Quality Evaluation of Innovation and Entrepreneurship Education Based on Modelling of Students' Behavior Sequences

https://doi.org/10.3991/ijet.v18i09.40227

Mingzhe Niu(✉)
College of Innovation and Entrepreneurship, Zibo Vocational College, Zibo, China
11017@zbvc.edu.cn

Abstract—In the Innovation and Entrepreneurship (I&E) education of some higher vocational colleges, there's a common problem: serious disconnection between professional education and practical education, which may result in poor quality of I&E education. With the help of I&E education quality evaluation, we can figure out the distribution and utilization of education resources, discover and solve problems during the teaching process in time, and optimize and adjust teaching content and methods in a targeted manner. Student behavior analysis can reveal the actual needs and questions encountered by students during I&E education, thereby attaining more pertinent and pragmatic evaluation results. For this reason, this paper aims to study the I&E education quality evaluation by means of modelling students' behavior sequences. At first, a student I&E behavior sequence feature extraction module was created based on attention mechanism, and the student I&E ability level feature extraction layer and student I&E ability level feature evolution layer contained in the module structure were introduced in detail. Then, the data sources of I&E education quality evaluation based on students' I&E behavior analysis were given, the I&E behavior sequences of students were modeled based on the single-sequence first-order linear differential equation model GM(1,1), and the established model was applied to I&E education quality evaluation. At last, experimental results verified the validity and accuracy of the proposed method.

Keywords—student behavior sequence, innovation and entrepreneurship (I&E) education, education quality evaluation, gate recurrent unit (GRU) model, grey prediction

1 Introduction

I&E education is doubtlessly important for higher vocational colleges to realize their ultimate goal of cultivating technical talents with professional skills [1–4], so I&E education and practice course should be built into the compulsory course system of higher vocational colleges, so that students could master skills and knowledge required for starting a business, and their employment opportunity and entrepreneurship success rate could both be increased [5–11]. Moreover, this can also train their ability to solve

problems and rise to challenges, from the perspective of society, this is conductive to creating more innovative enterprises and providing powerful impetus for economic development [12–17]. However, at present, there is a common problem with the I&E education in some higher vocational colleges: the serious disconnection between professional education and practical education. Teachers' awareness of I&E education is generally insufficient, which has led to a very poor quality of I&E education, and they couldn't provide a good educational environment for college students to innovate and start their own business [18–25]. In this context, it's a necessary work to evaluate the quality of I&E education, so that researchers of pedagogy could figure out situations of distribution and utilization of education resources, discover and solve problems during the teaching process in time, and optimize and adjust teaching content and methods in a targeted manner.

Scholars Yi and Cui [26] researched the development of computer major and built an Evaluation Index System (EIS) for computer science major for the first time, they employed a Back Propagation Neural Network (BPNN) model to give scientific evaluations on the target major, and empirically and quantitatively studied the innovation and employment mode using the established EIS, their work serves as an effective basis for social policy research of developing computer specialties. Knowledge map is an useful visualization tool in personalized learning systems used as a research object to analyze students' online evaluation data, Wu and Qin [27] developed a prototype system for improving teaching quality, namely a knowledge map generation and knowledge point recommendation path analysis system, their research findings provide new ways and methods to promote the reform of I&E education in colleges and universities and give full play to the proper role and value of I&E education. Another scholar Gou [28] proposed a multi-attribute group decision-making method based on the CoCoSo approach in Intuitionistic Fuzzy Set (IFS) environment for evaluating the quality of I&E education in vocational colleges. In the paper, the author extended CoCoSo to the IFS environment, built a new model based on the CoCoSo algorithm. In this algorithm, attribute weight was derived by subjective weight and objective weight, and the objective weights were determined by the CRITIC method, the effectiveness of decisions given by the algorithm was then verified through comparisons. Zhang [29] pointed out that improving the quality of I&E education based on big data analysis has become the focus of universities and the Chinese society, the author introduced the discrete dynamic modeling technology of complex systems in his/her paper, analyzed deficiencies and problems of college students' I&E education quality in many aspects, and discussed how to improve this quality based on cloud computing and big data.

Actually, the research topic of I&E education quality evaluation has received widespread attention in recent years and some results have been attained regarding it, however, after reviewing related literatures, it's found that there are many shortcomings with existing studies, such as the flawed EIS, over-emphasis on quantitative indicators, lack of long-term follow-up studies, and overlook of student participation, etc. To overcome these deficiencies, works need to be done to revise existing I&E education quality evaluation methods. By observing students' behavior during I&E, aspects that are hard to be measured by quantitative indicators could be found, such as the innovation ability of students, and their teamwork ability, etc. Therefore, introducing student behavior analysis into I&E education quality evaluation is a meaningful

work as it can reveal the actual needs and questions encountered by students during I&E education, attain more pertinent and pragmatic evaluation results, and assist students to understand their advantages and disadvantages in I&E, in this way, students could adjust their learning strategies and enhance their I&E ability. In view of these matters, this paper studied the I&E education quality evaluation by means of modelling students' behavior sequences. In the second chapter, a student I&E behavior sequence feature extraction module was created based on attention mechanism, the features of student I&E behavior sequences were extracted, and the student I&E ability level feature extraction layer and student I&E ability level feature evolution layer contained in the module structure were introduced in detail. In the third chapter, the data sources of I&E education quality evaluation based on students' I&E behavior analysis were given, the I&E behavior sequences of students were modeled based on the single-sequence first-order linear differential equation model GM(1,1), and the established model was applied to I&E education quality evaluation. At last, experimental results verified the validity and accuracy of the proposed method.

