Hindawi
Security and Communication Networks
Volume 2023, Article ID 9831438, 1 page
https://doi.org/10.1155/2023/9831438

Retraction

Retracted: Cultivation of Students' Independent Learning Ability in Teaching Chinese as a Foreign Language Based on the CDIO Model of Guiding Data Structures and Hidden Markov Algorithms

Security and Communication Networks

Received 17 October 2023; Accepted 17 October 2023; Published 18 October 2023

This article has been retracted by Hindawi following an investigation undertaken by the publisher [1]. This investigation has uncovered evidence of one or more of the following indicators of systematic manipulation of the publication process:

(1) Discrepancies in scope
(2) Discrepancies in the description of the research reported
(3) Discrepancies between the availability of data and the research described
(4) Inappropriate citations
(5) Incoherent, meaningless and/or irrelevant content included in the article
(6) Peer-review manipulation

The presence of these indicators undermines our confidence in the integrity of the article's content and we cannot, therefore, vouch for its reliability. Please note that this notice is intended solely to alert readers that the content of this article is unreliable. We have not investigated whether authors were aware of or involved in the systematic manipulation of the publication process.

In addition, our investigation has also shown that one or more of the following human-subject reporting requirements has not been met in this article: ethical approval by an Institutional Review Board (IRB) committee or equivalent, patient/participant consent to participate, and/or agreement to publish patient/participant details (where relevant).

Wiley and Hindawi regrets that the usual quality checks did not identify these issues before publication and have since put additional measures in place to safeguard research integrity.

We wish to credit our own Research Integrity and Research Publishing teams and anonymous and named external researchers and research integrity experts for contributing to this investigation.

The corresponding author, as the representative of all authors, has been given the opportunity to register their agreement or disagreement to this retraction. We have kept a record of any response received.

References

[1] Y. Wen and S. Peng, "Cultivation of Students' Independent Learning Ability in Teaching Chinese as a Foreign Language Based on the CDIO Model of Guiding Data Structures and Hidden Markov Algorithms," *Security and Communication Networks*, vol. 2022, Article ID 7114217, 7 pages, 2022.

Hindawi
Security and Communication Networks
Volume 2022, Article ID 7114217, 7 pages
https://doi.org/10.1155/2022/7114217

WILEY | Hindawi

Research Article

Cultivation of Students' Independent Learning Ability in Teaching Chinese as a Foreign Language Based on the CDIO Model of Guiding Data Structures and Hidden Markov Algorithms

Ye Wen and Shuang Peng

College of Arts, Northeast Normal University, Changchun 130024, China

Correspondence should be addressed to Ye Wen; weny459@nenu.edu.cn

Received 27 May 2022; Accepted 22 July 2022; Published 31 August 2022

Academic Editor: Hangjun Che

The systematic training of metacognitive strategies in teaching Chinese as a foreign language, cultivating learners' autonomous learning ability, and improving the effectiveness of teaching Chinese as a foreign language is of great significance for realizing the overall goal of teaching Chinese as a foreign language. Therefore, this paper designs a model based on CDIO to guide the teaching of data structures and algorithms, which emphasizes students' hands-on ability, advocates learning in use, students' autonomous learning, and teamwork. Taking massive online open courses(MOOC) and small private online courses (SPOC) learning data as a sample, hidden Markov algorithm and data mining technology are used to establish a student learning behavior evaluation model to evaluate students' learning behavior in real-time. Meanwhile, teachers adjust the teaching content according to the evaluation results and enhance students' learning performance and improve teaching quality.

1. Introduction

As the world enters the twenty-first century, with the information age and economic globalization, language science has become more and more important. The rapid development of China's economy and its international status in the past 20 years, as well as the vast market demand, have forced both developed and developing countries to deal with China for their peace and development and national interests, and their efforts to learn Chinese are also aimed at establishing an in-depth understanding of China [1].

In Asia, Japan has been one of the hottest countries for Chinese language teaching, almost every university has a Chinese language course, and Chinese has become one of the optional foreign languages in the college entrance examination for secondary school students [2]. In South Korea, China's closest neighbor, more than one million people are learning Chinese, two-thirds of the more than 300 universities have Chinese language courses, and language institutes for learning Chinese are located in all major cities [3].

