SIN-CHN SCIENTIFIC PRESS PTE.LTD.

Molecular & Cellular Biomechanics 2025, 22(2), 1021.
https://doi.org/10.62617/mcb1021

Article

Optimization of international talent training program in biological and biomechanical field of Shaanxi universities by integrating Transformer-GRU model under the "Belt and Road" initiative

Jinchao Chen

School of Literature and Media, Xi'an Fanyi University, Xi'an 710105, China; chenjinchao78@163.com

CITATION

Chen J. Optimization of international talent training program in biological and biomechanical field of Shaanxi universities by integrating Transformer-GRU model under the "Belt and Road" initiative. Molecular & Cellular Biomechanics. 2025; 22(2): 1021. https://doi.org/10.62617/mcb1021

ARTICLE INFO

Received: 5 December 2024
Accepted: 12 December 2024
Available online: 22 January 2025

Abstract: In the field of biology of Shaanxi universities, there are problems such as insufficient internationalization of course content, limited internationalization level of teachers, and difficulty in meeting the personalized needs of students' foreign language ability. To this end, under the Belt and Road Initiative, this paper proposes an intelligent solution based on Transformer and GRU (Gated Recurrent Unit) models, aiming to improve the quality of international education in the field of biology of universities by optimizing course content and teaching methods. This study first uses the Transformer model to integrate and analyze a large number of international education resources, identify global cutting-edge knowledge and cross-cultural education elements in biology courses, including biomechanical principles that underpin biological functions and interactions. This provides scientific support for the optimization of course content. At the same time, the GRU model is used to dynamically analyze the progress of teachers' international teaching and students' learning feedback. Just as organisms can adjust their metabolic rate according to the changes in the environment, the model automatically adjusts the pace and difficulty of the subsequent teaching content according to the students' speed of mastery and difficulties in understanding biomechanics knowledge, ensuring that each student can keep up with the pace of teaching. Additionally, the integration of biomechanical concepts into the curriculum helps students understand the mechanical properties and behaviors of biological systems, fostering interdisciplinary thinking and enhancing their global vision. Experimental results show that the students in Class A who adopt this research program are significantly better than the control Class B in terms of knowledge mastery, interdisciplinary thinking, and global vision ($P < 0.05$); after the experiment, the average foreign language ability score of the students in Class A is 7.04 points higher than that of Class B; the overall satisfaction of the students in Class A with the new teaching program is as high as 82.5%. This paper, based on the combination of Transformer and GRU models, can effectively promote the international talent training process of biology majors in Shaanxi universities, particularly by incorporating biomechanical insights, thereby enhancing the competitiveness of this major in global academic and scientific research cooperation.

Keywords: The Belt and Road; gated recurrent unit; Transformer model; biological field; biomechanics; international talent training; program optimization

1. Introduction

The internationalization of higher education is an important research topic worldwide. In this process, there are both the development laws of universities themselves and the needs of external competition. The "Belt and Road" has become China's conception of promoting common development in the world and building a community with a shared future for mankind [1–3]. With more and more global

exchanges, to meet the requirements for international talents, universities should focus more on the training of international talents, thereby opening up a new path for international cooperation in higher education. As an important region along the "Belt and Road", Shaanxi Province has a superior geographical location, rich biological resources, and strong scientific research capabilities. It is gradually becoming an essential window to western China. There are many problems in the biological field of Shaanxi universities in terms of talent training quality, promoting internationalized teaching, and keeping pace with the international community. To cultivate compound talents that meet the needs of global biological research and industry, Shaanxi universities need to integrate new technologies, innovate educational models, and cultivate interdisciplinary talents with a solid biological foundation and proficient in applying advanced technologies.

With its excellent self-attention mechanism, the Transformer model can efficiently extract core information from massive cross-cultural educational resources [4–6]. This is very important for universities and helps them adjust the setting of internationalized courses. The model can analyze the complexity of interdisciplinary course design, thereby precisely identifying the links that need to be strengthened in the course system, helping universities to improve the course structure more targetedly and broaden students' global vision. The GRU model has shown significant advantages in processing time series data [7,8]. It can continuously track students' learning trajectories and feedback, providing strong data support for implementing personalized education strategies. The organic integration of Transformer and GRU models can open up a new intelligent and personalized path for the international talent training of Shaanxi universities. This solution can not only help universities systematically optimize course content, but also improve students' foreign language skills and help schools stand out in the global education competition. At the same time, it breaks the shackles of the traditional education model, makes full use of the power of modern technology, and provides continuous support for the cultivation of talents with an international perspective in the field of biology in Shaanxi universities.

International talent cultivation in universities means cultivating talents with global vision, cross-cultural communication, and professional competitiveness through promoting the internationalization of education [9,10]. The internationalization of talent cultivation in the field of international higher education is a topic widely discussed by higher education institutions around the world. Lei [11] conducted a comparative study of higher education institutions and identified some differences in the internationalization of talent cultivation in different countries and regions. Xie [12] promoted knowledge sharing and cultural exchanges through academic exchanges, teacher visits, and other activities, improved the quality of education and teaching, and promoted the internationalization of education and teaching, laying a solid foundation for cultivating innovative talents. Ma [13] analyzed the current situation of international talent cultivation and Sino-foreign educational cooperation in agricultural universities, continuously expanded foreign exchanges and cooperation, and actively explored the international talent cultivation model. The "Belt and Road" initiative has promoted industrial integration and resource integration. Xu [14] aimed to explore a new talent cultivation model in which highly skilled international talents enhance mutual dependence through in-depth communication. Interdisciplinary and

integrated talent cultivation is an urgent need for social development. Hu [15] analyzed and summarized three types of multidisciplinary talent cultivation models in American universities, and proposed the design ideas of the curriculum system of China's international talent cultivation model. The most prominent problem in the process of economic globalization is the shortage of international talent. Xu [16] started from the problems existing in the practical teaching of international talent training in China and proposed corresponding solutions.

With its unique self-attention mechanism, the Transformer model has become an efficient deep learning tool that can help colleges and universities optimize curriculum settings and thus improve the quality of talent training [17]. Yang [18] developed a novel Transformer based on contextualized knowledge graphs, which could serialize entities and paths in meta-graphs into sequential inputs. Transformer-based transfer learning models have the potential to achieve high prediction accuracy with relatively few training data instances. To better use the Transformer model, Wankmuller [19] explained its benefits and limitations. Creating curiosity for learners in online learning is a challenging task. Mishra [20] proposed a hierarchical title generation method to automatically generate titles for given texts, mainly based on a pre-trained Transformer language model. Due to the dynamic and virtual environment and the personalized needs of different individuals, Wang [21] aimed to develop an effective prediction model for learning feature extraction, learning performance prediction, and result reasoning, and selected weighted pools in the new convolutional GRU network and Transformer model to predict learning performance. Mayer [22] used a prompt-based learning method and the Transformer model for classification tasks in specific fields, and fine-tuned the language model for a given classification task, which could better classify text for international learning content.