2 Feature extraction model of student I&E behavior sequences

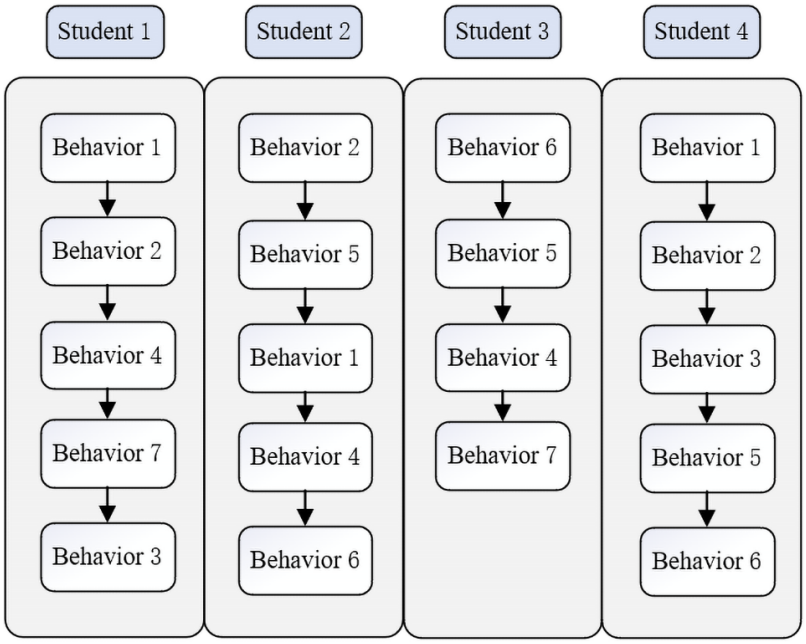

Fig. 1. I&E behavior sequences of different students

Thanks to digital information technologies, now it's easier to collect and analyze students' learning behavior data, so that real-time monitoring and timely intervention measures could be adopted for the cultivation of students' I&E ability. By analyzing the diverse, personalized and multidimensional big data of I&E education, teachers are

able to spot student' learning difficulties and take corresponding measures to intervene in time. In this context, making full use of the history information of students' I&E behavior sequences could contribute greatly to enhancing the performance of student I&E ability prediction models and improving the evaluation accuracy of I&E education quality. For example, before performing I&E behavior, students need to learn I&E-related knowledge or look for technical or business support for that, if a student clicks to browse a certain type of I&E resource, it means that the possibility of this student performing I&E behavior in the near future is greatly increased. If the student doesn't acquire this I&E resource after browsing it, it means that his/her I&E possibility is lower. By creating such behavior sequence information, the students' enthusiasm and preference for I&E behavior could be reflected more objectively. Then, by sorting out the I&E behavior sequence information, the data of a student's I&E behavior could be modeled as his/her I&E behavior sequence. Figure 1 gives a diagram showing the I&E behavior sequences of different students.

This paper built a student I&E behavior sequence feature extraction module based on attention mechanism and used it to extract the features of students' I&E behavior sequences. The text below introduced the feature extraction layer and feature evolution layer of students' I&E behavior ability level in detail. Figure 2 shows the structure of the said feature extraction model.

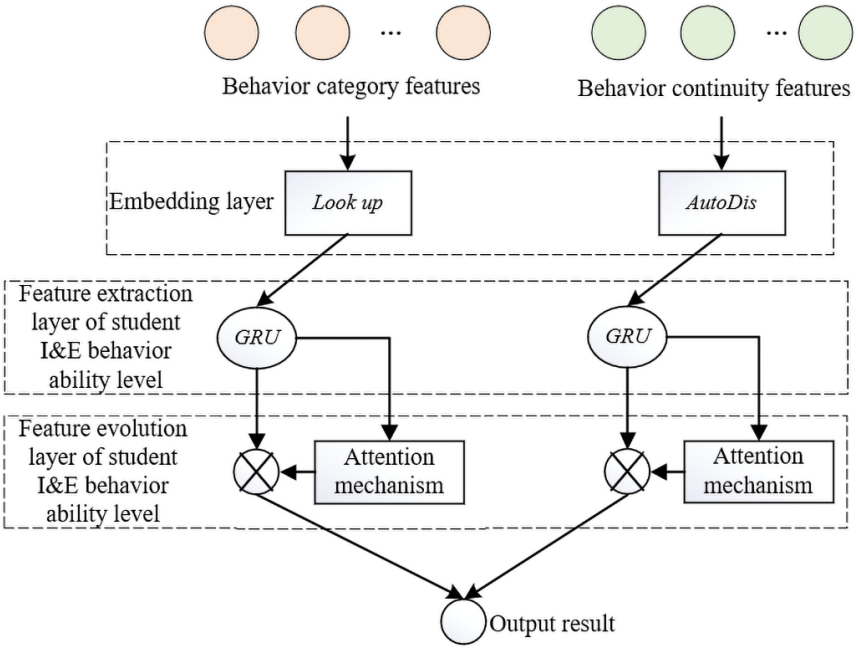

Fig. 2. Structure of feature extraction model

Digital information technologies could be used to collect and analyze various data generated during students' I&E process, such as learning records of online courses and interactions through social media, etc. This method can discover the hidden laws and trends of students' behavior, but it requires higher skills of data processing and analysis.

