Modeling and Decision Support of Students' Individualized Growth Trajectory under AI Empowerment

Su Zhang

Shanghai Industrial and Commercial Polytechnic, 201806, Shanghai, China

Keywords: Artificial Intelligence; Students' Individualized Growth; Trajectory Modeling; Decision Support

Abstract: This article focuses on the study of individualized growth of students with the help of AI (Artificial Intelligence). With the improvement of education's attention to students' individuality, the traditional education model is difficult to meet individual needs, and the development of AI technology brings opportunities. By integrating the theory of students' individualized development, the theory of intelligent technology empowerment education and the theory of tracing growth trajectory, this article establishes a multi-source data acquisition system, and uses AI data preprocessing technology and deep learning algorithm to build a model of students' individualized growth trajectory. At the same time, the paper builds a decision support system composed of data collection and preprocessing, intelligent analysis and decision output module. After a one-year follow-up experiment on 200 students, the results show that the model has an accuracy rate of 87% and a recall rate of 84%. It can effectively describe the growth trajectory of students, and the decision support system has a positive impact on improving students' grades and stimulating their interest in learning, providing scientific and powerful support for educators to make individualized education decisions.

1. Introduction

In today's education field, the individualized growth of students has become the core concern. With the continuous updating of educational concepts, people increasingly realize that every student is a unique individual, and their growth paths and development needs are significantly different [1]. The traditional education model, because of its unification and standardization, is difficult to fully meet the individual needs of students, and there are limitations in exploring students' potential and promoting integrated development [2]. With its powerful data processing ability, accurate prediction and analysis ability and efficient pattern recognition ability, AI has brought new opportunities for change in the field of education [3]. The intervention of AI in student learning is simply a tool to improve efficiency, but it continuously changes the behavior patterns of learners. AI has made it possible to break down and manage a large number of processes that previously required teachers to concentrate resources [4]. As a result, students' learning behavior presents a new pattern: the focus shifts from "completing homework" to "the process of problem-solving", and the time arrangement shifts from a single clear task to a more coherent learning cycle.

From the perspective of the phenomenon itself, AI has brought about three significant changes. Firstly, the controllability of learning is enhanced, and students can try different strategies at their own pace. AI acts as a companion, correcting and providing prompts at any time. Secondly, the task hierarchy becomes finer, complex problems are broken down into step-by-step exercises, and students receive targeted feedback at each step. Thirdly, the threshold for information acquisition has been lowered, and sea data has been organized into actionable learning paths, reducing exploration costs. In this context, research on modeling and decision support for personalized growth trajectories of students empowered by AI is particularly important [5]. By establishing a personalized growth trajectory model for students, it is possible to accurately depict their developmental status at different stages and capture subtle changes in their growth process [6]. Based on these models, decision support systems can help educators develop more targeted educational strategies.

  DOI: 10.25236/icfmhss.2025.062

This study combines the knowledge of pedagogy, psychology, AI and other disciplines, expands the research scope of educational theory and injects new vitality into the development of educational science. From a practical point of view, it provides practical methods and tools for education and teaching activities, which is helpful to improve the quality of education, promote the individualized development of students and cultivate innovative talents to meet the diversified needs of society. However, at present, the research in this field is still in the development stage, and there are still many challenges in the scientific model construction and the effectiveness of decision support [7]. Therefore, it is of far-reaching practical significance to carry out in-depth research on students' individualized growth trajectory modeling and decision support under AI empowerment, which will promote the innovative development of educational practice.

2. Analysis of key theoretical framework

In the research of AI-enabled students' individualized growth trajectory modeling and decision support, some key theories constitute its important foundation [8]. The theory of students' individualized development provides a cornerstone for understanding students' uniqueness.

Empowering educational theory with intelligent technology is the support for achieving this goal. Machine learning algorithms in AI can analyze large amounts of student data and mine students' learning patterns. The deep learning model can simulate the neural network structure of the human brain and automatically extract features from the data, so as to accurately predict the growth trajectory of students.

The tracing theory of growth trajectory provides methodological guidance for the construction of student growth model. Based on the systematic study of students' development process, it quantifies and visually presents students' growth process by setting a series of indicators and parameters. In this way, educators can clearly understand the development of students at different stages, and then provide strong support for formulating individualized education programs.