2. Optimization of international talent training programs in the biological field of Shaanxi universities

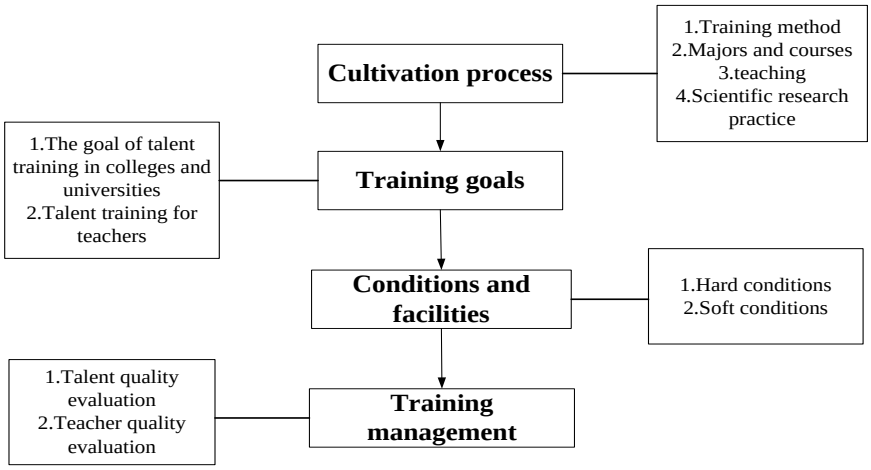

Figure 1. Schematic diagram of international talent training in colleges and universities.

Talent training under the "Belt and Road" initiative is actually an essential carrier for international talent training. Universities should better shoulder the mission of

cultivating first-class talents for the world [23–25]. China has unique conditions in constructing the "Belt and Road", especially in the field of higher education. Colleges and universities are important carriers for cultivating students, and the cultivation of talents is not static. On this basis, under the guidance of certain educational theories and methods, this paper gradually takes a steady and scientific path, as shown in **Figure 1**.

2.1. Internationalized course content

In the context of the rapid development of science and technology today, interdisciplinary talent training has become a major trend in higher education, especially in fields such as biology that are both complex and closely connected to other disciplines. Biology, a discipline that integrates experimental, theoretical and applied, is gradually blending with data science, artificial intelligence and other fields, giving birth to emerging interdisciplinary disciplines such as bioinformatics and environmental biology. In order to cultivate composite talents with an international perspective, the curriculum design of biology needs not only to deepen the content of this discipline, but also to effectively integrate with data science and other disciplines. This kind of interdisciplinary design aims to provide students with a broader knowledge perspective and help them master diverse skills and methods to better solve practical problems. The combination of biology and data science is particularly critical in interdisciplinary training. With the continuous deepening of research in genomics, proteomics, etc., the huge data generated in the field of biology can no longer be processed by traditional experimental techniques. Therefore, biology students urgently need to master the basic knowledge of computer science in order to use data science methods to conduct in-depth analysis of experimental results. For this reason, it is particularly important to integrate data science content into biology courses. An elective course with bioinformatics as the core can be offered to teach students how to process and analyze genomic data, how to use bioinformatics tools for data mining, etc. Through such a curriculum design, students can not only master the core knowledge of biology, but also learn practical skills in the fields of data science such as data cleaning and machine learning, so as to cultivate the comprehensive ability to solve complex biological problems.

In addition to carefully designing the course content, the teaching methods of interdisciplinary courses also need to be different from the traditional model. The first task is to change the teaching method to make it more interactive and practical. Traditional biology courses focus on theoretical teaching, while interdisciplinary teaching should pay more attention to cultivating students' practical skills. Taking the curriculum that combines biology and data science as an example, a project-driven teaching method can be adopted. In this model, teachers can ask specific biological questions, such as exploring the mechanism of genetic mutations in cancer, and guide students to use data science methods for data analysis. Students need to participate in the whole process from data collection, cleaning to analysis results. This method not only gives students the opportunity to transform theoretical knowledge into practical operations, but also effectively cultivates their teamwork skills, problem-solving skills, and innovative thinking. In addition, the teaching design of interdisciplinary

courses can also be integrated into case teaching methods to enhance students' practical ability. By showing real cases of the cross-application of biology and other disciplines, such as the close integration of data science, artificial intelligence and biology in the process of drug development, teachers can help students more intuitively understand the application value of interdisciplinary knowledge in practical problems. This teaching method can not only stimulate students' interest in exploring complex problems, but also cultivate their practical ability and innovative thinking.

With the deepening of the "Belt and Road" initiative, Shaanxi colleges and universities have encountered unprecedented challenges in cultivating internationalized talents in the field of biology, and the internationalization of course content has become a key issue that needs to be addressed urgently. Shaanxi colleges and universities must explore new paths to adapt to the needs of global education and improve students' international literacy in the field of biology. This requires students to not only master the global knowledge system in the field of biology but also cultivate cross-cultural communication and cooperation capabilities so that they can communicate effectively in academic and professional fields in the future. However, Shaanxi colleges and universities' current biology course settings have limitations, lack a systematic international education system, and lack a global vision. In response to the "Belt and Road" initiative, colleges and universities need to actively optimize biology courses' content, enhance its international characteristics, and help students cultivate global integration capabilities in a multicultural context [26–28]. To this end, this paper uses the Transform model to help colleges and universities optimize the content of internationalized courses and improve the quality of talent training. The Transform model is a model based on the attention mechanism, in which the attention includes the attention mechanism of the words in the input sentence itself and the attention mechanism of the words in the input sentence and the target sentence. Through the Transform model's semantic understanding and contextual analysis capabilities, the core knowledge points, key competency requirements, and elements of cross-cultural education in the course can be accurately extracted. The model can also be used to deeply analyze the latest achievements, education models, and cross-cultural communication examples in the international biological field, and then extract course content that fits the needs of international talent training in the biological field of Shaanxi universities.

The input text data must first be converted into vector form during the model training process. Then, these vectors are sent to the encoder layer for processing. After the data passes through the self-attention layer, it is passed to the feedforward neural network layer, and the results obtained by calculation are output and passed to the next encoder layer. When the encoding phase is completed, the decoding phase begins immediately. During the decoding process, each step outputs an element in the sequence until a special termination symbol appears, indicating that the output of the Transformer model decoder is complete. The self-attention layer in the decoder is different from the encoder. It only processes the front position in the output sequence and masks the subsequent positions before the softmax step. The model also uses a layer normalization method for data calculation. The calculation formulas of the layer normalization method are as follows.

$$\gamma^i = \frac{1}{G}\sum_{j=1}^{G} p_j^i \tag{1}$$

$$p^i = \sqrt{\frac{1}{G}\sum_{j=1}^{G}(p_j^i - \gamma^i)^2} \tag{2}$$

Among them, γ represents the mean; p represents the standard deviation; G represents the hidden unit.

In terms of optimizing course content, the Transformer model, with its excellent data integration capabilities, has opened up a new path for cultivating international talents in the field of biology in Shaanxi universities. International courses in the field of biology involve multiple disciplines. The application of the Transformer model enables Shaanxi universities to integrate international education resources from different disciplines efficiently. By deeply analyzing these resources, the model can reveal the intrinsic connections between disciplines and cultivate their interdisciplinary thinking and cross-cultural communication capabilities. The expression is as follows:

$$Attention(P_j, W_i, M_i) = softmax\left(\frac{P_j W_i^R}{\sqrt{d_a}}\right) M_i \tag{3}$$

P_j and W_i represent the query vector and key vector from different disciplines, respectively, and M_i is the value vector, reflecting the knowledge expression of the subject content. d_a is the dimension of the key vector.

