges and universities.

Keywords: similarity measure, correlation analysis, regression analysis, online learning behavior frequency, innovation and entrepreneurship education

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1. Introduction

With the development of economic globalization and the intensification of market competition, innovation and entrepreneurship have become an important means of development and progress in all walks of life. As an important place for talent cultivation, colleges and universities play an active role in promoting innovation and entrepreneurship education [1]. By carrying out innovation and entrepreneurship ability training courses, it can establish the correct career view of college students, cultivate college students' innovative consciousness, develop creative thinking, improve the comprehensive quality of career and entrepreneurial ability, which has profound practical significance for college students to participate in employment, entrepreneurship and social competition [2-5]. However, at this stage, influenced by many factors, innovation and entrepreneurship education in colleges and universities still has defects and deficiencies, and needs to be reformed and optimized [6-7].

In recent years, intelligent technology has been developed rapidly, and the digital course learning mode has become an important way to cultivate students' scientific and technological literacy and innovation ability [8]. And computational thinking, as an abstract thinking activity, is a core step in solving key problems in the process of students' innovation and entrepreneurship, and its integration into curriculum teaching is of great significance [9-10]. Computational thinking is defined as a problem solving process, which includes problem interpretation, data analysis, data presentation, solution development, the most effective use and integration of resources, and the application of problem solution migration [11]. Designing problems and tasks integrating computational thinking in the teaching of innovation and entrepreneurship education courses can stimulate students' interest and make them think and solve innovatively by applying the knowledge and skills they have learned under the drive of complex problems, which is conducive to the cultivation of students' innovative thinking ability [12-15].

This paper combines online learning and offline learning to design a hybrid teaching mode for teaching innovation and entrepreneurship education courses, in which the online learning platform serves as the core foundation, relying on computational technology and informatization teaching environment to build, and improves the learning effectiveness of innovation and entrepreneurship education for college students through a systematic teaching guidance method. We use similarity measure and cluster analysis to analyze students' learning behaviors in the online teaching platform, and then design a questionnaire to quantitatively analyze the level of students' innovation spirit and ability cultivation in computing-based innovation and entrepreneurship education. Finally, we carry out the teaching practice of innovation and entrepreneurship education courses, analyze the frequency of students' online learning behaviors and the changes of their innovative spirit and ability, and explore the practical effect of computing technology on the effectiveness of innovation and entrepreneurship education and its influence on innovation ability based on correlation analysis and regression analysis model.

2. Innovative entrepreneurship education curriculum model based on computing technology

2.1. *Teaching mode design of innovative entrepreneurship education program*

The computing-based digital innovation and entrepreneurship education course teaching mode is a hybrid teaching mode that integrates teaching, classroom teaching and offline learning under the digital learning environment created by computer technology, with the online classroom teaching platform as the core. There are three main elements in the teaching mode of innovation and entrepreneurship education based on computing, which are environment, subject and behavior, and it is to study the teaching methodology based on the combination of systematic and specific "informatization teaching environment" and "traditional classroom teaching environment" in the context of the course. Teachers' teaching methods in specific courses, with the purpose of promoting students' innovation ability level, is in essence an innovative exploration of digital teaching design. The teaching mode of computing-based innovation and entrepreneurship education courses has a specific subject applicable object, is based on the innovation and entrepreneurship education courses for college students to start designing a set of systematic teaching and guidance methods, is summarizing and drawing on the basis of the traditional computing dual-creation education model, builds a multi-dimensional teaching environment, and systematically puts forward how to better carry out the teaching activities under different learning stages, so that students can master knowledge and project training in the Cross-navigation. This model is not only conducive to improving students' ability to raise and solve problems and their ability to innovate higher-order knowledge and knowledge transfer, but also can play a certain role in promoting the cultivation of students' innovative spirit and creative ability.

According to the guiding principles of informatization teaching design and blended teaching design, the teaching mode of computing-based innovation and entrepreneurship education course is designed as shown in Figure 1. The participants of the computing-based innovation and entrepreneurship education course teaching model are teachers and students, and the main lecturer, teaching assistants and expert judges among the participants are encapsulated in the teacher team. Teaching behavior is a mixture of four types of teaching activities: computing technology-supported teaching, classroom teaching, offline learning, and class competition integration, with online teaching as the guide and classroom teaching, offline digital learning and class competition integration teaching as the realization channel of learning. The teaching environment is the digital teaching conditions built with the support of hardware environment, software platform and socialization as the structural support.