3. Growth trajectory modeling under AI empowerment

In the field of education, it is an innovative and challenging task to realize the modeling of students' individualized growth trajectory with the help of AI. This modeling process aims to use the powerful technical capabilities of AI to accurately outline the unique growth path of students. The primary goal of growth trajectory modeling under AI empowerment is to achieve a comprehensive and accurate portrayal of students' individualized growth. Under the traditional education mode, the evaluation of students is often limited to a few dimensions such as grades, which is difficult to reflect the complete growth dynamics of students. Through all-round data collection and analysis, a three-dimensional and vivid portrait of students' growth is constructed, which clearly shows the development level and characteristics of students at different stages. The modeling goal also includes the prediction of students' growth trend. With the help of AI's predictive analysis ability, according to students' past growth data, we can predict their possible future development direction and speed in various fields. This is helpful for educators to plan educational strategies in advance, guide students to move in a direction conducive to their own development, fully tap students' potential and avoid detours in the development process.

In order to achieve the above goals, modeling ideas need to be closely focused on AI technology. First of all, we should establish a rich data acquisition system. By integrating the school's teaching management system, online learning platform, student activity records and other multi-source data, we can obtain detailed information about students' study and life. These data include structured performance data, as well as unstructured text records and behavior logs. Then, the data preprocessing technology of AI is used to clean, transform and extract features from the collected massive data. After the data processing is completed, the model framework is built based on AI algorithms such as deep learning. With its powerful nonlinear fitting ability, deep learning model can automatically learn complex patterns and features in data. Taking the loss function of MLP as an example, the common formula of cross entropy loss function is:

$$L = -\frac{1}{N}\sum_{i=1}^{N}\sum_{j=1}^{C} y_{ij}\log\left(\hat{y}_{ij}\right) \quad (1)$$

Where N is the quantity of samples, C is the quantity of categories, y_{ij} is the true probability (usually 0 or 1) that the sample i belongs to the category j, and $\hat{y}_{ij}$ is the probability that the model predicts that the sample i belongs to the category j.

LSTM (Long-term and Short-term Memory Network) can be used to process the time series data in the process of students' growth. The core of LSTM lies in its memory unit and gating mechanism (as shown in Figure 1), and its forgetting gate calculation formula is:

$$f_t = \sigma\left(W_f \cdot \left[h_{t-1}, x_t\right] + b_f\right) \quad (2)$$

Where f_t is the output of the forgetting gate at t, σ is the sigmoid activation function, W_f is the weight matrix of the forgetting gate, $\left[h_{t-1}, x_t\right]$ represents the splicing of the hidden state h_{t-1} at the previous moment and the input x_t at the current moment, and b_f is the bias term of the forgetting gate. The forgetting gate determines which information is discarded from the memory unit, thus effectively capturing the dynamic changes in the growth process.

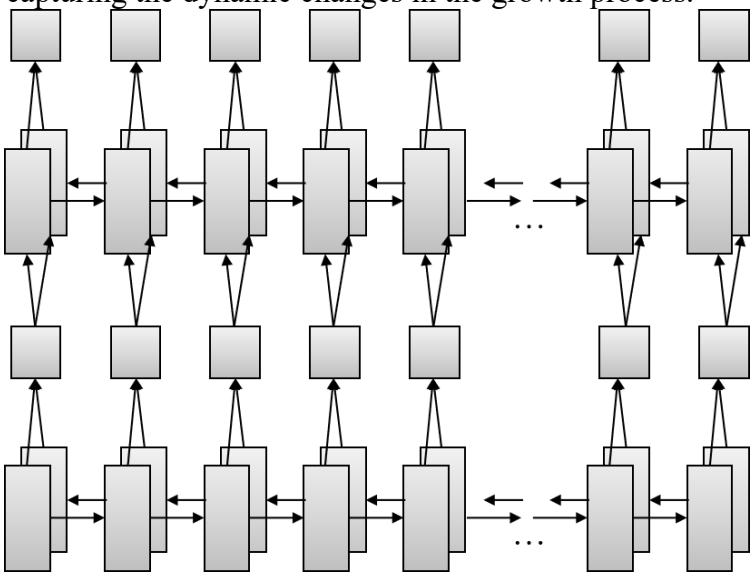

Figure 1 LSTM

A complete model framework of AI-empowered students' growth trajectory consists of multiple levels and modules. As the foundation, the data layer is responsible for storing and managing all kinds of student data to ensure the integrity and security of the data. The data interface module is responsible for docking with external data sources to realize real-time updating and synchronization of data.