Under the impetus of the "Belt and Road" initiative, the optimization of course content needs to fully understand and integrate the knowledge differences under the background of multiple cultures. The Transformer model can cleverly transform knowledge points from different cultural backgrounds into different vectors, and comprehensively improve the global vision and cross-cultural understanding depth of course content with the synergy of encoders and decoders. The expression is:

$$U_l Y_{global} = \sum_{l=1}^{L} Decoder\big(Encoder(U_l)\big) \tag{4}$$

$Encoder(U_l)$ is to encode the knowledge of various disciplines and cultural backgrounds; $Decoder$ is the decoder, which integrates the encoded knowledge into the final comprehensive course design.

In order to integrate the Transformer-GRU model into biology teaching, the curriculum needs to be appropriately adjusted and a personalized teaching plan is formulated according to the students' learning needs and teaching goals. Biology courses cover a number of fields, such as molecular biology, cell biology, etc., involving a large number of concepts, formulas, and time series data. Therefore, the advantages of the Transformer-GRU model can be used to optimize curriculum design and teaching methods in a data-driven manner. First, teachers need to determine which course content is suitable for auxiliary teaching using models. For example, when

discussing gene expression regulation or cell division cycles, this model can help students discover patterns in time series data. Secondly, teachers should cooperate with data analysis experts to obtain real biological experimental data, such as genomic data, as the basis for model training. In this way, students can not only learn theoretical knowledge, but also improve their analysis and processing power through practical operation of data. At the same time, curriculum adjustment also needs to consider students' learning progress and level differences. Using the Transformer-GRU model, students' learning trajectory can be analyzed, so as to intelligently adjust the teaching content and progress. For students who encounter difficulties, the model can automatically adjust the speed and depth of explanation of teaching difficulties to help them better understand and master complex concepts.

2.2. Personalized improvement of foreign language ability

Under the guidance of the "Belt and Road" initiative, Shaanxi universities are tasked with cultivating biological elites with international vision and cooperation capabilities. Among them, foreign language skills, especially the shaping of English communication skills, are particularly critical. Traditional foreign language teaching often adopts a one-size-fits-all approach, ignoring the differences in language talents and learning progress among students, making it difficult to meet personalized learning needs [29,30]. Therefore, this paper uses the GRU model to intelligently design learning paths to achieve accurate improvement of the foreign language ability of biology students. The GRU model, as an efficient variant of recurrent neural networks, is very good at processing time series data [31,32]. Through this model, learning resources and plans can be dynamically adjusted according to students' real-time learning performance. When the GRU model detects that students have insufficient English vocabulary in a certain field of biology, it can automatically increase the relevant reading materials and learning resources in this field to help students fill in the knowledge gaps in time. This is not only a strong support for students' individual development, but also a positive response to the goal of cultivating international talents under the "Belt and Road" initiative. The model for improving the foreign language ability of international talents based on the GRU model is shown in **Figure 2**.

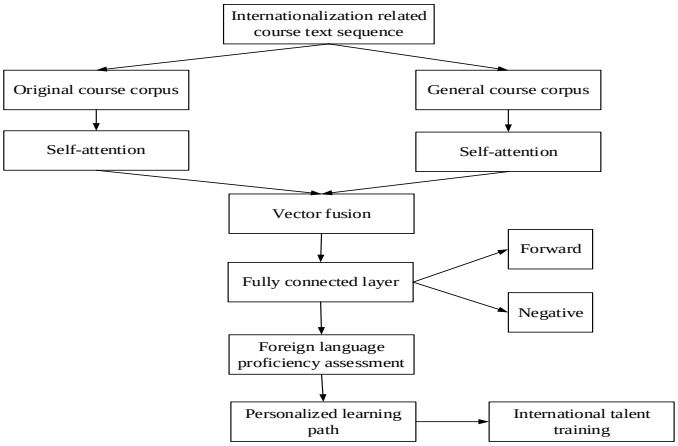

Figure 2. Foreign language ability improvement model for international talents based on the GRU model.

The GRU model has the ability to track students' foreign language learning data over a long period of time, so as to deeply analyze and predict their learning progress and possible difficulties. Its core advantage lies in its excellent sequence data processing, which closely fits the gradual process of foreign language learning. Students may encounter different challenges at various stages of language learning, whether it is grammar, vocabulary, listening, and speaking. Compared with the fixedness of traditional foreign language teaching models, the GRU model shows higher flexibility and can be dynamically adjusted according to students' real-time progress. By continuously updating students' learning data, the GRU model can accurately adjust the learning path and ensure the optimal configuration of personalized learning resources. The learning recommendation model can provide users with personalized recommendations, as shown in **Figure 3**.

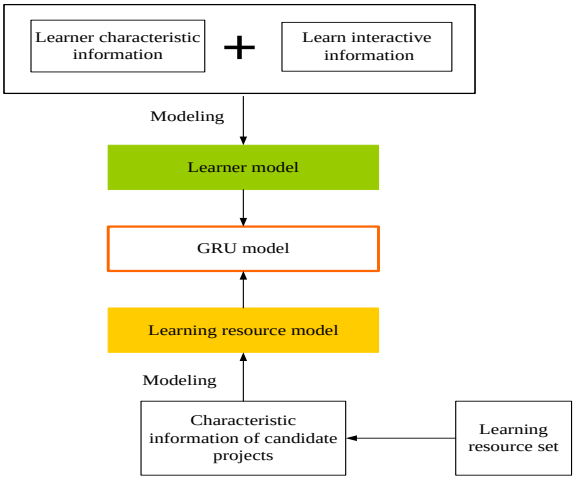

Figure 3. Framework diagram of the learning recommendation model.

Learner profiling involves in-depth collection and analysis of user characteristics while recording their learning interaction information, based on which learners' interests and preferences are modeled. The learning resource model focuses on using the learning resource set to carefully characterize the attributes, classifications, and labels of candidate items. GRU not only inherits the memory characteristics of RNN, but also effectively alleviates the gradient vanishing problem that RNN may face. GRU requires fewer parameters, which reduces the risk of overfitting to a certain extent. The gated recurrent unit module consists of multiple GRUs arranged in order, and its input data is the user's historical learning record vector. These learning behavior data can truly reflect the user's learning interest. GRU can accurately extract the user's hidden interest state from the complex learning behavior inside the module. The calculation formulas of GRU are as follows:

$$h_t = \beta(M_h j_t + Q_h r_{t-1} + a_h) \tag{5}$$

$$x_t = \beta(M_x j_t + Q_x r_{t-1} + a_x) \tag{6}$$

$$r_t = (1 - x_t) \times r_{t-1} + x_t \times \widetilde{x_t} \tag{7}$$

$$\beta(y_1, y_2) = \frac{1}{1 + exp(1 - [y_1, y_2])} \tag{8}$$

Among them, M_h, $M_x \in T$, Q_h, $Q_x \in m_R \times m_I$, and m_R are the sizes of hidden units, and m_I is the dimension of the input vector. j_t represents the embedding vector of the t-th learning behavior in the user's learning behavior sequence.