We can foresee that with the strong development of China and the accelerated development of economic globalization, we can further build a broad bridge of economic and cultural exchanges and people-to-people contact between China and foreign countries [4].

The teaching of Chinese as a second language to foreigners is not only to cultivate the communicative ability of Chinese but also to master the ability to use Chinese to listen, read, write and communicate and to shoulder the responsibility and mission of spreading Chinese culture [5].

Learner-directed learning has become a consensus in the field of language teaching, and learning-centeredness has gradually become the guiding ideology of second language teaching. The learner's subjectivity has not been fully appreciated and reflected. Only when we shift the focus of our research from "how teachers teach" to "how students learn" can we solve the problem of "how teachers teach" in a targeted way, and only then can we better improve learners' learning [6]. It is possible to better improve the learning efficiency of learners.

Therefore, in learning Chinese as a foreign language, it is meaningful to study students' learning, focus on learners, and cultivate the learning ability of foreign Chinese learners [7]. In classroom teaching, teachers tend to focus on cognitive strategies that are closely related to specific learning contents and tasks but neglect metacognitive strategy training, which makes it difficult to improve learners' strategy awareness and strategy application, and may lead to low learning efficiency [8]. The cultivation of learners' independent learning ability is one of the goals of the effectiveness of teaching Chinese as a foreign language, to achieve the overall goal of the international Chinese teaching curriculum and to realize the international promotion of the Chinese language [9].

A landmark achievement of the CDIO engineering education model is the introduction of the curriculum syllabus. The outline is a guiding document for CDIO engineering education, which specifies the objectives, contents, and specific operating procedures of the CDIO engineering education model in detail. Based on the Hidden Markov Chain Model (HMM), the evaluation index of students' learning behavior in teaching Chinese as a foreign language is constructed, and the final evaluation score of students' learning behavior is formed by combining the analytic hierarchy process.

2. Related Work

The ability of self-directed learning can be cultivated through various means. Researchers at home and abroad have been trying to find various ways to cultivate independent learning ability by conducting experiments and studies from various perspectives such as psychology, metacognitive theory, constructivism, and social cognitive theory [10]. At present, in the domestic foreign language teaching English, experts and scholars have commonly studied the cultivation of learners' autonomous ability, and many teachers, including primary and secondary schools and universities, have conducted research in their teaching practice and achieved good results. Lack of attention to the main role of students in teaching Chinese second language is a problem need to be solved.The independent learning of Chinese language of students can be realizedby a new learning pattern of "teacher-led and student-centered combining with equal attention in and outof the classroom" [11–13]. Researchers discussed the necessity of incorporating independent reading outside the classroom into reading instruction and analyzed the effectiveness of this classroom teaching model [14, 15]. The demotivation and motivation study demonstrates that pedagogical means and methods by bridging the gap between researchers and educational practitioners are essential in learning Chinese as a foreign language.

Teachers also need to strengthen instruction in learning strategies in a variety of ways. Teachers should present a range of learning strategies that students must master for them to understand and use [16]. The following are common approaches that teachers can use in teaching a second foreign language. Teachers can guide students to develop specific, detailed plans and identify specific activities and schedules related to their learning goals. They can also guide students to write down their learning process, methods, and experiences in a variety of appropriate ways, to self-evaluate and self-monitor their learning and to adjust their learning methods and strategies for the next stage accordingly [17, 18]. When doing exercises, pay attention to the ideas and techniques for solving various types of frequently tested questions and learn and master test-taking strategies and methods. Teachers should also guide students to make full use of resources, learn to create and grasp opportunities to use the target language, be good at using body language to improve the communicative effect, and guide the use of Internet resources for learning [19].

In this paper, a CDIO-based model is designed to guide the teaching of data structures and algorithms. Taking the MOOC + SPOC learning data of our school as a sample, the hidden Markov algorithm and data mining technology are used to establish a student learning behavior evaluation model and real-time evaluation of students' learning behavior. Learning behavior: teachers adjust teaching content according to the evaluation results and intervene in students' learning behavior to improve teaching quality. That is, it emphasizes students' practical ability and advocates learning bydoing students' independent learning, and teamwork.