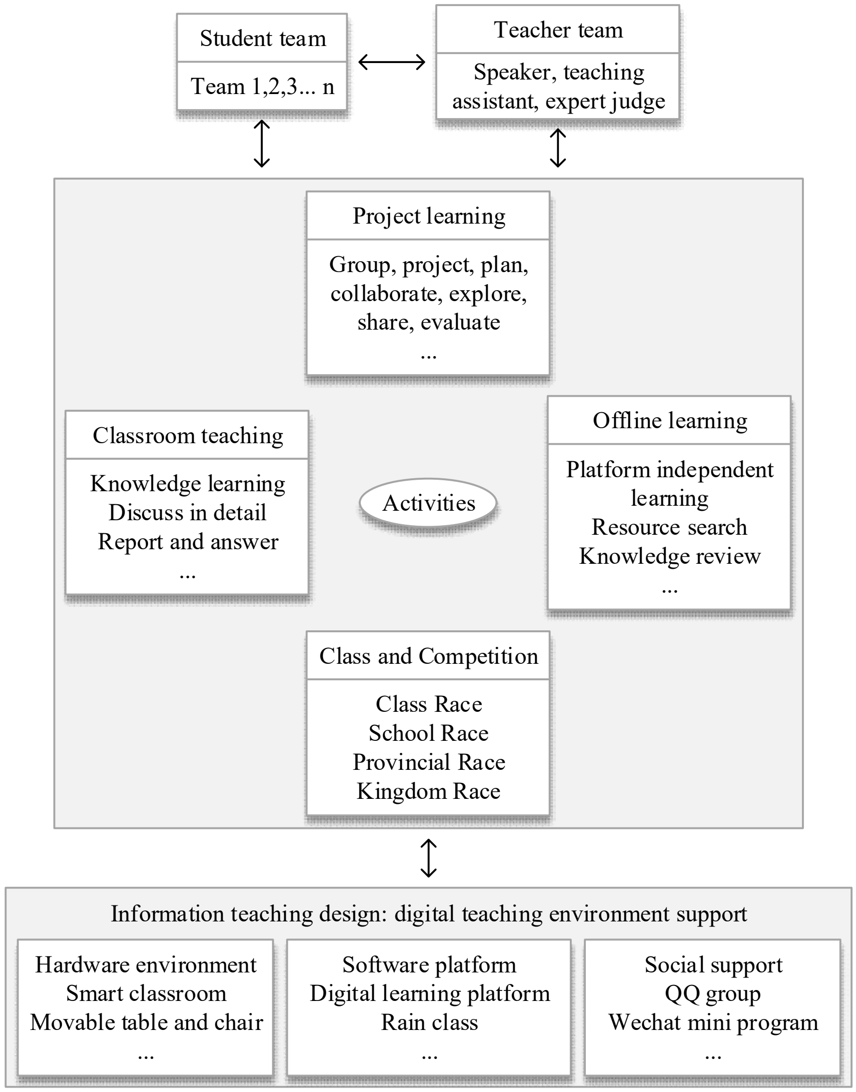


Fig. 1. Based on computational innovation entrepreneurship education course model

2.2. Online Learning Behavior Analysis Methods

Online learning behavior refers to the behavioral data generated by students' independent learning on online learning platforms as the basis for experimentation in the teaching design of computing-based innovation and entrepreneurship education courses, and this is collected and screened, and the data generated includes PC, mobile, Web and so on.

2.2.1. Calculating Similarity of Online Learning Behavioral Events. Similarity metric [16] is the computational basis for clustering mining of online learning behavior event sequence data. The following illustrates the similarity calculation method of online learning behavior event sequences of innovative entrepreneurship education courses. Setting:

$$TE_A = \{te_{A1}, te_{A2}, \cdots; te_{Am}\} \tag{1}$$

denotes the sequence of learning behavior events of innovative entrepreneurship education course for student u_A, and k denotes any characteristic attribute of the learning behavior events of innovative entrepreneurship education course, i.e., $k \in SA$. Equation (2) is used to calculate the mean and standard deviation of all the event attributes k in TE_A, and the result is denoted as $A_k = (AV_k, AS_k)$. Equation:

$$AV_k = \frac{1}{m}\sum_{j=1}^{m} te_{Aj}(s_A(k)); ASk = \sqrt{\frac{1}{m-1}\sum_{j=1}^{m}\left(te_{Aj}(s_A(k)) - AV_k\right)^2} \tag{2}$$

Similarly, vector $B_k = (BV_k BS_k)$ represents the vector of statistical values of student u_s innovative entrepreneurship education course learning behavior event sequence TE_B on event attribute k, and the vector similarity score of $A_{k,B}$ is calculated using the pinched angle cosine method with the following formula:

$$sim(A_k, B_k) = \frac{A_i \cdot B_i}{\|A_i\|^2 \times \|B_i\|^2} \tag{3}$$

Then TE_A, TE_B The similarity of the sequence of learning behavior events of two innovation and entrepreneurship education courses is calculated using equation (4):

$$Sim(TE_A, TE_B) = \sum_{k=1}^{d} sim(A_k, B_k) \tag{4}$$

where d is the number of attributes of the learning behavior events of the innovation and entrepreneurship education course, $d = 6$ in this paper, including sign-in attendance, course visits, learning resource hours, time to submit assignments, assignment assessment scores, and number of discussions.