In the above-mentioned scenarios (learning records of online courses and interactions through social media), although the time it takes for students to click, browse, and interact is quite short, the actions are performed for many times, so the generated student I&E behavior sequences are long. In the meantime, after the clicking, browsing, or interacting actions of students have happened, their I&E ability level will change, based on the sequence information of students' I&E behavior of "clicking", we could model the I&E ability level features of students.

Gate Recurrent Unit (GRU) model is a frequently-used neural network which is simpler in structure, faster in convergence speed, and can better handle the long dependence problem with long and short sequence data than the Long Short Term Memory (LSTM) model. This paper used the GRU model to iteratively calculate the students' I&E behavior sequence information and capture the information of their I&E ability level, the reset gate s_o of the GRU model could be attained based on the information of students' I&E ability level at time moment o–1, that is:

$$s_o = \varepsilon(Q_o a_o + V_s f_{o-1}) \tag{1}$$

Assuming: f_{o-1} represents the information of students' I&E ability level at time moment o–1, a_o represents the embedding vector of I&E resource acquired by students at time moment o, then the update gate c_o of the GRU model could be attained based on this embedding vector, that is:

$$c_o = \varepsilon(Q_o a_o + V_c f_{o-1}) \tag{2}$$

The students' I&E ability level information at time moment o can be reset through s_o, it's assumed that f_o represents students' I&E ability level information at time moment o, combining with the embedding vector of I&E resource acquired by students at time moment o, students' I&E ability level information at time moment o can be calculated, namely:

$$f_o = \tanh(Q a_o + V(s_o \otimes f_{o-1})) \tag{3}$$

Through c_o, students' final I&E ability level information f_o can be attained, namely:

$$f_o = (1 - c_o) \otimes f_{o-1} - c_o \otimes f_o \tag{4}$$

In this way, the GRU model can extract students' I&E ability level information at each time moment, output the hidden state of students at each time step, and further extract the behavior sequence features of students to get the expression of students' I&E ability level based on their I&E behavior sequences. Figure 3 shows the framework for extracting the features of students' I&E behavior sequences.

To effectively balance the performance and efficiency of the model, in the feature extraction layer, this paper described the relationship between students' history behavior and current behavior by constructing the GRU model and using it to capture the features in the variation of their I&E ability level. However, in real cases, there's a certain deviation between the I&E resource truly needed by students and the I&E resource they actually contact in their I&E behavior sequences, and such deviation has resulted

in that the I&E resource of students' I&E behavior sequences has a certain impact on the prediction results. To better simulate the I&E ability level improvement path of students and the target I&E resource, in this chapter, this paper introduced the attention mechanism based on the feature extraction layer and built a feature evolution layer of students' I&E ability level. This feature evolution layer can automatically learn the importance of students' behavior sequence data and assign weights, thereby enhancing the prediction model's performance and improving the accuracy of I&E quality evaluation. Figure 4 shows the calculation process of the adopted attention mechanism.