The core advantage of the Transformer-GRU model lies in its excellent sequence data modeling capabilities and personalized recommendation functions. The model can dynamically adjust each student's learning path based on the student's specific learning data, such as learning progress, knowledge mastery status, and wrong question types. If students perform well in the genetics part but encounter problems in the cell division part, the model can intelligently push relevant learning resources and auxiliary explanations, and even adjust the difficulty of the content in real time during the learning process. Teachers can use data analysis tools to monitor students' learning curve in order to intervene in learning in a timely manner. In actual operation, a "learning trajectory platform" can be established. The platform relies on the Transformer-GRU model to update students' learning status in real time, and provides students with targeted learning guidance through intelligent push of various teaching resources, such as course content, test questions, and video explanations. This can not only effectively enhance students' learning interest and efficiency, but also help teachers accurately identify students' weak links, so as to carry out targeted teaching and counseling.

The reset gate of GRU plays a key role in screening the historical learning records related to the final learning interest. The sigmoid activation function can calculate a correlation coefficient to help find course resources that are closely related to the current learning interest. When the learning goal is used as the input for the next step, GRU can precisely extract the knowledge points in the user's learning sequence that are closely related to this goal, and use this as a basis to deeply explore the current learning interest. In the individual learning of foreign language proficiency of college students in Shaanxi Province, the students' behavior sequence truly reflects their learning process. There is a clear causal relationship between these historical items. Position encoding is performed after the behavior embedding vector to deeply explore the temporal information in these behavior sequences and capture the dependencies between different sequential behaviors. This step significantly enhances the model's perception of temporal information. In the specific calculation process of position encoding, sine and cosine functions of different frequencies are used, and the formulas are as follows:

$$FG_{(pos,2j)} = sin\left(\frac{pos}{10\frac{2j}{d}}\right) \tag{9}$$

$$FG_{(pos,2j+1)} = cos\left(\frac{pos}{10\frac{2j}{d}}\right) \tag{10}$$

Among them, pos represents the specific position of the item in the user's behavior sequence; d represents a dimension in the position encoding vector; FG is a row composed of user historical behaviors. In the construction of the position encoding vector, a specific method is adopted: odd dimensions are encoded using cosine functions, while even dimensions are encoded using sine functions.

Biology education is uniquely challenging because of its complexity, experimentation and interdisciplinary nature. It not only covers a wide range of scientific and theoretical knowledge, but also is closely intertwined with many fields such as chemistry, physics, and medicine, requiring a variety of teaching methods to help students master. In this context, the introduction of the Transformer-GRU model can not only improve teaching efficiency, but also realize personalized teaching through data-driven, thereby helping students to better understand the complex concepts in biology. Experimental teaching occupies an important position in biology courses. It enables students to experience the practical application of theoretical knowledge firsthand and explore the inherent mechanisms of biological processes. However, traditional experimental teaching is often limited by factors such as experimental conditions, cost and operational risks, which affect the teaching effect and student experience. In addition, many experimental content and phenomena in biology have dynamic and microscopic characteristics, which require students to conduct in-depth observation and analysis in changeable situations. At this time, the Transformer-GRU model can simulate experiments, build a virtual experiment platform, etc., so that students can feel the whole process and results of the experiment without actual operation, so as to effectively make up for the shortcomings of traditional experimental teaching.

In addition to experimental teaching, case teaching also occupies an important position in biology education. Through case teaching, students can closely integrate theoretical knowledge with practical applications and think deeply about complex biological problems. Studying cases of genetic mutations helps students understand the impact of gene expression on biological function, while analyzing cases of global health problems allows students to learn how to deal with the spread and control of epidemics. These cases not only cover specific biological knowledge, but also involve social, ethical, policy and other levels, requiring students to consider various factors comprehensively in their studies. The introduction of artificial intelligence models, such as Transformer-GRU, can further enhance the effectiveness of case teaching through data analysis and intelligent recommendation. The model can recommend personalized learning materials and cases for students based on their learning progress and interests, so as to help students gain an in-depth understanding of biological principles while also mastering the application of these principles in practice. In addition, the Transformer-GRU model can also provide students with more diverse perspectives and resources. For global health issues in biology courses, such as the relationship between climate change and infectious diseases, food safety, vaccine research and other complex issues, the model can help students draw information from research results in multiple subject areas, generate interdisciplinary learning resources and cases, and effectively broaden students' knowledge.

2.3. Optimization of the teaching staff

Teachers are the key force for universities to cultivate international talents, while students are an essential yardstick for measuring the internationalization level of universities [33,34]. In the process of cultivating international talents in the field of biology, it is particularly essential to cultivate the international awareness of teachers and students. This is not only related to the global competitiveness of students but also directly affects the achievements of universities in internationalization. Therefore, improving the international literacy of teachers and students has become the core task of talent cultivation in the field of biology in Shaanxi universities. In response to the call of the "Belt and Road" initiative, Shaanxi universities should actively apply teachers with international backgrounds and rich teaching experience, and promote the overall improvement of the teaching staff of biology majors through their international vision and cross-cultural teaching strength. To achieve this goal, universities should make full use of national policy support, take international background as an important consideration for teacher recruitment, and actively recruit excellent teachers with international vision. At the same time, overseas visiting professors, as valuable resources for improving teaching quality, should be fully utilized to bring students the latest international academic trends and cutting-edge knowledge [35,36]. These activities not only help broaden the international vision of students in the field of biology but also improve their cross-cultural communication skills, thereby enhancing their competitiveness in the field of international biological research.

In the process of promoting the internationalization level of teachers and students, Shaanxi universities actively implement the "going out" strategy to further strengthen the internationalization of the biological field. At the teacher training level, teachers are organized to go abroad for short-term academic exchanges or teaching inspections during the summer vacation. Such an arrangement not only ensures that teachers can be exposed to the latest concepts of international biology education without interfering with the normal teaching order, but also helps to improve their participation and influence in international cooperation. In addition, promoting the "one-to-one" overseas teacher exchange program is also an effective measure, which not only helps to promote the in-depth interaction and sharing of teacher resources on both sides but also can directly improve the ability and level of teachers in international teaching and scientific research cooperation in both schools.

Regarding course content optimization, the Transformer model has opened up a new path for the cultivation of international talents in the biological field of Shaanxi universities with its excellent data integration capabilities. Given that international courses in the biological field involve multiple disciplines and majors, how to achieve the integration and coordination of course content has become a significant challenge facing the current education system. By applying the Transformer model, Shaanxi universities can integrate international education resources from different disciplines more efficiently. The model can also deeply analyze these resources, revealing the inherent connections between disciplines and the similarities and differences of biological knowledge under different cultural backgrounds. At the same time, the unique advantage of the GRU model in processing time series data enables it to process teachers' learning progress and feedback information effectively. The specific

measures for optimizing the teaching staff are shown in **Table 1**.

Table 1. Optimization measures for the teaching staff.