2.2.2. Learning Behavioral Sequence Clustering Algorithm. Since there are multiple student learning behavior data in online learning platforms, clustering algorithms are needed to assign various types of data in clusters. The k-means clustering algorithm [17], which uses the principal factor method to select the initial cluster centers, is a commonly used clustering method for grouping data. In the clustering processing of learning behavior event sequences of innovative entrepreneurship education courses, event sequences with similar characteristics can be grouped into the same cluster by this method. The method of selecting the initial cluster center by the principal factor method is as follows.

1) Calculate the correlation coefficient between the attributes of learning behavior events of innovation and entrepreneurship education courses and academic performance.

2) Determine the learning behavior attribute with the largest absolute value of correlation coefficient as the main factor.

3) Calculate the principal factor allometric R, divide R into K groups, and determine the group limits and group median values for each group.

4) Select the record in the dataset whose main factor value is closest to the K group median values as the initial clustering center.

The flow of k-means clustering algorithm is as follows.

Inputs to define the dataset of students' innovative entrepreneurship education course learning behavior event sequences. $TE_{Data} = \{TE_1, TE_2, \ldots TE_n\}$, n are the number of learning users and the number of clusters K. K student innovative entrepreneurship education course learning behavior event sequences are selected as the initial cluster centers from TE_{Data} by one-factor method. For each student innovative entrepreneurship education course learning behavior event sequence TE_i in TE_{Data}.

1) Calculate the similarity between TE_i and K clustering centers.

2) Sort the similarity values from highest to lowest.

3) Assign TE_i to the cluster with the highest similarity.

Finally, recalculate the K cluster centers based on the sequences of online learning behaviors of students in innovative entrepreneurship education courses assigned to each cluster.

3. Quantitative measurement of the development of students' creative abilities

This questionnaire is mainly composed of 3 parts, the first part is the basic information of the respondents, including gender, grade, type of school, type of major, and home location. The second part is the Innovative Spirit Scale for College Students, which is used to measure the innovative spirit of the respondents. The third part is the Innovative Ability Scale for College Students, which is used to observe the students' innovative ability.

3.1. Innovative Spirit Scale Design

In this study, the Psychological Measurement of College Students' Innovative Spirit [18] was used to understand the state of students' innovative spirit, and the questionnaire included four dimensions: flexibility, unconventionality, criticality, and reflectivity, with a total of 25 questions. Topics 1, 4, 6, 12, 15, 16 and 22 constitute the flexibility dimension, topics 2, 8, 17, 19, 22, 23 and 25 constitute the dimension of unconventionality, questions 3, 7, 11, 13, 18 and 20 constitute the critical dimension, and questions 5, 9, 10, 14 and 24 constitute the reflective dimension. The scale uses a five-point Likert score, with "not at all agreeing", "not quite agreeing", "not sure", "somewhat agreeing", and "completely agreeing", respectively, assigning "1-5" points. In this study, the mean level of the total score of the scale was used to measure the level of innovation, with 1-2 being low, 2-3 being lower-middle, 3-4 being upper-middle, and 4-5 being high.

3.2. Scale for Measuring Students' Creative Skills

The Innovation Ability Cultivation Level Measurement Scale [19] examines the ability to explore opportunities, organize and manage the ability, strategic decision-making ability, resource integration ability, innovation and creativity ability, and frustration tolerance ability, with a total of 22 questions. Among them, questions 1, 2, 3 and 4 constitute the dimension of opportunity exploration ability, topics 5, 6 and 7 constitute the dimension of organizational management ability, topics 8, 9 and 10 constitute the dimension of strategic decision-making ability, topics 11, 12, 13 and 14 constitute the dimension of resource integration ability, questions 15, 16, 17 and 18 constitute the dimension of innovation and creativity ability, and questions 19, 20, 21 and 22 constitute the dimension of frustration tolerance. The scale also uses a five-point Likert score, with "not at all agreeing", "not quite agreeing", "not very sure", "somewhat agreeing" and "completely agreeing", respectively, with a score of 1-5. In this study, innovation ability was measured using the mean level of the scale total score, with 1-2 being low, 2-3 being lower-middle, 3-4 being upper-middle, and 4-5 being high.