3. The Guiding Principle of the CDIO Model in Teaching

The CDIO model for teaching data structures and algorithms is based on how to combine the course with practical cases to improve students' hands-on skills. The main aspects are as follows.

3.1. Emphasis on Practical and Hands-On Skills. The main idea of the CDIO model is to focus on practice and operation. Only when the teaching data structure and algorithm is combined with actual cases the practical and hands-on ability can be reflected under the guidance of theory. A large number of cases will greatly improve the practical and hands-on ability [20].

3.2. Promote Independent Learning and Problem Solving. The CDIO model is a prerequisite and foundation for developing students' independent skills, and we should strive to improve the efficiency of teaching data structures and algorithms. Generally speaking, it is possible to use to arrange students' independent learning by listing knowledge points. Teachers must master the main points of knowledge and recommend some required reading to students, while students are required to track themselves and read the literature. One can also learn to learn by comparison. Encourage students not to blindly believe in textbooks but to understand why this view is mainstream and classical and why all other views are gradually being eliminated in practice, by actually comparing them to what was thought at the time and what was the way of understanding without distinction. The most important thing is the brainstorming method. The teacher participates equally in the students' discussion and addresses a point of knowledge, and teachers and students freely present their views, allowing students to analyze themselves afterward, stimulating their thinking, and deepening their understanding of the point.

3.3. Professional Competence and Teamwork. The model recognizes the imbalance of competencies in the study team and emphasizes the best model to equip the study team to explore the competencies of the students. During learning and discussion, group members' performance should be recorded, and the best organizers and implementers should be selected through three to five rounds of observation of student readiness and mutual assessment. In a research team, it is not only important to ensure that the research direction does not deviate but also to allow members to have a process of meeting ideas, through debate, so that new ideas and new thoughts can be generated, taking into account economic performance, social impact, simplifying and streamlining as much as possible, emphasizing user interface intuition and ease of operation.

4. Research Framework

The assessment of student learning behavior status in this study was based on data from student learning trajectories on the MOOC + SPOC platform. HMM was used to obtain the student learning status matrix, and then the scores were calculated based on the learning behavior data evaluation method, i.e., the corresponding learning evaluation scores. Historical judgment data of more than two consecutive weeks are retained, and student learning state trends and continuous period student learning behavior evaluation scores are calculated based on these data. The HMM algorithm is used to map the observed state student learning state data to hidden state trends, and the Viterbi algorithm is used to solve for future time student learning behavior change trends and learning evaluation scores. The hidden state and continuous period of student learning behaviors are used as inputs for the process shown in Figure 1.

4.1. Framework Model HMM Model. Since students' learning states are more likely to be disturbed by various factors, such as the surrounding environment, psychological state, physiological cycle, and many other factors, this makes the change of students' learning states a typical random process. At the same time, the change in students' learning state is generally associated with the state of the previous period only. If it is determined by the previous state only, it is a first-order Markov model, and if it is influenced by several previous time states at the same time, it is an n-order Markov model. In Reference [21], a Markov model describes an important class of stochastic processes, which is a stochastic function that varies with time.

In a Markov model, each state represents an observable event, which limits the use of the model to certain states where the event is not easily observable [22]. For teaching, a teacher may want to determine the next state of a student's learning behavior by looking at the student's online learning, questioning, and correctness of assignments when the next state is not yet present. This algorithm is known as HMM which predicts students' next learning state by observing their usual learning process data and the Markov hypothesis. [23].

One of the basic assumptions in HMM model is the assumption of the chi-square Markov chain, that is, the hidden state at any moment depends only on the hidden state at the previous moment.

The model obtains the probability of each observation by the current state where b_{ij} represents the probability that at any moment t, if the state is S_i, then the observation is O_j.

There are three problems in the HMM model: first is the evaluation problem, given an HMM, i.e., $\lambda = [A, B, \pi]$, to calculate the probability of sequence; second is the decoding problem,given an HMM, i.e., $\lambda = [A, B, \pi]$, to find the optimumsequence ofstates to a sequence of observations .