Serial number	Measures	Method	Effect
1	Introduction of foreign teachers	Introduce foreign mathematicians or overseas experts	Improve the internationalization level of the teaching staff
2	Lectures and exchanges by overseas experts	Regularly invite internationally renowned scholars to communicate	Enhance teachers' cross-cultural communication skills
3	Teacher "Going Global" strategy	Send foreign teachers to overseas for academic exchanges	Improve teachers' international experience and understand the frontiers of international education
4	One-to-one teacher communication	Implement a "one-to-one" overseas teacher exchange program	Deepen teachers' understanding of different education models
5	Transformer-GRU model application	Use the model to develop personalized training programs	Dynamic optimization training program

3. Experiments on international talent cultivation in the biological field based on the Transformer-GRU model

To study the superiority of the Transformer-GRU model for international talent cultivation in colleges and universities, this paper takes students from Shaanxi W University as the research object, and extracts two classes from the biology major of Shaanxi W University for experiments, with 40 students in each class. Class A uses the international talent cultivation program based on the Transformer-GRU model, while Class B uses the traditional cross-cultural training course program. The experimental period is 1 semester. Among them, the number of male and female students in Class A is 12 and 28 respectively, and the number of male and female students in Class B is 13 and 27 respectively.

Under the "Belt and Road" initiative, the international talent cultivation program of W University is optimized based on the Transformer-GRU model, which achieves great success. Because the Transformer model is used in the Transformer-GRU model for large-scale semantic understanding and contextual association analysis, the knowledge points in different courses can be well analyzed, thereby improving the internationalization level of the courses of W University and helping the students of the school to provide internationalization capabilities. Students from the two classes are invited to evaluate different plans, mainly from the perspectives of comprehensive knowledge points, interdisciplinary relevance, and degree of globalization. The evaluation is presented in the form of scoring, with a full score of 10. The higher the score, the better the evaluation. The specific research results are shown in **Table 2**.

As shown in **Table 2**, there are significant differences between Class A and Class B in terms of comprehensive knowledge points, interdisciplinary relevance, degree of globalization, and course update speed ($P < 0.05$). In terms of comprehensive knowledge points, the average score of Class A is as high as 9.21, which is significantly better than Class B's 7.02 ($P = 0.014 < 0.05$), which shows that the curriculum based on the Transformer-GRU model has better performance in covering a wide range of knowledge points and ensuring that students have a deep understanding of the subject content. In the dimension of interdisciplinary relevance, Class A also shows its advantages, with an average score of 8.91, which is significantly

higher than Class B's 6.31 ($P = 0.004 < 0.05$). This shows that the Transformer-GRU model not only focuses on the deep learning of a single subject, but also pays attention to the integration and application of interdisciplinary knowledge, which helps to cultivate students' comprehensive ability and innovative spirit. Regarding globalization, the average score of Class A is 9.04, which is significantly higher than that of Class B's 7.14 ($P = 0.008 < 0.05$). This reflects that the new program pays more attention to the expansion of international vision and the integration of global culture in the course design, which helps to improve students' international competitiveness and cross-cultural communication ability. Although the average scores of Class A and Class B are similar in terms of the rationality of course content, and there is no significant statistical difference ($P = 0.086 > 0.05$), this does not prevent the new program from continuously optimizing the course design, and paying more attention to the logic and practicality of knowledge to better meet students' learning needs.

Table 2. Comparative study on the internationalization ability of students from the two classes.

Evaluation index	Class A	Class B	*P* value
Comprehensive knowledge points	9.21 ± 0.34	7.02 ± 1.53	0.014
Interdisciplinary relevance	8.91 ± 0.51	6.31 ± 0.97	0.004
Degree of globalization	9.04 ± 0.37	7.14 ± 1.27	0.008
Course update speed	8.87 ± 0.41	6.53 ± 1.42	0.002
Rationality of course content	8.78 ± 0.66	8.31 ± 0.74	0.086

In the Transformer-GRU model, the GRU model can be applied to the improvement of foreign language ability to help improve students' foreign language ability. The two classes are still studied, mainly from the five aspects of language comprehension ability, vocabulary mastery, oral expression ability, listening comprehension ability, and writing ability. The evaluation level is divided into 4 levels: excellent, good, pass, and fail. The teacher divides the levels of these 5 aspects of students in Classes A and B after the experiment. The specific division results are shown in **Figure 4**.

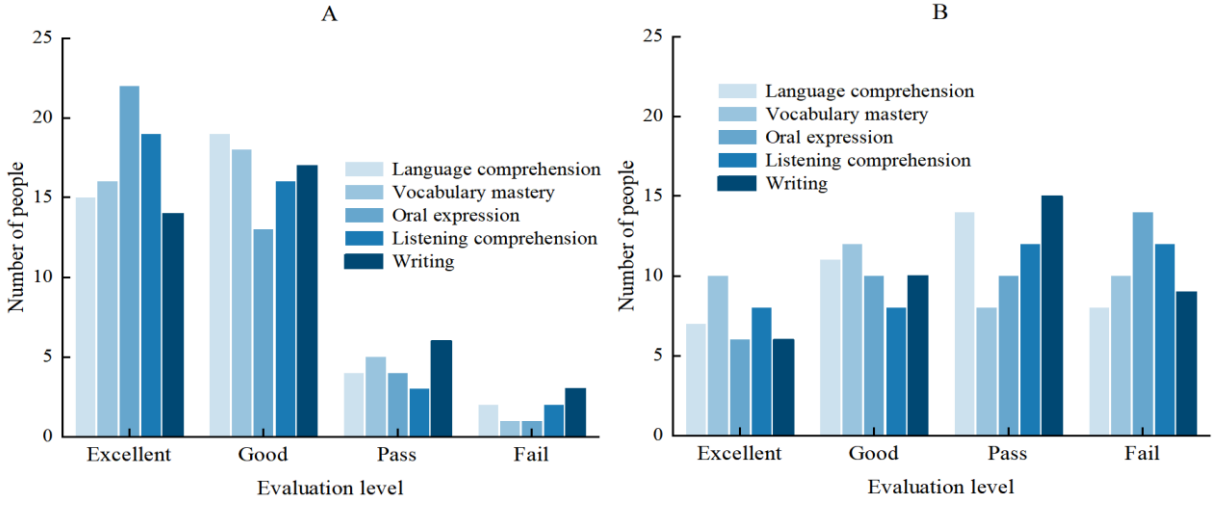

Figure 4. Comparative study of foreign language ability of students in two classes.

Figure 4A: Class A.

Figure 4B: Class B.

As shown in **Figure 4**, students in Class A show more obvious progress in most language abilities. As shown in **Figure 4A**, in terms of language comprehension ability, the number of excellent students in Class A reaches 15, which is significantly higher than the 7 in Class B; in terms of vocabulary mastery and oral expression ability, Class A also shows significant advantages, with 16 and 22 excellent students respectively, far exceeding the 10 and 6 in Class B. Through further observation, it is found that the number of students in Class A at the good level is relatively large, and the development of various abilities is relatively balanced. As shown in **Figure 4B**, although Class B also has many "good" students in multiple dimensions, it has shortcomings in listening comprehension, oral ability and writing ability. In terms of pass and fail grades, the number of students in Class A is significantly less than that in Class B, which shows that the teaching program based on the Transformer-GRU model has significant advantages in improving students' overall language level and reducing learning difficulties. This advantage is not only reflected in the increase in the number of "excellent" grade students, but also in the comprehensive improvement of students' multiple language ability dimensions. Therefore, the Transformer-GRU model successfully improves students' foreign language level and comprehensive quality. In contrast, although the traditional cross-cultural training course program can also enhance students' foreign language ability to a certain extent, the overall effect is obviously not as good as that based on the Transformer-GRU model.