4. Analysis of the effects of the development of innovative entrepreneurship education programs

4.1. Analysis of changes in students' innovative spirit and ability

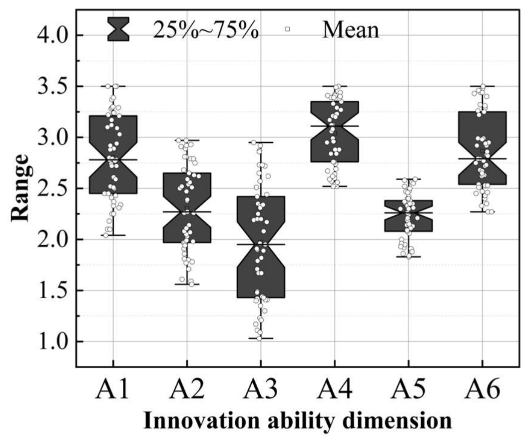
In order to understand the actual situation of innovative teaching mode of computing-based innovation and entrepreneurship education course in the cultivation of innovation and entrepreneurship ability of college students, this study chooses S college as the practice site, randomly selects two classes (115 students) to carry out the 12-week teaching mode practice, and analyzes the level of innovation and ability cultivation of the students of the class in the pre-, mid-, and post-phases of the teaching practice through questionnaires. Analyze.

4.1.1. Innovative Spirit Development Survey Results. The results of the questionnaire on the innovation spirit of college students were analyzed with descriptive statistics and the overall performance on each dimension was explained, and the results of the analysis are shown in Table 1. In the survey on the improvement of the level of students' innovative spirit cultivation, it was found that the mean values of students' scores on the four dimensions under the innovative spirit, namely, flexibility and adaptability, novelty, criticality and reflection, increased from 2.85, 2.83, 2.44 and 2.49 at the initial stage to 4.05, 4.10, 4.42 and 4.91 at the later stage, respectively. It indicated that students generally believed that their own innovative spiritual qualities such as critique and questioning, challenging themselves and perseverance were enhanced after learning under the computing-based innovation and entrepreneurship education program.

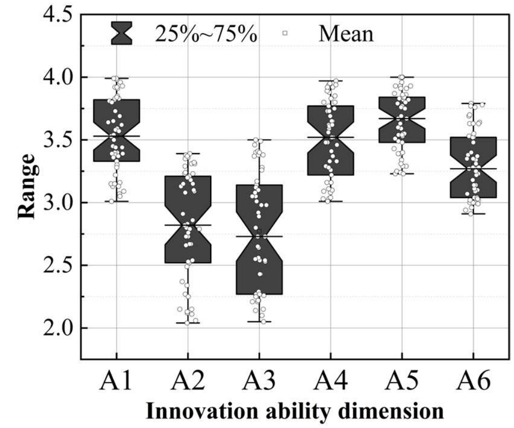
Table 1. Student innovation spirit score analysis

Week 1				
Dimension	Maximum value	Minimum value	Mean value	Standard deviation
Flexibility	1.32	3.72	2.85	1.2
New diversity	1.37	3.05	2.83	1.02
Critically	1.45	3.77	2.44	1.32
Reflectivity	1.37	3.95	2.49	0.78
Week 6				
Dimension	Maximum value	Minimum value	Mean value	Standard deviation
Flexibility	1.01	3.74	3.36	1.25
New diversity	1.08	3.75	3.24	0.56
Critically	1.16	3.66	3.09	1.3
Reflectivity	1.42	4.43	3.08	1.04
Week 12				
Dimension	Maximum value	Minimum value	Mean value	Standard deviation
Flexibility	2.77	5.00	4.05	0.69
New diversity	2.62	5.00	4.10	0.56
Critically	2.83	5.00	4.42	0.82
Reflectivity	2.43	5.00	4.91	0.66