For the problem of early prediction and timely intervention of students' learning behavior, it is the learning problem and decoding problem of HMM. The learning problem is solved by the EM algorithm, and the decoding problem is solved by the Viterbi algorithm based on dynamic programming. Using the parametric model $\lambda = [A, B, \pi]$ derived from the EM algorithm and the existing observed sequence of student learning states $O = \{O_1, O_2, \ldots, O_T\}$, the most likely sequence of student learning behavior states $I^* = \{i_1^*, i_2^*, \ldots, i_T^*\}$, i.e., $P(I^*|O)$ is to be maximized under the given conditions.

4.2. Evaluation Indexes of Student Learning Behavior Analysis. According to the construction ideas and methods of online teaching quality evaluation indexes at home and abroad, the overall evaluation indexes are divided into 2 primary indexes and 6 secondary indexes, as shown in Table 1.

The matrix was constructed using hierarchical analysis to obtain the weights. The indicators at the same level were assigned with the Starr relative importance scale (9 levels) to form a judgment matrix. Take the secondary index of learning attitude as an example, Table 2 shows its importance scale, in which the parameter levels are obtained from student questionnaires and expert ratings in reference literature [24–26].

The single-sort judgment matrix is obtained at this level:

$$B = \begin{bmatrix} 1 & 1/5 & 1/3 & 1/3 \\ 5 & 1 & 3 & 2 \\ 3 & 1/3 & 1 & 2 \\ 3 & 1/2 & 1/2 & 1 \end{bmatrix}. \tag{1}$$

Due to possible biases in perceptions, the design of student learning behavior index weights may have inconsistent biases. Therefore, we conducted a consistency test based on the hierarchical analysis method (AHP). The test formula is as follows:

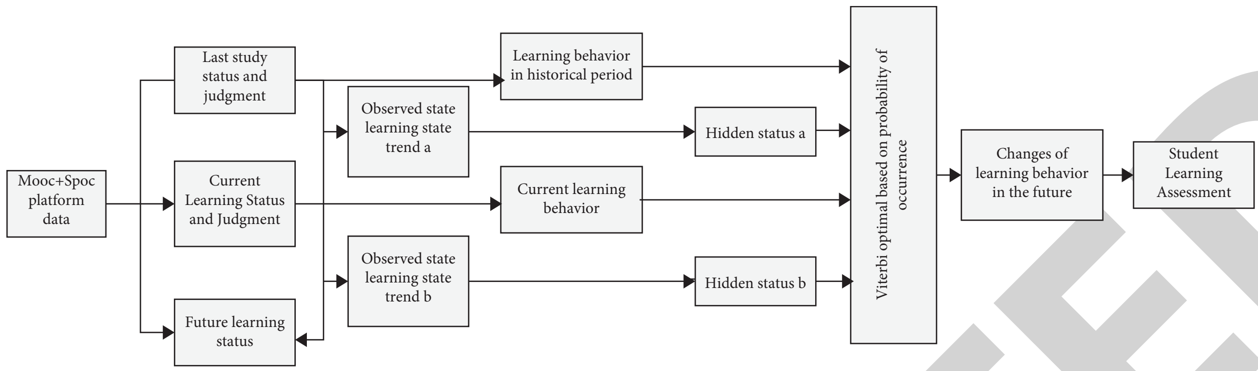

Figure 1: Block diagram of the learning behavior assessment.

Table 1: Overall evaluation indexes of learning behavior.

Primary indicators	Secondary indicators	Evaluation criteria
Learning attitude	Course access	Number of visits to the course platform
	Course learning	Length of course study, length of videos watched
	Online interaction	The number of effective postings and discussions by students
	Interaction with teachers	Students' questions, teachers' answers, and discussions
Professional ability	Assignment completion rate	The ratio of the number of completed assignments to the total number of assignments
	Assignment pass rate	The ratio of the number of graded homework questions to the total number of questions

Table 2: Importance ranking of secondary indicators of learning attitudes.

	1.1 course access	1.2 course learning	1.3 online interaction	1.4 interaction with teachers
1.1 course access	5	1/3	1/3	1/5
1.2 course learning	3	5	3	3
1.3 online interaction	3	1/3	1/3	3
1.4 interaction with teachers	1	1/3	1/3	1

$$CR = \frac{CI}{RI}, \tag{2}$$

where RI is the average random consistency index (see Table 3 for the values of RI).