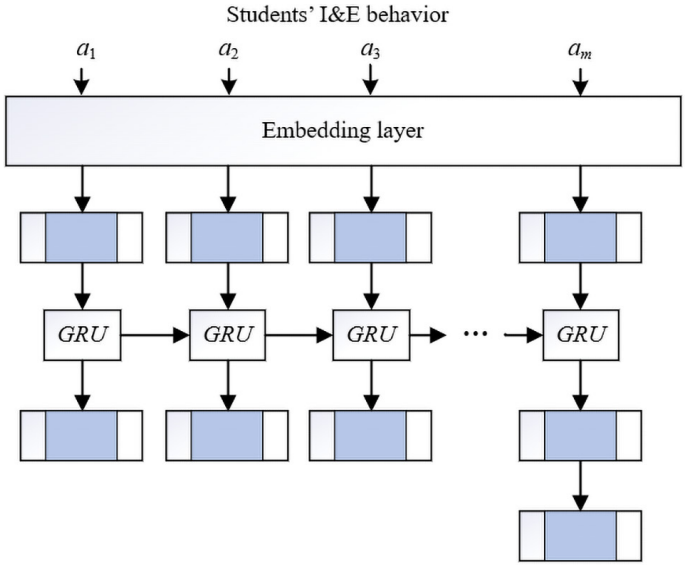

Fig. 3. The behavior sequence feature extraction framework

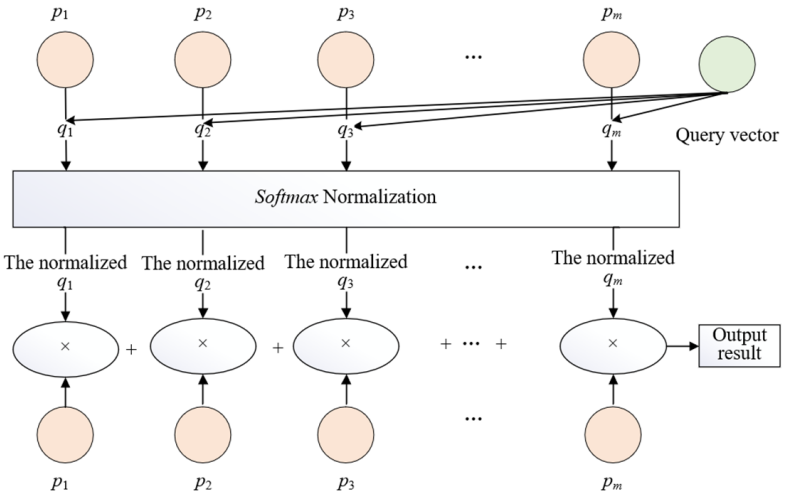

Fig. 4. Calculation process of attention mechanism

In this paper, the eigenvector of students' I&E behavior sequences is defined as $P = \{p_1, p_2, p_m, ..., p_m\}$; assuming: p_i represents the i-th vector of sequence features, w represents the query vector, then the detailed calculation steps are:

At first, based on the perceptron method and the dot product method, the correlation of query vectors and feature vectors was calculated, assuming: *comcat*(.) represents the concatenate function, Q_1, Q_2, y_1, and y_2 represent learning parameters, then the formula for calculating the perceptron is:

$$q_i = Q_2 \tanh(Q_1 comcat(p_i, w) + y_1) + y_2 \tag{5}$$

Assuming: q_i represents the weight of query vector w and eigenvector p_i, then the formula for calculating the dot product of query vector and eigenvector is:

$$q_i = p_i^T w \tag{6}$$

Then, based on the *softmax* function shown in the following formula, the weight attained by the perceptron method and dot product method was normalized:

$$\hat{q}_i = \frac{\exp(q_i)}{\sum_{j=1}^{m} \exp(q_j)} \tag{7}$$

At last, based on the following formula, the eigenvector and normalized vector weight were subjected to dot product calculation and accumulation processing, finally, we can get the output result of students' I&E behavior sequence features based on the attention mechanism:

$$c = \sum_{i=1}^{m} (\hat{q}_i, p_i) \tag{8}$$

3 I&E education quality evaluation based on modeling of students' I&E behavior sequences

The monitoring of I&E education quality evaluation of students' I&E behavior is composed of five parts: monitoring of teachers' teaching level, monitoring of students' I&E behavior status, monitoring of students' I&E achievements, monitoring of students' I&E ability, and monitoring of students' employment status, wherein monitoring teachers' teaching level is the key to ensure I&E education quality. Through evaluations on aspects including teachers' teaching contents, methods, and classroom management, etc., the teachers' merits and shortcomings during the process of I&E education could be figured out. Besides, through teacher training, teaching feedback, and teaching evaluation, we can also help teachers improve their teaching level. Paying attention to students' I&E behavior status is also helpful for teachers to know about students' learning motivations, interests, and requirements in I&E education, by monitoring students'

online course learning records and their interactions on social media, we can evaluate the effects of I&E education on the improvement of students' I&E ability. Monitoring students' behavior status can help teachers find out the difficulties encountered by students during I&E, so that effective measures could be taken to solve them. In terms of monitoring students' I&E achievements, we can track and assess the I&E programs participated by students and the I&E outcomes so as to figure out the progress of the programs, the transformation of achievements, and the brought beneficial effects, these are conductive to evaluating the actual effect of I&E education and providing evidences for educational improvements. Via monitoring students' I&E ability, we can know about students' development in creative thinking, teamwork, market analysis, and other aspects, and the evaluation results of students' I&E ability could instruct the optimization of curriculum setting and teaching methods. By monitoring students' employment status, we can evaluate the influence of I&E education on students' competitiveness in job market. By collecting students' information after graduation, we can figure out whether I&E education could help students find satisfactory jobs or not, thereby offering references for educational improvements. Figure 5 shows the data sources of I&E education quality evaluation based on student I&E behavior analysis.

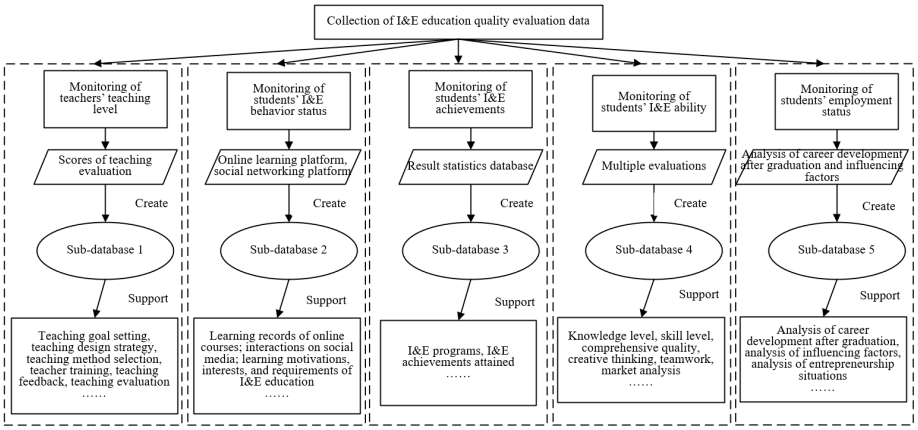

Fig. 5. Data sources of I&E education quality evaluation

Since the monitoring evaluation result data of above five parts were real-time monitoring data, in terms of time series, they have valuable feature information and correlation information.