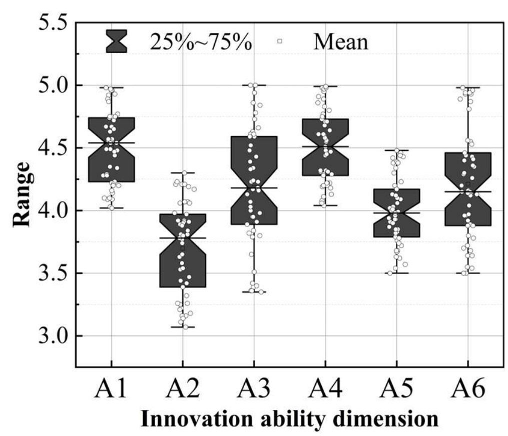
4.1.2. Status of the level of innovation capacity development. There are often holistic changes between the six sub-competencies that constitute the innovation competence, in which a change in one of the competencies will drive the overall change. The results of the descriptive analysis of the level of students' innovation ability cultivation are shown in Figure 2, with (a)-(c) representing the statistical results of the surveys in the pre (week 1), middle (week 6), and post (week 12) stages of the teaching practice, respectively. A1-A6 in the figure represent opportunity discovery ability, organizational management ability, strategic decision-making ability, resource integration ability, innovation and creation ability, and frustration tolerance ability, respectively. The overall mean value of the six innovative abilities cultivated by college students in the previous stage is about 2.54 points, and this ability score mean value is not satisfactory, and the students' innovative abilities are at a poor level. Among these 6 constituent competencies, the mean value of each competency ranged from 1.97 to 3.04 points, with the mean value of resource integration competency (3.04 points) being the highest and the mean value of strategic decision-making competency being the lowest (1.97 points). The main influencing factor of this score is the guidance of the university to the students, and the division of the students' stage-by-stage tasks and what kind of goal requirements they need to achieve may be the reason for the lowest mean value of the students' strategic decision-making ability. When the teaching practice of innovation and entrepreneurship education courses was carried out until the 6th week, the level of all dimensions of students' innovation ability was improved, and the mean values of opportunity discovery ability, organizational management ability, strategic decision-making ability, resource integration ability, innovation and creativity ability, and frustration tolerance ability were 3.53, 2.82, 2.77, 3.51, 3.64, and 3.30, respectively. By the later stage (week 12), the average level of the students' innovative ability flat development reached 4.18 points, which is a high level.



(a) Week 1



(b) Week 6



(c) Week 12

Fig. 2. Innovation ability training level statistics

Independent samples t-test was used to compare whether there was a significant difference between the students' innovative ability in the pre and post stages of teaching practice, and the results of the comparative analysis are shown in Table 2. In the six dimensions of innovation ability development, there is a significant difference between the mean scores of the surveys in the 1st week and the last week (P=0.032, 0.021, 0.042, 0.006, 0.025, 0.035<0.05), which indicates that the innovative mode of innovation and entrepreneurship education program based on computing technology has a significant role in promoting the development of the students' innovation ability.

Table 2. Analysis of the level of innovation ability culture (Week 1 VS Week 12)

Dimension	Week		T	P
	1	12		
Opportunity	2.80	4.50	1.263	0.032
Organizational management	2.30	3.70	1.665	0.021
Strategic decision-making ability	1.97	4.18	1.023	0.042

Resource integration capability	3.04	4.51	2.154	0.006
Creative ability	2.23	3.99	1.528	0.025
Frustration	2.87	4.21	1.728	0.035

4.2. Analysis of Online Learning Behavior in Innovation and Entrepreneurship Education

4.2.1. Curriculum data collection. The online teaching part of the innovative entrepreneurship education course based on computing technology is mainly carried out on the Super Star Learning Channel platform, in which a total of 60 learning resources for innovative entrepreneurship education, such as graphics and videos, have been uploaded, and there is an in-class discussion forum and a post-course Q&A and discussion forum. The learning content of the course is more knowledge about innovation and focuses on the improvement of students' innovation ability. The data source of learners' online learning behavior in this study is based on the exportable learning activity data of the online course learning platform, and the content analysis of the learning outcome data on the platform is used as a supplement. First, Excel is used to perform basic statistics and organization of the raw data set of online learning behaviors obtained from the background learning logs of the online course learning platform, such as students' task completion, resource learning, discussion, and homework detection. Second, the learning behavior data obtained from the analysis of the discussion forums, assignments and other content are added, and all the data are checked and counted again to improve the accuracy of the analyzed data and to confirm that all the data required for the study are collected and complete.

4.2.2. Data pre-processing. In order to obtain a correct and complete dataset of learners' online learning behaviors for innovative entrepreneurship education courses, the raw dataset needs to be preprocessed. In the first step, the required data in the raw data set are screened out, irrelevant data are deleted and processed, and inconsistent items between the background exported data and the content analysis data in the raw data set are deleted after checking again and deleting the erroneous items. In the second step, according to the online learning behavior indicators, for the learning behaviors that cannot be directly represented by raw data, the raw data will be obtained by formula conversion and other means. Step 3: Observe whether there are missing or incomplete values in the processed data set, and if so, process and analyze them separately. In the fourth step, the personal information of the learners in the online learning behavior dataset is hidden, and the name part is represented using UID. The processed online learning behavior dataset of learners is shown in Table 3. The learning behavior dataset includes check-in attendance, course access, learning resource duration, homework submission time, homework assessment score, and number of discussions.