When $CR \leq 0.1$, it means that the consistency test is passed and the design can be carried out according to the results of the matrix representation; when $CR > 0.1$, it means that the deviation of the judgment matrix is too large and there are contradictions in the process, and the scoring needs to be modified and reconstructed until the consistency is satisfied. This hierarchical single ranking matrix is calculated to know $\mathrm{CR} = 0.048 \leq 0.1$; therefore, it passes the test [27]. In this paper, we also used AHP to test the other dimensional indicators. In this paper, the other dimensional indicators were also tested by AHP, and they all passed the consistency test, and the weights of the indicators at each level were calculated, and the total ranking of the hierarchy was thus calculated, as shown in Table 4.

5. Research Object

The key to the study of learning behavior analysis is as follows: first, to score the indicators for evaluating learning behavior in order to obtain the current state (current week) learning behavior evaluation; second, to obtain the related behaviors (such as learning attitude, learning initiative, and learning effect) that reflect the learning behavior state in order to judge the trend of learning state change and then to predict the learning behavior state change according to the HMM model [28]. The formulation of this problem in the Hidden Markov Model for each parameter variable set is as follows.

The set of hidden variables (learning behavior) is as follows:

Learning attitude state set

$$I_s = \{i_1 = 1 = \text{“Active”}, i_2 = 0 = \text{“General”}\}. \tag{3}$$

Learning initiative state set

$$I_a = \{i_1 = 1 = \text{“Proactive”}, i_2 = 0 = \text{“Passive”}\}. \tag{4}$$

Learning effect status set

$$I_r = \{i_1 = 1 = \text{“Good”}, i_2 = 0 = \text{“General”}\}. \tag{5}$$

Set of observed variables (learning states) is as follows.

The set of learning attitude events $O_s = \{o_1 = 1 = $ "time to watch video" $\geq a_1$ and "number of times to hand in notes" $\geq b_1, o_2 = 0 =$ "time to watch video" $< a_1$ and "number of times to hand in notes" $< b_1\}$.

Table 3: RI values of judgment matrices of various orders.

Determine the matrix order n	1	2	3	4	5	6	7	8	90
RI value	0	0	0.55	0.92	1.10	1.26	1.35	1.44	1.47

Table 4: Total weights of learning behavior evaluation indicators.

Secondary indicators		Primary indicators: Learning attitude 0.675	Primary indicators: Professional ability 0.325	Total ranking of secondary indicators
Learning attitude	Course access	0.078		0.055
	Course learning	0.455		0.305
	Online interaction	0.264		0.178
	Interaction with teachers	0.209		0.141
Professional ability	Assignment completion rate		0.675	0.223
	Assignment pass rate		0.332	0.112

Learn the active event set:

$$O_a = \left\{ \begin{array}{l} o_1 = 1 = \text{“number of proactive and answer session, interactions”} \geq c_1 \\ o_2 = 1 = \text{“number of proactive and answer session, interactions”} < c_1 \end{array} \right\}. \quad (6)$$

Learning effect event set:

$$O_r = \left\{ \begin{array}{l} o_1 = 1 = \text{“assignment test scores”} \geq \mathrm{d}_1 \\ o_2 = 1 = \text{“assignment test scores”} < d_1 \end{array} \right\}. \quad (7)$$

In the specific experimental process, first, the data were transformed into a learning attitude dataset, learning initiative dataset, and learning effect dataset according to the definition of the observed dataset; then, the parameters of the student learning behavior model were obtained using the observed dataset in weeks 1–5 using the EM algorithm, and the obtained parametric model was applied to the observed dataset in weeks 6–9 for model validation. The model parameters and observed student data were then used to predict student learning behaviors over the next 10–15 weeks, and the weekly predictions were used to disrupt some students' learning [29, 30].

6. HMM Model Parameters Calculation

The solution to HMM model parameters is divided into two cases. The EM iterations are then performed until the values of the model parameters converge. The algorithm proceeds as follows:

One is to randomly initialize all $\pi_i, a_{ij}, b_j(k)$.