The two selected classes are still studied, and the foreign language ability test of the students in the two classes is conducted to evaluate the improvement of students' ability. The students in the two classes are tested before the experiment, with a full score of 100 points. After the one-semester experiment, they are tested again. The test questions are the same, and the full score is also 100 points. The specific test results are shown in **Table 3**.

As shown in **Table 3**, before the experiment, the foreign language ability of students in Class A and Class B is evaluated. The results show that the average score of Class A is 68.06, and the average score of Class B is 68.73. Through the *t*-test, it is found that the foreign language ability levels of the two classes are comparable before the experiment, and there is no significant difference ($P > 0.05$). However, after one semester of experimental teaching, the foreign language ability of the two classes changes significantly. The average score of students in Class A increases significantly to 80.31, which is 7.04 points higher than that of the 73.27 in Class B. This significant difference is verified statistically ($P = 0.016$), indicating that the foreign language ability of students in Class A is significantly higher than that of Class B after the experiment ($P < 0.05$). In addition, there is an extremely significant difference in the foreign language ability of students in Class A before and after the experiment ($P = 0.008 < 0.05$), while although students in Class B also show some improvement, it does not reach the significant level ($P = 0.079 > 0.05$). In summary, this study has confirmed through a one-semester experimental observation that the teaching program based on the Transformer-GRU model has significant advantages in quickly improving students' foreign language ability.

Table 3. Comparison of student scores before and after the experiment in the two classes.

Before and after the experiment	Class A	Class B	*t* value	*P* value
Before the experiment	68.06 ± 7.64	68.73 ± 7.14	1.341	0.354
After the experiment	80.31 ± 2.67	73.27 ± 4.29	10.773	0.016
t value	12.435	4.206	-	-
P value	0.008	0.079	-	-

The Transformer-GRU model is used to adjust the internationalization training of the faculty of W University, improving the internationalization and cross-cultural teaching ability of teachers. At the same time, the Transformer-GRU model is used for course optimization and personalized learning, which helps students improve their foreign language ability and internationalization ability, making students more satisfied with the international talent training program based on the Transformer-GRU model. To better understand the degree of student satisfaction, a survey is conducted on students in Class A and Class B, and the satisfaction level is divided into five levels, namely very satisfied, satisfied, indifferent, dissatisfied and very dissatisfied. The specific survey results are shown in **Figure 5**.

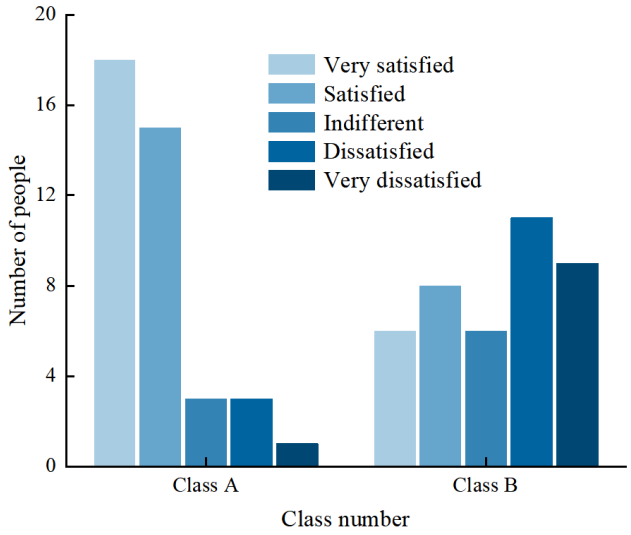

Figure 5. Comparative study on the satisfaction of students in two classes with different aspects of international talent training.

As shown in **Figure 5**, the students in Class A are very satisfied with the new teaching program. 18 students express "very satisfied", accounting for 45%, which clearly reflects the students' strong recognition and love for the international talent training program based on the Transformer-GRU model; 15 students express "satisfied", which further verifies the effectiveness of the new program in improving student satisfaction. The total satisfaction rate of Class A is 82.5%, and only a very small number of students expresses dissatisfaction. In Class B, only 6 students express "very satisfied", 12 fewer than Class A, and the number of students who express "satisfied" is also small. More students in Class B express dissatisfaction, which shows that the traditional teaching program is not popular among some students. The total

dissatisfaction rate of Class B is 50%. The teaching program based on the Transformer-GRU model is favored by students in Class A, mainly due to its obvious advantages in course optimization and personalized teaching. This model can provide customized teaching content based on students' individual differences and learning needs, thereby effectively improving learning effects and student satisfaction. At the same time, through international training, teachers' teaching ability has also been significantly improved, which further enhances students' recognition and love for the new program.

In the context of globalization, the internationalization of higher education has become an important strategy for universities. Chinese universities, especially in Shaanxi Province, are gradually strengthening the training of international talents. Taking Tsinghua University and Shanghai Jiaotong University as examples, they promote the process of internationalization in different ways. Tsinghua University has established an international cooperation platform to provide dual-degree programs, encourage students to participate in overseas exchanges, internships and other activities, and integrate into the international environment. Its cooperation with international companies and institutions provides students with exercise opportunities in a global scientific research environment and enhances the competitiveness of the global workplace. Shanghai Jiaotong University adopts the strategies of "bilingual teaching" and "globalization Project", focusing on improving students' English proficiency, and providing a wealth of foreign language courses and international cooperation opportunities. Through cooperation with the world's top universities and research institutions, to help students accumulate international experience. The practice of these two universities shows that the internationalization of higher education can effectively enhance the international vision and competitiveness of talents and adapt to the development trend of globalization. Harvard University and the National University of Singapore (NUS) are examples of international education. Harvard promotes the globalization of academic and scientific research through diversified international cooperation, emphasizes interdisciplinary and cross-cultural exchanges, provides international projects and enriches cultural exchange platforms, and enhances students' cross-cultural adaptation and international communication skills. NUS implements the concept of global education, provides overseas internships, international cooperation and double degree programs, establishes extensive cooperative relations, organizes international academic conferences, and enhances students' international competitiveness and professional abilities. The practice of the two schools provides valuable experience for the internationalization of higher education.

4. Response measures

4.1. Clarify the goals of talent training and the balanced development of inter-school internationalization

It is essential for universities to clarify the training goals of international talents, which helps to transport international talents with knowledge and skills in specific fields to the society. On the basis of common training, colleges and universities should also create personalized international talent training programs based on subject

characteristics. For example, for biological disciplines, we can focus on cultivating composite talents with innovation ability, biotechnology ability, and cross-cultural communication ability. In addition, the freedom of universities to carry out internationalization work depends to a large extent on the support of policies and funds. In view of the current imbalance in the internationalization process of Shaanxi universities, the government and related departments should actively take measures to help, such as providing business guidance, implementing policies, and giving financial support. These measures aim to change the dilemmas encountered by some universities on the road of internationalization, enhance their awareness and participation in internationalization of running schools, and thus promote the balanced development of the overall internationalization level of higher education in Shaanxi.