Table 3. The learner online learning behavior data set

UID	Check-in attendance rate	Course traffic	Learning length (h)	Submit time (min)	Job test results	Discussion number
1	73.34%	91	51.47	11.29	92.55	15
2	87.87%	70	39.82	22.67	91.58	11
3	79.60%	62	46.99	17.71	86.11	7
4	97.85%	91	36.6	21.28	81.59	29
5	85.00%	91	37.31	24.94	80.87	11
6	94.15%	69	35.48	28.41	83.2	8
7	78.84%	99	55.61	32.29	81.48	29
8	79.30%	66	36.15	23.08	96.41	15
9	80.40%	79	34.53	17.14	63.07	9
……	……	……	……	……	……	……

114	95.38%	84	40.43	31.59	96.41	15
115	86.36%	67	42.39	17.41	74.35	7

4.2.3. Statistical Analysis of Online Learning Behavior. In order to understand the basic situation of students' online learning behavior of innovative entrepreneurship education courses, this study conducted a descriptive statistical analysis of online learning behavior, and the statistics included the minimum, maximum, median, mean, standard deviation, and sample size of each index of online learning behavior. The descriptive statistics of each index of online learning behavior of innovation and entrepreneurship education courses are shown in Table 4. Most of the learners in the sample visit the innovation and entrepreneurship education course above the mean (74.91 times), indicating that the majority of the learners who continue to study repeatedly in the online course learning platform, the span between the maximum value (100 times) and the minimum value (60 times) is large, and the standard deviation (36.52) is large, which indicates that there is a large difference in the number of visits to the innovation and entrepreneurship education course among the learners. Learners performed better in terms of sign-in attendance (86.12%), with only individual learners having poor sign-in attendance. The average assignment submission time for the whole sample was 28.10 minutes, i.e., the time taken to complete the course assignments, indicating that the students had engaged in reflection in completing the assignments. It is understood that the grades for assignments posted on the platform account for a portion of the overall course grade, and students are more active in completing assignments in order to achieve better course grades.

Table 4. Study behavioral descriptive statistical analysis results

Dimension	Sample size	Maximum value	Minimum value	Mean value	Standard deviation
Check-in attendance rate	115	100%	70.00%	86.12%	11.62%
Course traffic	115	100	60	74.91	36.52
Learning length (h)	115	60.32	29.56	48.15	19.65
Submit time (min)	115	41.23	9.65	28.10	11.24
Job test results	115	99.32	60.00	75.99	10.36
Discussion number	115	30	0	13.36	5.36

4.2.4. Cluster Analysis of Online Learning Behaviors. Since the scale of each indicator is different, the existence of the scale will affect the comparison between the indicators. Before carrying out the analysis of online learning learning behavior, this paper adopts the min-max method to normalize the indicator data, and normalizes the value range of the data to [0, 1], after the normalization of the data, it is convenient to analyze the connection between the data of each indicator, improve the comparability between the indicator data, and facilitate the calculation of the data, so as to improve the precision of the analysis of online learning behavior. This study uses SPSS to complete the clustering analysis, the analysis shows that the online learning behavior of innovation and entrepreneurship education courses tends to slow down when the number of categories is 4-7, so we consider the number of clustering categories of the learning group to be taken in this interval, and after many attempts, the number of categories of the learning group of this study is finally set at 4. The final clustering center analysis results when the number of clustering categories is taken to be 4 are shown in Table 5, and the analysis of the characteristics of online learning behavior is analyzed according to of the four clustering types of learners are 39, 26, 19 and 31 respectively.

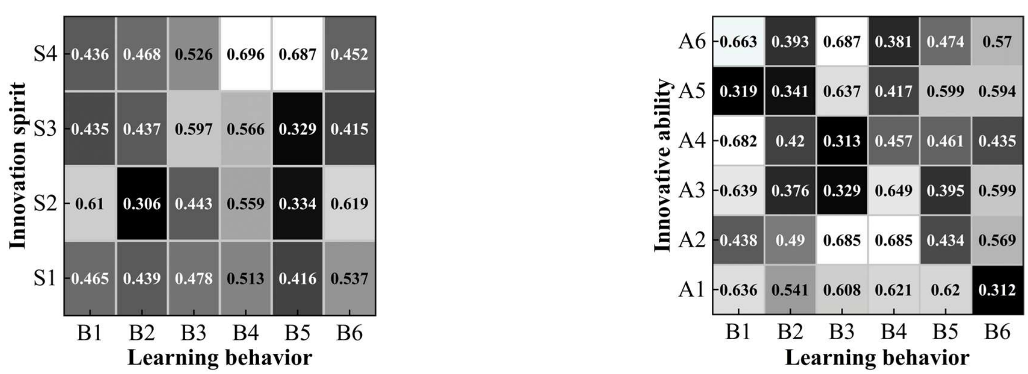
Table 5. The k value takes 4 and the final cluster center result