Grey prediction is a forecasting method established based on the theory of grey system and is applicable to problems with uncertainties, incomplete information, and small data volume. In the evaluation of I&E education quality, grey prediction has a few merits including low requirements for data, good ability in dealing with uncertain problems, fast prediction speed, and ability to dynamically adjust prediction results based on new data, it enables education administrators to acquire more comprehensive and systematic prediction results in a shorter period of time and better respond to changes in education quality.

The grey prediction based on regular data sequences of I&E education quality evaluation can build corresponding differential equation models to forecast the future development trend. This paper selected to use the single-sequence first-order linear differential equation model GM(1,1) to evaluate the I&E education quality based on students' I&E behavior sequences.

At first, the *Lasso* parameter estimation adopted by the model was defined, assuming μ represents non-negative regular parameter, then there is:

$$\hat{\gamma}(lasso) = \underset{\gamma}{argmin}^2 \left\| b - \sum_{j=1}^{t} a_j \gamma_j \right\|^2 + \mu \sum_{j=1}^{t} \left| \gamma_j \right| \tag{9}$$

where, $\mu \sum_{j=1}^{t} \left| \gamma_j \right|$ is a penalty term. To improve the above formula is to assign weights to different coefficients $\hat{\theta}_j = \frac{1}{\left| \hat{\gamma}_j \right|^{\alpha}}$, then there is:

$$\hat{\gamma}^{*(n)}(lasso) = \underset{\gamma}{argmin}^2 \left\| b - \sum_{j=1}^{t} a_j \gamma_j \right\|^2 + \mu_m \sum_{j=1}^{t} \hat{\theta} \left| \gamma_j \right| \tag{10}$$

where, $\hat{\gamma}_j$ is the coefficient attained by the ordinary least squares method. Next, a grey prediction model was constructed, assuming variable $A^{(0)} = \{A^{(0)}(i), i = 1,2,\ldots,m\}$ is a non-negative monotone raw data sequence, $A^{(0)}$ was subject to one-time accumulation to attain the cumulative sequence $A^{(1)} = \{A^{(1)}(l), l = 1,2,\ldots,m\}$, for $A^{(1)}$, a first-order linear differential equation shown as the following formula could be built, namely the GM(1,1) model:

$$\frac{dA^{(1)}}{dp} + \beta A^{(1)} = v \tag{11}$$

By solving the above formula, the attained education quality evaluation model is:

$$\hat{A}^{(1)}(l+1) = \left[\hat{A}^{(1)}(1) - \frac{\hat{v}}{\hat{\beta}} \right] o^{-\hat{\beta} l} + \frac{\hat{v}}{\hat{\beta}} \tag{12}$$

Because the result given by the model was a cumulative quantity, the data attained by the model $\hat{A}^{(1)}(l+1)$ was subject to cumulative substraction and reduced to $\hat{A}^{(0)}(l+1)$, then the gray prediction model of $A^{(0)}$ can be expressed as:

$$\hat{A}^{(0)}(L+1) = (o^{-\hat{\beta}} - 1) \left[A^{0}(m) - \frac{\hat{v}}{\hat{\beta}} \right] o^{-\hat{\beta} l} \tag{13}$$

After that, the model was verified, assuming $\hat{A}^{(0)}$ and residues are calculated according to above modeling steps, and R_1^2 and R_2^2 respectively represent the variance of $A^{(0)}$ and residual sequence O, then there are:

$$R_1^2 = \frac{1}{m}\sum_{l=1}^{m}\left[a^{(0)}(l) - \bar{a}\right]^2 \tag{14}$$

$$R_2^2 = \frac{1}{m}\sum_{l=1}^{m}\left[o(l) - \bar{o}\right]^2 \tag{15}$$

where, $\bar{a} = \frac{1}{m}\sum_{l=1}^{m} a^{(0)}(l), \bar{o} = \frac{1}{m}\sum_{l=1}^{m} o(l)$.

Posterior error ratio and small error probability were calculated, $FR = FR\{/o(l)–\bar{o}/<0.6745R_1\}$. The smaller the posterior error ratio, the better, and the larger the *FR* value, the better.

4 Experimental results and analysis

According to factor analysis of questionnaire survey results and the ways for monitoring I&E education quality with students' I&E behavior taken into account, this paper adopted factor rotation to explain the meaning of factors, and finally formed an EIS consisted of 5 first-level indicators (teachers' teaching level, students' I&E behavior, students' I&E achievement, students' I&E ability, and students' employment status) and 14 second-level indicators (Table 1). The grading of evaluation results is given in Table 2.