4.2. Innovative talent training system

The training of international talents should be closely integrated with the national development strategy, committed to serving the "Belt and Road" initiative, promoting exchanges and mutual learning among civilizations, and helping Chinese culture to the world. In order to achieve this goal, it is necessary to innovate a composite talent training model and create a high-level team of specialized talents who can freely travel between two languages, literature and culture. At the macro level, the hierarchical classification and training of talents is particularly important. In the undergraduate education stage, emphasis should be placed on cultivating composite talents with the knowledge and ability structure of "foreign language + foreign language" or "foreign language + non-foreign language". This talent training model aims to enhance students' comprehensive quality and cross-cultural communication skills, and lay a solid foundation for them to work in an international environment in the future. Entering the postgraduate stage, it is necessary to persevere in cultivating professionals who are proficient and interested in engaging in foreign language biological sciences. At the same time, efforts should be made to cultivate another type of high-end talents: they should be familiar with the party and the country's policies and policies, understand China's national conditions, have an international perspective and the ability to be familiar with international rules, so as to become a comprehensive and comprehensive language service talent that the country and society urgently need. Through these measures, it will provide strong talent support for the long-term development of the country.

4.3. Strengthen external publicity and build a bridge for cross-cultural exchanges

Education for studying in China occupies an important position in China's education industry. It is not only a window to showcase the image of Chinese education to the outside world, but also an important bridge for friendly exchanges between China and foreign countries. Local universities should actively play the role of bridges and links for external communication, vigorously promote China's policies, resources, markets and other advantages, seize the opportunity for the education of international students in China, and effectively improve their own level of international exchanges. Universities need to establish an advanced concept of

international talent training, establish a sound international cooperation mechanism, and continue to explore effective international talent training paths to create and expand more international exchange opportunities for students, so as to promote the continuous and in-depth development of international exchanges. At the same time, local universities in Shaanxi should build a work and service system for studying in China that matches our country's international status, scale and level of education, build a high-quality and professional team of educational teachers for studying in China, and form a group of educational universities and high-level subject groups with distinctive characteristics for studying in China. We are committed to cultivating a large number of outstanding graduates who understand China and are friendly to China. Through these measures, we can attract and train more high-quality international students. At the same time, with the help of the training process of international students in China, we can further broaden the international horizons of our students, enhance their awareness of international cooperation, and lay a solid foundation for cultivating internationally competitive talents.

5. Conclusions

Under the promotion of the Belt and Road Initiative, Shaanxi universities have new opportunities in cultivating international talents in the field of biology while facing many challenges. To meet these challenges, this study has constructed an optimization strategy for international talent training programs that integrates the Transformer-GRU model. Using the powerful text processing capabilities of the Transformer model, this study deeply optimizes the course content to achieve the integration of global vision and cross-cultural understanding. Through the encoder and decoder of the model, biological knowledge points under different cultural backgrounds are converted into vectors, and then integrated into a course design with distinctive international characteristics. To meet the personalized needs of students to improve their foreign language ability, this study applies the GRU model and dynamically adjusts learning resources and plans based on its advantages in processing time series data. In addition, it also focuses on the faculty's internationalization optimization measures. By applying foreign teachers and implementing the "going out" project for teachers, the international literacy of the faculty in the field of biology in Shaanxi universities has been comprehensively improved. These measures not only expand the international vision of teachers but also enhance their cross-cultural teaching ability, providing a solid guarantee for the cultivation of international talents.

Funding: This research was funded by Research Projects of Shaanxi Provincial 14th Five-Year Plan for Education Science in 2023, Innovative Research on the International Talent Training Mode of Shaanxi Universities under the "the Belt and Road" Initiative. (Grant number SGH23Y2771).

Ethical approval: Not applicable.

Conflict of interest: The author declares no conflict of interest.

References

1. Johnston, Lauren A. “The Belt and Road Initiative: what is in it for China?.” Asia & the Pacific Policy Studies 6.1 (2019): 40-58.https://doi.org/10.1002/app5.265.
2. Zou, Longcan, Shen, J. H., Zhang, J., & Lee, C. C. ”What is the rationale behind China’s infrastructure investment under the Belt and Road Initiative.” Journal of Economic Surveys 36.3 (2022): 605-633.https://doi.org/10.1111/joes.12427.
3. Li, Jiatao, Van Assche, A., Li, L., & Qian, G. “Foreign direct investment along the Belt and Road: A political economy perspective.” Journal of International Business Studies 53.5 (2022): 902-919.https://doi.org/10.1057/s41267-021-00435-0.
4. Acheampong, Francisca Adoma, Henry Nunoo-Mensah, and Wenyu Chen. “Transformer models for text-based emotion detection: a review of BERT-based approaches.” Artificial Intelligence Review 54.8 (2021): 5789-5829.https://doi.org/10.1007/s10462-021-09958-2.
5. Nassiri, Khalid, and Moulay Akhloufi. “Transformer models used for text-based question answering systems.” Applied Intelligence 53.9 (2023): 10602-10635.https://doi.org/10.1007/s10489-022-04052-8.
6. Ciniselli, Matteo, Cooper, N., Pascarella, L., Mastropaolo, A., Aghajani, E., Poshyvanyk, D.et al. “An empirical study on the usage of transformer models for code completion.” IEEE Transactions on Software Engineering 48.12 (2021): 4818-4837.DOI: 10.1109/TSE.2021.3128234.
7. Lin, Haiping, Gharehbaghi, A., Zhang, Q., Band, S. S., Pai, H. T., Chau, K. W., et al. “Time series-based groundwater level forecasting using gated recurrent unit deep neural networks.” Engineering Applications of Computational Fluid Mechanics 16.1 (2022): 1655-1672.https://doi.org/10.1080/19942060.2022.2104928.
8. Zhang, WengangLi, H., Tang, L., Gu, X., Wang, L., & Wang, L. “Displacement prediction of Jiuxianping landslide using gated recurrent unit (GRU) networks.” Acta Geotechnica 17.4 (2022): 1367-1382.https://doi.org/10.1007/s11440-022-01495-8.
9. Li, Jun, and Heyao Wang. “The Explore of College Talent Training Mode under the City of Production-Education Integration.” Adult and Higher Education 5.3 (2023): 94-101.DOI: 10.23977/aduhe.2023.050314ISSN 2523-5826 Vol. 5 Num. 3.
10. Zheng, Weibo, Yilei Wen, and Lu Zheng. “An “embedded” mode of international talent training boosts the two-way opening of higher education.” Open Journal of Social Sciences 7.3 (2019): 136-145.DOI:10.4236/jss.2019.73010.
11. Lei, Ming. “Comparative study of internationalized talent cultivation models in international higher education programs.” Journal of Contemporary Educational Research 7.7 (2023): 19-25. https://doi.org/10.26689/jcer.v7i7.5122.
12. Xie, Ma. “Talent cultivation strategies and path choices in the process of internationalization of higher education.” Adult and Higher Education 6.2 (2024): 171-177. DOI:10.23977/aduhe.2024.060224ISSN 2523-5826 Vol. 6 Num. 2
13. Ma, Yunfei. “Research on Talent Internationalization Cultivation Mode of Agricultural Universities—Illustrated by the Case of TJAU-MU Cooperative Education.” Open Journal of Social Sciences 7.10 (2019): 96-104.https://doi.org/10.4236/jss.2019.710009.
14. Xu, Yuan, and Lei Guo. “IMPLEMENTING NEW TALENT CULTIVATION MODE THROUGH CROSS-BORDER HIGHER EDUCATION FOR “ONE BELT ONE ROAD” ENTERPRISES IN ASEAN COUNTRIES.” Asian journal of management sciences & education 11.1 (2022): 57-65. http://www.ajssh.leena-luna.co.jp/.
15. Hu, Xiaomei, Fan Liu, and Yuan Yuan. “Research on talent training mode of interdisciplinary integration in colleges and universities.” International Journal of Education and Humanities 1.1 (2021): 28-35. https://doi.org/10.54097/ijeh.v1i1.198.
16. Xu, Yiping. “Exploration of practical teaching reform based on high-quality international talent cultivation.” ICCCM Journal of Social Sciences and Humanities 1.3 (2022): 38-48. https://doi.org/10.53797/icccmjssh.v1i3.5.2022.
17. Pilicita, Anabel, and Enrique Barra. “Using of Transformers Models for Text Classification to Mobile Educational Applications.” IEEE Latin America Transactions 21.6 (2023): 730-736.DOI: 10.1109/TLA.2023.10172138.DOI: 10.1109/TLA.2023.10172138.
18. Yang Yang, Chubing Zhang, Xin Song, Zheng Dong, Hengshu Zhu, Wenjie Li. “Contextualized knowledge graph embedding for explainable talent training course recommendation.” ACM Transactions on Information Systems 42.2 (2023): 1-27. https://doi.org/10.1145/3597022.
19. Wankmuller, Sandra. “Introduction to neural transfer learning with transformers for social science text analysis.” Sociological Methods & Research 53.4 (2024): 1676-1752.DOI:10.1177/00491241221134527.
20. Mishra, Prakhar, Diwan, C., Srinivasa, S., & Srinivasaraghavan, G. “Automatic title generation for learning resources and