Categories	Cluster 1	Cluster 2	Cluster 3	Cluster 4
Inner number of classes	39	26	19	31

Check-in attendance rate	0.3391	0.1329	0.7834	0.1441
Course traffic	0.4004	0.6781	0.7985	0.6159
Learning length (h)	0.8822	0.7354	0.7266	0.1288
Submit time (min)	0.2237	0.1722	0.6936	0.639
Job test results	0.359	0.7498	0.8516	0.2037
Discussion number	0.6971	0.7452	0.8792	0.6254

4.3. Analysis of the relationship between online learning and the cultivation of innovation ability

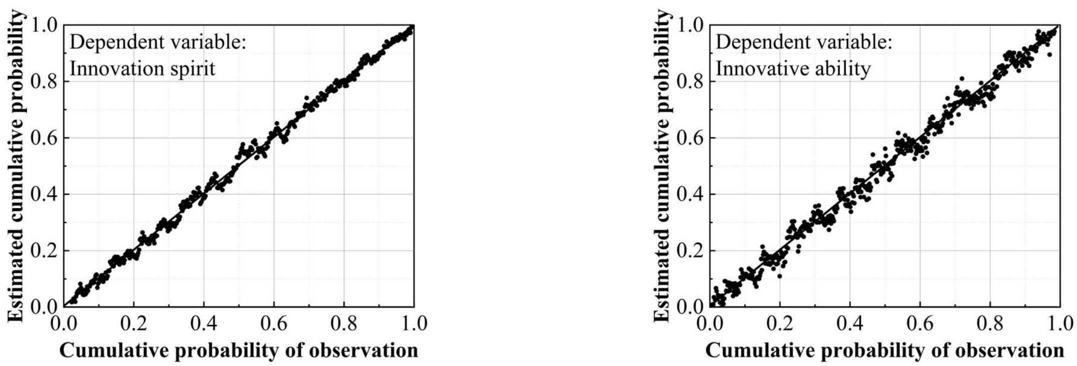
4.3.1. Correlation analysis. Using SPSS Statistics 20.0 software, Spearman correlation analysis was conducted between online learning behaviors of innovation and entrepreneurship education and the cultivation of students' innovative spirit and ability, and the output results are shown in Fig. 3, (a) and (b) are the results of the correlation analysis of learning behaviors, innovative spirit, and learning behaviors and innovative ability, respectively. In the figure, B1-B6 represent the sign-in attendance rate, course access, learning resource duration, assignment submission time, assignment assessment score and discussion number under the dimension of learning behavior, respectively.A1-A6 represent the opportunity exploration ability, organizational management ability, strategic decision-making ability, resource integration ability, innovation and creativity ability, and frustration tolerance ability under the innovation ability, respectively. S1-S4 represent the four dimensions of flexibility and adaptability, innovativeness, criticality and reflectiveness of innovative spirit, respectively. The Spearman's correlation coefficients between the length of learning resources and the dimensions of innovative spirit in learning behavior are 0.443-0.597, and the significance coefficients are all 0.000 less than 0.05, which means that the length of learning resources is moderately correlated with the innovative spirit, and it is thus clear that the longer the length of learning resources, the better the learning effect. The highest Spearman correlation coefficients of sign-in attendance rate and course access with resource integration ability and opportunity exploration ability in innovation ability are 0.682 (P=0.000<0.05) and 0.541 (P=0.000<0.05) respectively. Taken together, the above analysis shows that there are different degrees of correlation between learning behaviors and the cultivation of students' innovative spirit and ability in the online learning platform of computation-based innovation and entrepreneurship education.



(a) Innovation spirit (b) Innovative ability

Fig. 3. Study behavior and innovation ability culture correlation analysis

4.3.2. Multiple regression analysis. Through the above analysis of the correlation between the online learning behaviors of the computation-based innovation and entrepreneurship education course and the cultivation of the spirit of innovation and competence, it was determined that there is a correlation between these behavioral indicators and the cultivation of the spirit of innovation and competence of college students. However, this correlation does not reliably identify the key behavioral indicators that affect the cultivation of innovation ability, nor does it accurately summarize the degree of influence of each key indicator on the cultivation of innovation ability. Therefore, it is also necessary to conduct a multiple regression analysis of the behavioral indicators related to the cultivation of innovation ability, using the stepwise entry method, to further explore the influence effect of each indicator of online learning behavior on the cultivation of innovation ability, in which each indicator of online learning behavior is an explanatory variable (independent variable), and the level of the cultivation of the spirit of innovation and the cultivation of innovation ability is an explanatory variable (dependent variable). First, the data were subjected to standardized residual normality test, and the results of the normality test are shown in Figure 4, with (a) and (b) representing the test results when the spirit of innovation and innovation ability are used as dependent variables, respectively. By observing the normal P-P plot of the standardized residuals, most of the points are concentrated on the diagonal straight line, which indicates that the data residuals obey the normal distribution, i.e., they satisfy the assumptions of the stepwise regression analysis.