Table 1. Importance of evaluation indicators

Indicator	Mean	Indicator	Mean
Teacher training *B*11	4.46	I&E achievement *B*32	4.13
Teaching feedback *B*12	4.61	Creative thinking *B*41	4.21
Teaching evaluation *B*13	4.51	Teamwork *B*42	4.31
Learning motivation of I&E *B*21	4.56	Market analysis ability *B*43	4.13
Learning interest of I&E *B*22	4.34	Career development after graduation *B*51	4.18
Requirement for I&E education *B*23	4.24	Influencing factor of employment *B*52	4.04
I&E program *B*31	4.12	Entrepreneurship situation *B*53	4.16

Table 2. Grading of evaluation results

Grade	Level	Eigenvalue of the Level
Very high quality (5)	5++	4.66~5
	5+	4.27~4.74
	5	4~4.24
High quality (4)	4+	3.71~4
	4	3.21~3.69
	4–	3~3.21
Average quality (3)	3	2.5~3.1
	3–	2~2.5
Low quality (2)	2	1~2
Very low quality (1)	1	0~1

The different lengths of students' I&E behavior sequences can better reflect the prediction effect of student I&E ability prediction model, thereby more accurately judging the grade and level of I&E education quality. This paper chose to use two indexes, *AUC* value and *Logloss* value, to evaluate the performance of the constructed feature extraction model. Experiments were carried out on different sample sets, and the influence of sequence lengths on model performance is shown in Figures 6 and 7.

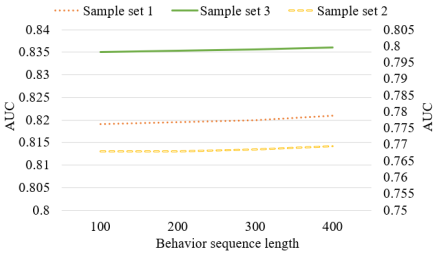

Fig. 6. Influence of behavior sequence length on *AUC* value of the model

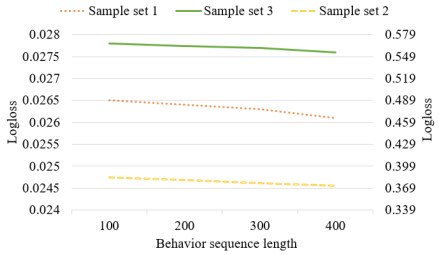

Fig. 7. Influence of behavior sequence length on *Logloss* value of the model

According to Figures 6 and 7, the length of students' I&E behavior sequences indeed has an influence on the performance of the prediction model. On the sample sets adopted in this paper, the *AUC* index of the model increased as the behavior sequence length grew, and the *Logloss* index decreased accordingly, which had verified that the constructed GRU model could extract the long-term memory information of students' I&E behavior, and increasing the behavior sequence length can enhance the performance of the prediction model to a certain extent.

Figures 8 and 9 respectively compare the evaluation scores of second-level and first-level indicators. According to the figures, on different sample sets, the evaluation results of second-level indicators fluctuated gently, while the fluctuation of evaluation results of first-level indicators was greater. Overall speaking, on each sample set, more than half of the indicators achieved a high quality level, only a few samples reached a very high quality level. On sample set 1, about 35% of the indicators reached a high quality

level, about 60% of the indicators reached an average quality level. On sample set 2, about 50% of the indicators reached a high quality level, and the other 50% reached an average quality level. The situation of sample set 3 was similar to that of sample set 2. Besides, on different sample sets adopted in this study, there were large differences in the dimension of students' employment status (first-level indicator), the main reason is that once a student has started a business and attained certain achievements, the evaluation score of I&E education quality is higher, but this kind of students only takes a small proportion, and more students would choose to find a job after graduation.

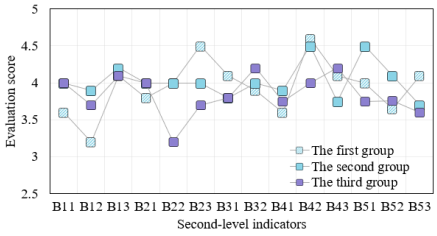

Fig. 8. Comparison of evaluation scores of second-level indicators of I&E education quality

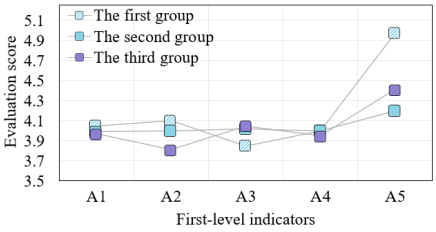

Fig. 9. Comparison of evaluation scores of first-level indicators of I&E education quality

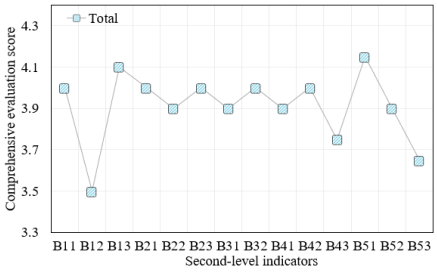

Fig. 10. Comparison of comprehensive evaluation scores of second-level indicators