Second, for each sample $\mathrm{d} = 1, 2, \ldots, D$, the backward and forward algorithm is used to compute $r_t^{(d)}(i), \xi_t^{(d)}(i, j), t = 1, 2, \ldots, T$

Third, update the model parameters:

$$\begin{aligned} \pi_i &= \frac{\sum_{d=1}^{D} r_1^{(d)}(i)}{\mathrm{D}}, \\ a_{ij} &= \frac{\sum_{d=1}^{D} \sum_{t=1}^{T-1} \xi_t^{(d)}(i, j)}{\sum_{d=1}^{D} \sum_{t=1}^{T-1} r_1^{(d)}(i)}, \\ b_j(k) &= \frac{\sum_{d=1}^{D} \sum_{t=1}^{T-1} \mathrm{O}_t^{(d)} = v_k r_t^{(d)}(i)}{\sum_{d=1}^{D} r_1^{(d)}(i)}. \end{aligned} \quad (8)$$

Fourth, if the value of $\pi_i, a_{ij}, b_j(k)$ has converged, the algorithm is finished; otherwise, go back to the second step to continue the iteration.

The HMM parameters π, A, and B of learning attitude, learning initiative, and learning effect obtained by iteration are shown in Table 5.

7. Experimental Results

The prediction results of the scheme in this paper are shown in Table 6, where $W6, W7, W8,$ and $W9$ denote weeks 6, 7, 8, and 9, and the values in Table 6 are the probabilities of transferring states.

The prediction results obtained from the model were compared with the actual student results in weeks 6–9. Figure 2 shows the comparison of the HMM prediction results. The learning motivation prediction result shows that the HMM misfit rate is 3%, the learning method prediction result shows that the HMM misfit rate is 2.668%, and the learning effect prediction result shows that the HMM misfit rate is 1.335%.

Table 5: HMM model parameters.

Learning attitude	$\pi = [01], A = \begin{bmatrix} 0.68 & 0.32 \\ 0.57 & 0.43 \end{bmatrix}, B = \begin{bmatrix} 0.84 & 0.16 \\ 0.22 & 0.78 \end{bmatrix}$
Learning initiative	$\pi = [01], A = \begin{bmatrix} 0.85 & 0.15 \\ 0.19 & 0.81 \end{bmatrix}, B = \begin{bmatrix} 0.76 & 0.24 \\ 0.21 & 0.79 \end{bmatrix}$
Learning effectiveness	$\pi = [01], A = \begin{bmatrix} 0.91 & 0.09 \\ 0.10 & 0.90 \end{bmatrix}, B = \begin{bmatrix} 0.82 & 0.18 \\ 0.25 & 0.75 \end{bmatrix}$

Table 6: HMM prediction results.

Predicted results	$W6$	$W7$	$W8$	$W9$
Learning attitude	0.69/0.35	0.6427/0.3449	0.6355/0.3585	0.6327/0.3575
Learning initiative	0.89/0.17	0.7512/0.2497	0.6862/0.3145	0.6431/0.3587
Learning effectiveness	0.92/0.12	0.8287/0.1632	0.7539/0.2213	0.6862/0.2672

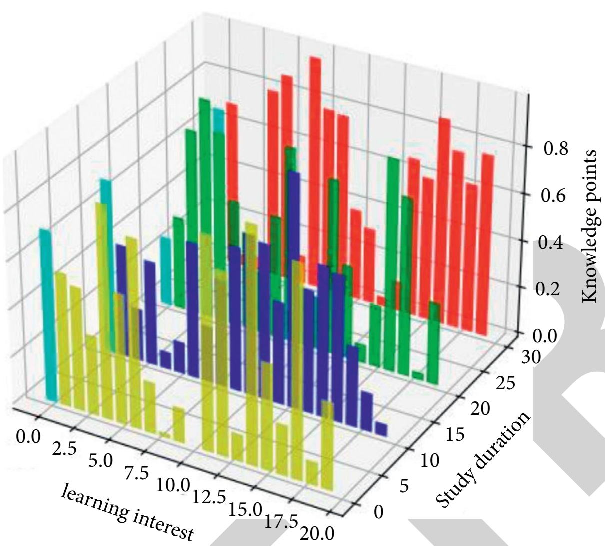

Figure 2: Comparison of HMM prediction results.

The validity of the model was judged by the consistency of the results. Students' scores were calculated according to the weights of student learning behavior evaluation indexes, and the predicted results were verified with the actual results for consistency, and the calibration results are shown in Table 7.

The validation analysis of the model shows that the HMM prediction model established in this paper has a certain validity.