The model evaluation layer is used to assess the performance of the trained model. By setting a series of evaluation indicators, the performance of the model in predicting students' growth trajectory is quantitatively assessd. If the model evaluation result is not ideal, it will be fed back to the model training layer, and the model will be adjusted and optimized until the satisfactory performance index is achieved. Finally, the application layer will put the trained and qualified model into practical use. It shows the analysis results of students' growth trajectory to educators in an intuitive and understandable way, and provides an intuitive basis for educational decision-making. At the same time, this layer also has an integrated interface with education management system and teaching platform, so that the model analysis results can be seamlessly integrated into daily education and teaching activities.

4. Construction and experiment of decision support system

After completing the modeling of students' individualized growth trajectory under AI empowerment, it is very important to build a decision support system and carry out experiments to verify the effectiveness of the model and realize the optimization of educational decision. The decision support system takes the students' individualized growth trajectory model as the core, aiming at providing scientific, accurate and operational decision-making suggestions for educators. The system mainly consists of data collection and preprocessing module, intelligent analysis module and decision output module. Intelligent analysis module uses modeling results to deeply analyze students' growth data and dig out potential laws and problems. According to the analysis results, the decision-making output module generates individualized educational decision-making suggestions, such as curriculum recommendation and counseling strategies.

In order to assess the performance of decision support system and growth trajectory model, targeted experiments were carried out. A total of 200 students of different grades in a middle school were selected as samples to track the data of one school year. During the experiment, the improvement of students' academic performance and the change of their interest in learning were recorded.