(a) Innovation spirit

(b) Innovative ability

Fig. 4. Standardized residual normal P-P diagram

The dimensions of innovation spirit and innovation ability are taken as dependent variables, and the learning behavior in the online learning platform for innovation and entrepreneurship education is taken as the independent variable for multiple linear regression analysis. The results of the multiple linear regression analysis (Model 1) of learning behavior on the enhancement of innovation spirit cultivation are shown in Table 6, and the results of the regression analysis (Model 2) on the enhancement of innovation ability cultivation are shown in Table 7. The R^2 of model 1 and model 2 are 0.635 and 0.684 respectively, and the F value of the holistic test of the regression model is 584.236 and 632.512 (P=0.000<0.05). Thus the predictor variables together can effectively explain 63.5% and 68.4% of the variance in students' creativity and innovativeness. According to the table of coefficients of Model 1 and Model 2, the VIF of the respective variables is less than 5, indicating that the independent variables are not correlated with each other. The online learning behavior of innovation and entrepreneurship education has a significant effect on the development of innovation spirit and ability, and the standardized coefficients are all positive, indicating a positive effect. The coefficient of the sign-in attendance score is the largest, with coefficients of 0.375 and 0.784 in the two models, which are significant at the 0.01 level.

Table 6. Results of regression analysis of the innovation spirit culture (Model 1)

Independent variable	Unnormalized coefficient		Normalization factor	t	P	Common linear statistics	
	B	Standard error	Beta			Tolerance	VIF
Constants	1.632	0.018	——	4.058	0.043	0.878	1.122
B1	0.379	0.012	0.375	5.535	0.01	0.885	1.096

B2	0.148	0.011	0.145	2.048	0.026	0.898	1.196
B3	0.246	0.013	0.248	3.513	0.041	0.95	1.125
B4	0.131	0.015	0.135	3.95	0.004	0.882	1.173
B5	0.163	0.019	0.164	4.131	0.024	0.867	1.158
B6	0.129	0.017	0.128	3.766	0.035	0.943	1.109
R^2	0.635						
Adjust R^2	0.628						
F	F=584.236, P=0.000						

Table 7. Results of regression analysis of the innovation ability culture (Model 2)

Independent variable	Unnormalized coefficient		Normalization factor	t	P	Common linear statistics	
	B	Standard error	Beta			Tolerance	VIF
Constants	2.365	0.02	——	4.576	0.039	0.862	1.064
B1	0.799	0.019	0.784	2.07	0.032	0.859	1.057
B2	0.523	0.018	0.524	4.201	0.022	0.881	1
B3	0.487	0.01	0.487	4.59	0.015	0.913	1.016
B4	0.529	0.012	0.526	4.947	0.044	0.946	1.065
B5	0.57	0.01	0.572	4.96	0.049	0.855	1.014
B6	0.473	0.016	0.468	4.348	0.034	0.884	1.041
R^2	0.684						
Adjust R^2	0.679						
F	F=632.512, P=0.000						

5. Conclusion

This paper designs an innovative teaching mode for innovation and entrepreneurship education courses based on computing technology and digital teaching environment, analyzes students' online learning behaviors and the level of cultivation of innovation spirit and ability after the practice of the teaching mode, and finds that the level of innovation spirit and innovation ability is improved with the teaching, and the practice of innovation and entrepreneurship education courses based on computing has a significant contribution to the cultivation of innovation ability ($P<0.05$). Students had a higher attendance rate (86.12%) in the online learning platform, and were more active in completing assignments and discussions. Correlation and regression analyses found that the Spearman correlation coefficients of the online learning behaviors of innovation and entrepreneurship education courses for college students and the dimensions of innovation spirit and innovation ability were all higher than 0.3, showing a medium-high correlation, which could effectively explain 63.5% and 68.4% of the variance of students' innovation spirit and innovation ability, respectively.

In summary, the practical results of this study show that the computing-based innovation and entrepreneurship education model is important for the cultivation of students' innovation spirit and ability level, and in the future, universities can combine their own actual situation with the digital resources to realize the teaching of innovation and entrepreneurship education courses with digital technology support.

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