After 4 weeks, the learning behaviors of the two groups were compared and analyzed to see if the performance of the group of students who had been disturbed by the teacher improved compared to the group of students who had not been disturbed by the teacher. The results of the learning evaluation comparison shown in Table 7, where the learning evaluation scores were calculated based on the learning evaluation indicators, and demonstrate effectiveimprovement of students‘ Chinese learningperformance.

Table 7: Comparison of calculation results.

	1–5 weeks	6–9 weeks
Average of predicted results	77.9	79.85
Average of actual results	84.22	85.69
Consistency	91.97%	93.56%

8. Conclusion

In this paper, the evaluation indexes of students' learning behaviors in teaching Chinese as a foreign language were constructed based on the Hidden Markov Chain Model and combined with the hierarchical analysis method to form the final evaluation scores of students' learning behaviors. Based on the comprehensive scores, we determine the current state of students' learning behavior, predict the trend of students' learning behavior changes with the help of the Hidden Markov Model, and realize the early warning of students' learning behavior state, so that teachers can take disturbing measures in time to achieve the purpose of dynamic monitoring and improving students' learning state.

Data Availability

The experimental data used to support the findings of this study are available from the corresponding author upon request.

Conflicts of Interest

The authors declare that they have no conflicts of interest regarding this work.

Acknowledgments

This work was supported by The National Social Science Fund of China (No. 20BYY057) and the Major Program of International Chinese Education of Center for Language Education and Cooperation of Chinese Ministry of Education (No. 21YH01A).

References

[1] L. Xu, "The Analyses on Culture Identity in Chinese Cultural Economy under the Banckground of Globaliazaition," *International Cultural Administration*, vol. 29, pp. 103–116, 2013.

[2] J. W. Chen, X. K. Sigalingging, J. S. Leu, and J. I. Takada, "Applying a hybrid sequential model to Chinese sentence correction," *Symmetry*, vol. 12, no. 12, p. 1939, 2020.

[3] Y. J. Yang and H. Shih-Chang, "On the types of Chinese-related departments at the higher education level in South Korea:with universities in the seoul area as the example," *Journal of International Chinese Teaching*, vol. 2, pp. 49–64, 2018.

[4] X. U. Lanyue and L. Huang, "The Development of Headquarters Economy from Overseas Experiences and its Enlightenment to china," *Science and Technology Management Research*, vol. 34, no. 16, pp. 104–108, 2014.

[5] C. Shei, "From 'Chinese to foreigners' to 'Chinese international education': China's efforts in promoting its language worldwide," in *The Routledge Handbook of Chinese Language Teaching*, pp. 32–46, Routledge, Oxfordshire, England, UK, 2019.

[6] M. Burns, E. Pierson, and S. Reddy, "Working together: how teachers teach and students learn in collaborative learning environments," *International Journal of Instruction*, vol. 7, no. 1, 2014.

[7] W. Diao and H. Y. Liu, "Starting college, quitting foreign language: the case of learners of Chinese language during secondary-postsecondary transition," *Journal of Language, Identity and Education*, vol. 20, no. 2, pp. 75–89, 2021.

[8] M. F. Teng, "The benefits of metacognitive reading strategy awareness instruction for young learners of English as a second language," *Literacy*, vol. 54, no. 1, pp. 29–39, 2020.

[9] M. Cáceres-Lorenzo, "Teenagers learning Chinese as a foreign language in a European Confucius Institute: the relationship between language learner strategies and successful learning factors," *Language Awareness*, vol. 24, no. 3, pp. 255–272, 2015.

[10] Y. Du, "Study on cultivating college Students' English autonomous learning ability under the flipped classroom model," *English Language Teaching*, vol. 13, no. 6, p. 13, 2020.

[11] R. Bao and X. Du, "Learners' l1 use in a task-based classroom: learning Chinese as a foreign language from a sociocultural perspective," *Journal of Language Teaching and Research*, vol. 6, no. 1, p. 12, 2015.

[12] R. Bao and X. Du, "Implementation of task-based language teaching in Chinese as a foreign language: benefits and challenges," *Language Culture and Curriculum*, vol. 28, no. 3, pp. 291–310, 2015.