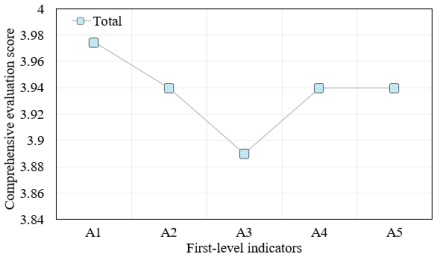

Fig. 11. Comparison of comprehensive evaluation scores of first-level indicators

Figures 10 and 11 respective compare the comprehensive evaluation results of second-level and first-level indicators. According to the figures, all indicators were concentrated at 3–5 levels, which respectively represent the very high quality level, high quality level, and average quality level, wherein 60% of the second-level indicators belonged to the average quality level, and 40% belonged to the high or very high quality levels. The results could be interpreted as that the following aspects need to be improved further: students' creative thinking, teamwork, and market analysis ability and teachers' knowledge contribution and teaching evaluation. Besides, the first-level indicators belonged to the high quality level, the indicator of students' I&E achievement showed an obvious low quality of I&E education, so it's known that during the process of I&E, whether students' I&E behavior will bring I&E achievement or not has a great impact on the quality of I&E education. If students' I&E behavior has brought certain I&E achievement, then it can be considered that the students' I&E behavior is

effective, and teachers' guidance and the well utilized I&E resource have assisted the outcome, so the quality of I&E education must be good.

5 Conclusion

This paper studied the evaluation of I&E education quality by modeling students' behavior sequences. At first, this paper constructed a student I&E behavior sequence feature extraction module based on attention mechanism, and used it to extract students' I&E behavior sequence features, the feature extraction layer and feature evolution layer contained in the module structure were introduced in detail. Then, this paper gave the data sources of I&E education quality evaluation based on students' I&E behavior analysis, modeled students' I&E behavior sequences based on the single-sequence first-order linear differential equation model GM(1,1), and evaluated the I&E education quality based on the constructed model. After that, this paper proposed an EIS consisted of 5 first-level indicators (teachers' teaching level, students' I&E behavior, students' I&E achievement, students' I&E ability, and students' employment status) and 14 second-level indicators for evaluating the I&E education quality. Combining with experiment, this paper analyzed the impact of the length of I&E behavior sequences on the performance of the constructed model, and verified that increasing the length of students' I&E behavior sequences can enhance the performance of the model to a certain extent. At last, the evaluation scores and comprehensive evaluation scores of first-level and second-level indicators were compared and the corresponding analysis conclusions were drawn.

6 References

[1] Li, F. (2022). Research on the management system of college students' innovation and entrepreneurship education based on b/s architecture. Journal of Applied Science and Engineering, 26(5): 597–604. https://doi.org/10.6180/jase.202305_26(5).0002

[2] Hua, S.Y., Ren, Z.W. (2020). "Online + Offline" course teaching based on case teaching method: A case study of entrepreneurship education course. International Journal of Emerging Technologies in Learning, 15(10): 69–85. https://doi.org/10.3991/ijet.v15i10.13999

[3] Pratikto, H., Hanafiya, R., Ashar, M., Akbar, M.I., Harsono, Y.T. (2021). Entrepreneurship game apps to enhancement student skill thinking analytic in class online. International Journal of Interactive Mobile Technologies, 15(8): 155–162. https://doi.org/10.3991/ijim.v15i08.21575

[4] Ma, L., Lan, Z.Z., Tan, R. (2020). Influencing factors of innovation and entrepreneurship education based on the theory of planned behavior. International Journal of Emerging Technologies in Learning, 15(13): 190–206. https://doi.org/10.3991/ijet.v15i13.15345

[5] Han, Y., Yan, R., Gou, C. (2023). An integrated multiple attribute decision making methodology for quality evaluation of innovation and entrepreneurship education with interval-valued intuitionistic fuzzy information. Journal of Intelligent & Fuzzy Systems, 44(2): 2231–2249. https://doi.org/10.3233/JIFS-221701

[6] Wang, W., Qiu, D., Chen, X., Yu, Z. (2023). An empirical study on the evaluation system of innovation and entrepreneurship education in applied universities. Computer Applications in Engineering Education, 31(1): 100–116. https://doi.org/10.1002/cae.22573

[7] Teymurova, V., Abdalova, M., Babayeva, S., Huseynova, V., Mammadov, E., Islamova, N. (2020). Implementation of mobile entrepreneurial learning in the context of flexible integration of traditions and innovations. International Journal of Interactive Mobile Technologies, 14(21): 118–135. https://doi.org/10.3991/ijim.v14i21.18445

[8] Chen, X. (2022). Internet plus innovation and entrepreneurship education model based on machine learning algorithms. Mobile Information Systems, 2022: 6176675. https://doi.org/10.1155/2022/6176675

[9] Zhu, H., Wang, Q. (2022). The development dilemma and path choice of innovation and entrepreneurship education based on game theory. Advances in Multimedia, 2022: 2232253. https://doi.org/10.1155/2022/2232253

[10] Tretyakova, N., Lyzhin, A., Chubarkova, E., Uandykova, M., Lukiyanova, M. (2021). Mobile-learning platform for the development of entrepreneurial competences of the students. International Journal of Interactive Mobile Technologies, 15(9): 118–135. https://doi.org/10.3991/ijim.v15i09.20225

[11] Yu, F. (2022). Construction of innovation and entrepreneurship MOOC education resource library based on distributed information storage and retrieval intelligence. In 2022 International Conference on Edge Computing and Applications (ICECAA), Tamilnadu, India, pp. 1053–1056. https://doi.org/10.1109/ICECAA55415.2022.9936365