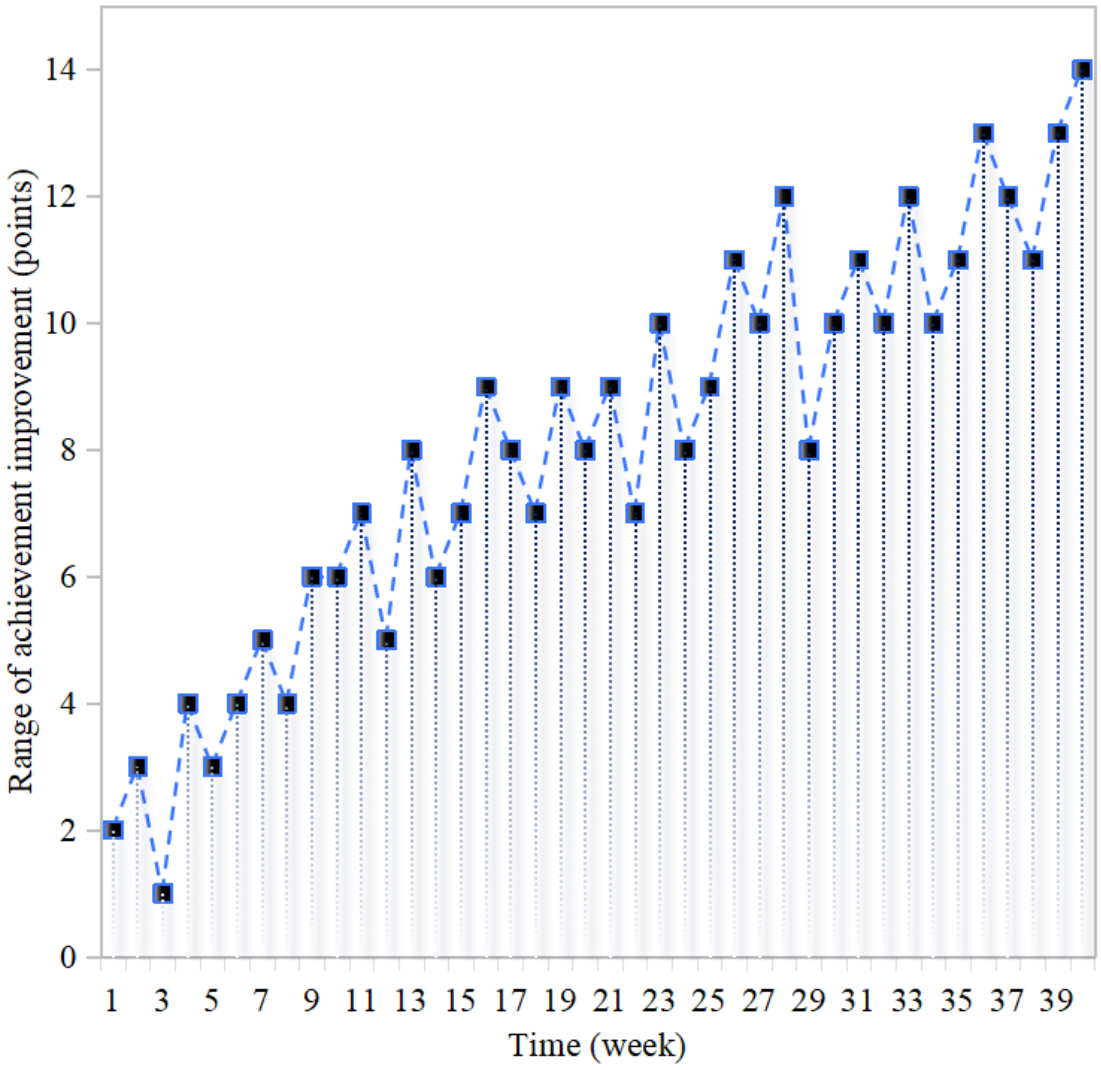

Figure 2 The improvement of students' academic performance changes with time

Figure 2 shows the dynamic changes of students' academic performance improvement at different time points. From the first week, some students have a small improvement in the initial stage. With the passage of time, after the implementation of individualized education decision, most students' grades have increased significantly, showing an upward trend. This shows that the decision support system has a positive impact on the improvement of students' grades.

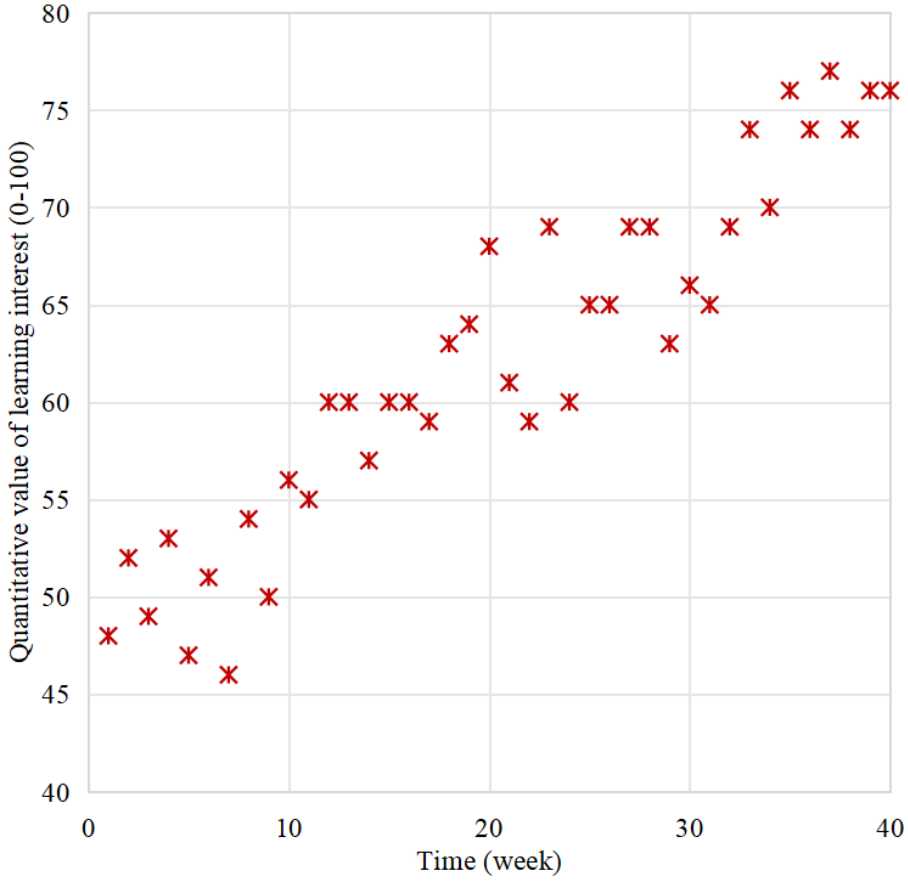

Figure 3 The changing trend of students' interest in learning.

Figure 3 shows the fluctuation of students' interest in learning. At the beginning of the experiment, the quantitative value of students' interest in learning fluctuated around 50, and from the 10th week, with the adjustment of individualized education strategies, the quantitative value of students' interest in learning gradually increased, which reflected that the decision support system had a certain effect on stimulating students' interest in learning.

