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Constructing an Instructional Pathway for Thinking Visualization in Senior High School English Reading Empowered by Generative Artificial Intelligence

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Abstract

Against the background of the deep integration of artificial intelligence technology and education, generative AI provides new technical support for higher-order thinking cultivation and metacognitive training in senior high school English reading instruction. Most of the current research focuses on reading result analysis and static visualization. It lacks dynamic tracking of students' reading and thinking process, and has not yet formed a systematic instructional pathway supported by AI. Based on this, this study takes the senior high school English reading class as the foothold to build the instructional pathway of "data collection - AI-based intelligent analysis - dynamic visualization - emotional support - instructional intervention", and develops instructional designs in combination with specific texts. This path helps to improve the visualization of students' thinking processes during reading and the ability of metacognitive monitoring, enhance the effectiveness and precision of English reading instruction, and provide reference for the innovation of senior high school English reading instruction supported by artificial intelligence.

Keywords

generative artificial intelligence, senior high school English reading, thinking visualization, metacognition, instructional pathway

1. Introduction

In recent years, new technologies represented by Generative Artificial Intelligence (hereinafter referred to as AI) have continuously entered the field of education. With the continuous advancement of digital strategy, AI technology has been applied in many instructional settings. Especially in senior high school English reading instruction, the introduction of AI not only helps to improve teaching efficiency, but also provides technical support for the cultivation of students' higher-order thinking ability and personalized learning.

However, in daily teaching, "emphasizing outcomes while neglecting processes" is still a common phenomenon. Teachers still face two major problems: First, students' thinking during reading is invisible and intangible, and it is difficult to diagnose [1]; Second, metacognitive training lacks concrete tools, which can only be emphasized verbally, and it is difficult to put it into practice [2].

In recent years, research has begun to pay attention to the application of thinking visualization and AI technology in English reading instruction. The application of AI in the scope of English reading covers personalized resource recommendation [3], error diagnosis and other contents [4]. However, most of the existing studies focus on static visualization tools, or focus on the auxiliary analysis of learning results by AI. They rarely really track the dynamic thinking changes of students from reading to understanding, and rarely form a replicable and operable systematic instructional pathway between AI analysis, thinking visualization and metacognitive training.

Based on this, this study takes senior high school English reading instruction as the scenario, tries to build an instructional pathway of "data collection - AI-based intelligent analysis - dynamic visualization - emotional support - instructional intervention", and explores its classroom realization path in combination with specific teaching cases, in order to provide theoretical and practical reference for the innovation of senior high school English reading instruction under AI support.

2. Practical Challenges in Senior High School English Reading Classrooms

2.1 Difficulties in Effectively Visualizing the Reading Thinking Process

With the advancement of the core literacy of English subjects year by year, senior high school English reading instruction has gradually changed from language knowledge learning. However, in the actual teaching classroom, teachers usually pay more attention to reading results and pay less attention to students' thinking in the reading process. This makes it difficult for students to clearly talk about their reading strategies and thinking paths even though they can complete the reading tasks. Therefore, it is difficult for higher-order thinking training and metacognitive cultivation to be truly implemented in the classroom.

2.2 Lack of Effective Approaches to Metacognitive Training

Metacognitive theory [5] was proposed by Flavell (1979), which includes the understanding, experience and regulation of one's own cognitive process [6]. It can help students monitor the use of strategies, optimize the efficiency of understanding, and connect shallow information acquisition and deep thinking development, which is crucial to the formation of lifelong learning ability [7]. However, in English reading instruction, it is difficult to capture students' thinking process, teachers cannot accurately diagnose learning pain points, and it is difficult for students to independently monitor the use of reading strategies.

2.3 Limitations of Existing Applications of Thinking Visualization

Mind maps, concept maps and other tools have been proven to help students sort out information and build logic [8]. Under a multi-modal perspective, visualization can also combine text, images and other resources to enhance understanding [9]. However, most of these methods present the results after reading. They do not pay enough attention to the dynamic characteristics such as the gradual formation, correction and stuttering of ideas in the reading process, and are highly dependent on teachers' manual analysis. The feedback is slow and the accuracy is limited, and the technical advantages of AI are not really used.

In summary, how to realize reading process collection and thinking visualization with the help of generative AI, and support metacognitive training, has become an important direction for the current optimization of senior high school English instruction.

3. Construction of an AI-empowered Instructional Pathway for Thinking Visualization in Senior High School English Reading

Drawing on the research idea of combining The Design-Based Research (DBR) theory and teaching practice, this research emphasizes the construction, testing and optimization of educational intervention schemes in real classroom situations. The DBR approach not only emphasizes the rigor of theoretical construction, but also pursues the practical usability of research results, which is more suitable for new teaching models and classroom path research.