[13] Y. Lin, "The study on the teaching of Chinese as a foreign language basic on the learning style preferences and national personality between south Korean students and Japanese students," *Journal of Chinese Humanities*, vol. 67, pp. 169–181, 2017.

[14] M. Grenfell and V. Harris, "Memorisation strategies and the adolescent learner of Mandarin Chinese as a foreign language," *Linguistics and Education*, vol. 31, no. 4, pp. 1–13, 2015.

[15] G. Xie, "A study of demotivators in Chinese university's English as a foreign language teaching and learning," *Higher Education Research*, vol. 5, no. 4, p. 143, 2020.

[16] Satoko, Sugie, Makoto, and Mitsugi, "The practice of blended learning with distance learning for Chinese as a foreign language and the evaluation with mix methods data analysis," *Transactions of Japanese Society for Information and Systems in Education*, vol. 32, no. 2, pp. 160–170, 2015.

[17] X. Lu, Y. Zheng, and W. Ren, "Motivation for learning Spanish as a foreign language: the case of Chinese l1 speakers at university level," *Círculo de Lingüística Aplicada a la Comunicación*, vol. 79, pp. 79–98, 2019.

[18] X. Xie, X. Pan, F. Shao, W. Zhang, and J An, "MCI-Net: multi-scale context integrated network for liver CT image segmentation," *Computers & Electrical Engineering*, vol. 101, Article ID 108085, 2022.

[19] S. Zhang, "Chinese-as-a-foreign-language learners' use of self-regulated learning in flipped/blended learning environments – a descriptive study," *Studies in Self-Access Learning Journal*, vol. 10, no. 2, pp. 181–204, 2019.

[20] D. Song, "Comparison of CDIO and Chinese engineering education accreditation for animation specialty of TUST," *Procedia Computer Science*, vol. 131, pp. 765–770, 2018.

[21] M. Khadr, "Forecasting of meteorological drought using Hidden Markov Model (case study: the upper Blue Nile river basin, Ethiopia)," *Ain Shams Engineering Journal*, vol. 7, no. 1, pp. 47–56, 2016.

[22] C. M. Chen, D. J. Guan, Y. Z. Huang, and Y. H. Ou, "Anomaly network intrusion detection using hidden Markov model," *Int. J. Innov. Comput. Inform. Control*, vol. 12, pp. 569–580, 2016.

[23] S. Boumi and A. Vela, "Application of Hidden Markov Models to Quantify the Impact of Enrollment Patterns on Student Performance," *Proceedings of The 12th International Conference on Educational Data Mining*, pp. 264–269, 2019.

[24] Q. Liu, C. Liu, and Y. Wang, "Integrating external dictionary knowledge in conference scenarios the field of personalized machine translation method [J]," *Journal of Chinese Informatics*, vol. 33, no. 10, pp. 31–37, 2019.

[25] R. Ali, M. H. Siddiqi, and S. Lee, "Rough set-based approaches for discretization: a compact review," *Artificial Intelligence Review*, vol. 44, no. 2, pp. 235–263, 2015.

[26] R. Ali, S. Lee, and T. C. Chung, "Accurate multi-criteria decision making methodology for recommending machine learning algorithm," *Expert Systems with Applications*, vol. 71, pp. 257–278, 2017.

[27] S. Nagi Alsubari, S. N. Deshmukh, A. Abdullah Alqarni, N. Alsharif, T. H. H. Aldhyani, and F. O. Waselallah Alsaade, "Data analytics for the identification of fake reviews using supervised learning," *Computers, Materials & Continua*, vol. 70, no. 2, pp. 3189–3204, 2022.

[28] S. S. Seyhan, F. N. Alpaslan, and M. Yavaş, "Simple and complex behavior learning using behavior hidden Markov model and CobART," *Neurocomputing*, vol. 103, pp. 121–131, 2013.

[29] H. Chen, Y. Dai, H. Gao, D. Han, and S. Li, "Classification and analysis of moocs learner's state: the study of hidden Markov model," *Computer Science and Information Systems*, vol. 16, no. 3, pp. 849–865, 2019.

[30] H. Jingchao and H. Zhang, "Recognition of classroom student state features based on deep learning algorithms and machine learning," *Journal of Intelligent and Fuzzy Systems*, vol. 40, no. 2, pp. 2361–2372, 2021.