Table 1: Evaluation Indicators Table for Model Performance

Evaluation Indicator	Value
Accuracy	85%
Recall	82%
F1 Score	83.4%
Mean Squared Error	4.8
Precision	86%
Specificity	83%

Table 1 assesses the performance of the model from multiple dimensions. The table includes accuracy, recall, F1 value, mean square error and other indicators. According to the data in the table, the accuracy rate is 85%, the recall rate is 82%, the F1 value is 83.4%, and the mean square error is controlled within 5.2. These data show that the model has high accuracy and reliability in predicting students' growth trajectory, and can provide strong support for decision support system, thus effectively assisting educators to make scientific and reasonable individualized education decisions.

5. Conclusions

This article focuses on the modeling and decision support of students' individualized growth trajectory under AI empowerment, and has achieved practical guiding results. In the aspect of modeling, this article establishes a modeling idea based on multi-source data acquisition and AI

algorithm by establishing the goal of comprehensively and accurately depicting students' individualized growth and predicting their growth trend. Based on this, a complete model architecture including data layer, feature engineering layer, model training layer, model evaluation layer and application layer is designed. This framework realizes the deep mining and analysis of students' multi-dimensional data, can accurately outline the growth trajectory of students, and provides a reliable basis for subsequent decision support.

The decision support system takes this model as the core, and each module works closely together, from data collection and processing to intelligent analysis, and then to generating specific decision suggestions, forming an organic whole. The results strongly prove the effectiveness of the model and decision support system. The model performs well in key indicators such as accuracy and recall, which reflects its reliability in predicting students' growth trajectory. At the same time, by tracking the improvement of students' academic performance and the change of their interest in learning, we can know that the individualized educational decision provided by the decision support system has effectively promoted the positive development of students' academic performance and interest in learning.

This study has introduced innovative methods and concepts into the field of education, realized the accurate modeling and effective decision support of students' individualized growth trajectory with the help of AI technology, and provided scientific basis and powerful tools for educators to implement individualized teaching. However, the study also recognizes that there is still room for further optimization and exploration in the universality and adaptability of the model to more complex educational scenarios, and it is expected to be continuously improved by expanding data sources and optimizing algorithms in the future.

References

[1] Ge Xinyong, Dai Shaodong, Deng Lei. Digital-Intelligent Panoramic Profiling Empowers Developmental Student Assessment: Mechanisms, Challenges, and Pathways[J]. Journal of Southwest University (Social Sciences Edition), 2025, 51(01): 216-226+306. DOI:10.13718/j. cnki. xdsk.2025.01.017.

[2] Fan Minsheng, Wu Fati. Design of a Data-Driven Dynamic Learning Intervention System[J]. e-Education Research, 2020, 41(11): 87-93. DOI:10.13811/j.cnki.eer.2020.11.012.

[3] Zeng Fanzhi, Xu Luqian, Zhou Yan, et al. A Survey of Knowledge Tracing Models for Smart Education[J]. Journal of Frontiers of Computer Science and Technology, 2022, 16(08): 1742-1763.

[4] Li Xiangyong, Zuo Mingzhang, Wang Zhifeng. Research on a Data-Driven Adaptive Learning Analytics Model[J]. Modern Educational Technology, 2017, 27(10): 19-25. DOI:CNKI: SUN: XJJS. 0.2017-10-004.

[5] Wang Xiaogen, Lü Jialin. From Learner Model to Learner Digital Twin: A Review of Learner Modeling Research[J]. Distance Education Journal, 2021, 39(02): 53-62. DOI:10.15881/j. cnki. cn33-1304/g4.2021.02.006.

[6] Peng Hongchao, Zhu Zhiting. Analysis of Personalized Adaptive Learning Strategies Supported by Human-Computer Collaborative Decision-Making[J]. e-Education Research, 2019, 40(02): 12-20. DOI:10.13811/j.cnki.eer.2019.02.002.

[7] Yang Lina, Wei Yonghong, Xiao Kexi, et al. Research on the Mechanism of Educational Big Data-Driven Personalized Learning Services[J]. e-Education Research, 2020, 41(09): 68-74. DOI: 10.13811/j.cnki.eer.2020.09.010.

[8] Xiong Yu, Zhang Jian, Wang Ying, et al. An Evolutionary Knowledge Tracing Model Based on Deep Learning[J]. e-Education Research, 2022, 43(11): 23-30. DOI:10.13811/j.cnki. eer.2022.11. 003.