[12] Sun, X., Zhang, Y. (2022). An improved BP neural network algorithm for the evaluation system of innovation and entrepreneurship education in colleges and universities. Mobile Information Systems, 2022: 1007538. https://doi.org/10.1155/2022/1007538

[13] An, K. (2022). Exploration of intelligent teaching methods for ideological and political education in colleges and universities under the background of "mass entrepreneurship and innovation". International Journal of Antennas and Propagation, 2022: 2294908. https://doi.org/10.1155/2022/2294908

[14] Wu, W. (2022). Probabilistic linguistic PROMETHEE I and II methods for evaluation of the reform scheme of postgraduate innovation and entrepreneurship education talent training mode under the big data environment. Mathematical Problems in Engineering, 2022: 8341052. https://doi.org/10.1155/2022/8341052

[15] Loh, A.P., Law, E., Putra, A.S., Koh, E., Zuea, T.K., Tat, K.E. (2021). Innovation, design & entrepreneurship in engineering education. Advances in Engineering Education, 9(3): EJ1316313.

[16] Rashid, E., Ansari, M.D., Gunjan, V.K. (2022). Innovation and entrepreneurship in the technical education. In ICCCE 2021: Proceedings of the 4th International Conference on Communications and Cyber Physical Engineering, pp. 1199–1203. https://doi.org/10.1007/978-981-16-7985-8_125

[17] Tan, L., Du, F. (2022). Integrating entrepreneurship and innovation education into higher vocational education teaching methods based on big data analysis. Wireless Communications and Mobile Computing, 2022: 4616446. https://doi.org/10.1155/2022/4616446

[18] Ng, F., Au, K. (2022). Entrepreneurship and innovation in a metropolis: Education and policy implications in Hong Kong. Journal of Product Innovation Management, 39(4): 489–491. https://doi.org/10.1111/jpim.12636

[19] Wang, B. (2022). Exploration of the path of innovation and entrepreneurship education for college students from the perspective of mental health education. Journal of Healthcare Engineering, 2022: 2659160. https://doi.org/10.1155/2022/2659160

[20] Zeng, W., Qin, F., Li, L., Li, Y., Bai, N. (2022). Ecosystem of innovation and entrepreneurship education in universities based on cloud computing. In 2021 International Conference on Big Data Analytics for Cyber-Physical System in Smart City, pp. 737–745. https://doi.org/10.1007/978-981-16-7469-3_82

[21] Sun, X. (2022). Financial management system for undergraduate innovation and entrepreneurship education based on grid algorithm. In Innovative Computing: Proceedings of the 4th International Conference on Innovative Computing (IC 2021), pp. 1517–1522. https://doi.org/10.1007/978-981-16-4258-6_188
[22] Yang, F. (2022). Random matrix model for the ecological model of innovation and entrepreneurship education for college students. Mathematical Problems in Engineering, 2022: 2103614. https://doi.org/10.1155/2022/2103614
[23] Sun, Y. (2022). Design and application of collaborative experiment management platform for innovation and entrepreneurship education based on an intelligent sensor network. Journal of Sensors, 2022: 9542280. https://doi.org/10.1155/2022/9542280
[24] Luo, J. (2021). Information-based education in college students' guidance of innovation and entrepreneurship. In Frontier Computing: Proceedings of FC 2020, Singapore, pp. 1621–1627. https://doi.org/10.1007/978-981-16-0115-6_188
[25] Tian, S. (2021). Female university students' innovation and entrepreneurship education model in the information age. In 2020 International Conference on Applications and Techniques in Cyber Intelligence: Applications and Techniques in Cyber Intelligence (ATCI 2020), Fuyang, China, pp. 945–949. https://doi.org/10.1007/978-3-030-53980-1_138
[26] Yi, J., Cui, X. (2022). Deep learning BP neural network guided evaluation of students' innovation and entrepreneurship education. Journal of Robotics, 2022: 2425069. https://doi.org/10.1155/2022/2425069
[27] Wu, X., Qin, Z. (2022). Multivariate statistical analysis of quality improvement effect of innovation and entrepreneurship education based on random matrix theory. Mathematical Problems in Engineering, 2022: 3789315. https://doi.org/10.1155/2022/3789315
[28] Gou, C. (2022). An integrated CoCoSo-CRITIC-based decision-making framework for quality evaluation of innovation and entrepreneurship education in vocational colleges with intuitionistic fuzzy information. Mathematical Problems in Engineering, 2022: 6071276. https://doi.org/10.1155/2022/6071276
[29] Zhang, W. (2022). Quality improvement of college students' innovation and entrepreneurship education based on big data analysis under the background of cloud computing. Scientific Programming, 2022: 8734474. https://doi.org/10.1155/2022/8734474

7 Author

Mingzhe Niu, female, now a doctoral student and associated professor at the Innovation and Entrepreneurship school of the Zibo Vocational College of China, chief of the Innovation and Entrepreneurship Teaching Research Office, and director of the Entrepreneurship Research Institute; dedicated in the research of innovation and entrepreneurship education, education management, and international education of Chinese language for more than 20 years; writer of more than 10 published papers and 2 monographs, and host of 5 municipal-level and above scientific research programs.

Article submitted 2023-02-07. Resubmitted 2023-04-08. Final acceptance 2023-04-11. Final version published as submitted by the authors.