pathways with pre-trained transformer models." International Journal of Semantic Computing 15.04 (2021): 487-510.https://doi.org/10.1142/S1793351X21400134.

21. Wang, Xizhe, Wu, P., Liu, G., Huang, Q., Hu, X., & Xu, H. "Learning performance prediction via convolutional GRU and explainable neural networks in e-learning environments." Computing 10.1 (2019): 587-604.https://doi.org/10.1007/s00607-018-00699-9.
22. Mayer, Christian WF, Sabrina Ludwig, and Steffen Brandt. "Prompt text classifications with transformer models! An exemplary introduction to prompt-based learning with large language models." Journal of Research on Technology in Education 55.1 (2023): 125-141.https://doi.org/10.1080/15391523.2022.2142872.
23. Hui, Wang, Peng Shuzhen, and Dong Hongxia. "Innovation Research of International Talent Training Mode of Tourism Management Major in" The Belt and Road" Regions." Journal of Landscape Research 12.5 (2020): 109-112.DOI:10.16785/j.issn1943-989x.2020.5.025.
24. Ge, Yun, and Kong Chong Ho. "Belt and Road Initiatives: implications for China's internationalisation of tertiary-level education." Educational Research and Evaluation 27.3-4 (2022): 260-279.https://doi.org/10.1080/13803611.2022.2041858.
25. Liu, Fang. "Research on the Cultivation of International and Innovative Talents in Colleges and Universities under the context of Belt and Road Initiative." Journal of Contemporary Educational Research 4.2 (2020): 45-49.https://doi.org/10.26689/jcer.v4i2.1021.
26. Kakarougkas, Andreas, and Reham Abdellatif. "A flipped classroom approach and digital learning in an undergraduate molecular biology course." Journal of College Science Teaching 51.3 (2022): 43-50.https://doi.org/10.1080/0047231X.2022.12290559.
27. Zeng, Yihua, and Juan Yang. "A Research on the Construction of an International Talent Training Curriculum System for Economics and Management Majors in Higher Vocational Colleges Under the "One Belt, One Road" Initiative." Education Reform and Development 4.1 (2022): 79-83.https://doi.org/10.26689/erd.v4i1.4158.
28. Hu, Na, and Hua Xie. "Analysis of SWOT on the Development and Internationalization of China's Vocational Education in the context of "The Belt and Road Initiative" Strategy." Journal of Contemporary Educational Research 3.2 (2019): 18-23.DOI:10.54097/jeer.v2i2.6296.
29. Reinhardt, Jonathon. "Metaphors for social media-enhanced foreign language teaching and learning." Foreign Language Annals 53.2 (2020): 234-242.https://doi.org/10.1111/flan.12462.
30. Celik, Bunyamin, Recep Bilgin, and Yunus Yildiz. "The views of instructors in foreign language teaching with distance education model during the Covid 19 pandemic process: A study at Tishk International University in Erbil, Iraq." International Journal of Social Sciences & Educational Studies 9.1 (2022): 148-176.https://doi.org/10.23918/ijsses.v9i1p148.
31. Mahjoub, Sameh, Chrifi-Alaoui, L., Marhic, B., & Delahoche, L. "Predicting energy consumption using LSTM, multi-layer GRU and drop-GRU neural networks." Sensors 22.11 (2022): 4062.https://doi.org/10.3390/s22114062.
32. Shu, Wanneng, Ken Cai, and Neal Naixue Xiong. "A short-term traffic flow prediction model based on an improved gate recurrent unit neural network." IEEE Transactions on Intelligent Transportation Systems 23.9 (2021): 16654-16665.DOI: 10.1109/TITS.2021.3094659.
33. Zelenkova, Anna, and Dana Hanesova. "Intercultural competence of university teachers: a challenge of internationalization." Journal of Language and Cultural Education 7.1 (2019): 1-18.DOI: 10.2478/jolace-2019-0001.
34. Romani-Dias, Marcello, Jorge Carneiro, and Aline dos Santos Barbosa. "Internationalization of higher education institutions: the underestimated role of faculty." International Journal of Educational Management 33.2 (2019): 300-316.https://doi.org/10.1108/IJEM-07-2017-0184.
35. Renfors, Sanna-Mari. "Internationalization of the curriculum in Finnish higher education: Understanding lecturers' experiences." Journal of Studies in International Education 25.1 (2021): 66-82.DOI:10.1177/1028315319888464.
36. Mananay, Janet A., Sanchez, J. M. P., Beltran, N. Y., & Boholano, H. B."Patterns and Pathways: Teachers' Perceptions, Readiness, Support, and Barriers to Internationalization in Higher Education." International Journal of Learning, Teaching and Educational Research 23.9 (2024): 401-431.https://doi.org/10.26803/ijlter.23.9.21.