The establishment of the instructional pathway is mainly based on three considerations. Metacognitive theory emphasizes that learners have the behavior of planning, monitoring and regulating the cognitive process, and the instructional pathway should help students show the thinking process in reading. Thinking visualization emphasizes the presentation of cognitive activities in diagrams to help students understand the logic of the article and the loopholes of their own thinking. Generative AI enables timely feedback, learning analysis, content generation and other functions, which can provide conditions for dynamic diagnosis and personalized support in the reading process.

Based on the above theoretical foundation and teaching needs, this study integrates metacognitive theory, multimodal discourse analysis framework [10] and attention mechanism technical principle [11], and establishes an English reading thinking visualization pathway of "data collection - AI-based intelligent analysis - dynamic visualization - emotional support - instructional intervention".

4. Design of the Instructional Pathway

Based on the DBR methodology and core design principles, the instructional pathway of this study is divided into five implementation steps: "data acquisition - AI-based intelligent analysis - dynamic visualization - emotional support - instructional intervention". The process is as follows.

4.1 Reading Process Data Collection

Teachers use the digital reading platform to let students complete the reading and leave traces of the process through highlighting, annotation, recording, etc. Students should circle the key points and record the questions, logical relationships and feelings in the reading. At the same time, the platform automatically records the reading time, paragraph dwell time, page jump and other behavioral data. Multi-dimensional information collection can realistically reconstruct students' thinking processes during reading and provide support for follow-up instruction.

4.2 AI-based Intelligent Analysis Design

AI conducts a preliminary analysis of students' thinking characteristics in the reading process by integrating multiple types of learning data. AI combines highlighting, annotation and other operation behaviors to judge the key content and thinking nodes of students when reading; AI combines the text content and the characteristics of learning behavior to extract students' logical reasoning ideas; AI analyzes the information collation method from the reading behavior, and judges the level of students' self-monitoring reading from the log content. AI tools will ultimately identify specific problems according to students' reading focus and behavioral characteristics and give corresponding explanations for the reasons, so that teachers can observe why students encounter difficulties.

4.3 Thinking Visualization Design

In order to solve the problem of "invisible thinking", teachers can use AI to generate mind maps, etc., and turn abstract ideas into intuitive charts. Students can clearly see the deviation between the structure of the article and their own understanding at a glance, and teachers can also quickly grasp the common problems of the class. By comparing personal mind map and reference mind map, it is easier for students to reflect and adjust their reading strategies, thus improving the ability of metacognitive monitoring.

4.4 Design of Instructional Intervention Strategies

Teachers carry out accurate interventions based on AI analysis and visualization results. For students with confused logical structure, they can be guided to reconstruct the text argumentation framework; for students with incomplete information extraction, they can be organized to carry out key information positioning training; For students who have obvious fear or anxiety in the reading process, students' reading self-confidence can be enhanced through the positive feedback mechanism [12]; In addition, teachers can also combine visual charts to guide students to compare the differences between their own thinking process and the standard model, reflect on the effect of using reading methods, and further strengthen the higher-order thinking training in reading.

4.5 Personalized Feedback and Iterative Optimization

After the reading activity, AI generates a personalized reading report for each student, pointing out the advantages, problems and suggestions for improvement. Teachers combine classroom performance and student feedback to constantly adjust the visualization form, task difficulty and activity design to ensure that the AI-enabled English reading instructional pathway continues to adapt to students' needs and teaching reality.

5. Instructional Case Design

5.1 Case Background

In order to verify the operability of the above path, this article takes the People's Education Edition of High School English Compulsory Volume 2 Unit 1 Reading Text From Problems to Solutions as an example for case design. The theme is “Balance between Development and Cultural Heritage Protection”. The structure is clear and the logical chain is complete. It not only fits the cognitive level and language ability of senior high school students, but also provides a sufficient carrier for information extraction, logical organization, contradiction analysis, critical thinking and other higher-order thinking activities. It can better present students' common cognitive difficulties and metacognitive monitoring problems in reading. Therefore, it is suitable as a case text for AI-enabled thinking visualization in English reading instruction.

5.2 Demonstration of the Instructional Process

Based on the closed-loop instructional pathway of “data collection-AI-based intelligent analysis-dynamic visualization-emotional support-instructional intervention” constructed in this study, this study takes the second volume of senior high school English compulsory volume 2 Unit 1 reading text From Problems to Solutions as the instructional material to carry out instructional design.

5.2.1 Multimodal Reading Data Collection

In the initial stage of instructional implementation, teachers push the text From Problems to Solutions to students in the experimental class through the digital reading platform, and design a structured reading task list to guide students to form process data that can be analyzed during the reading process.

Students need to complete three types of tasks in the process of reading. The first is the text annotation task. When reading, highlight important information, and use the annotation tags provided by the platform to mark problems, logic and emotions, focusing on the advantages and disadvantages of dams, protective measures and other key information. Next is the logging task. Students need to fill in a short log after each paragraph of reading to record the thinking process, the source of obstacles, the use of strategies and the emotional experience in reading, such as “The passive voice of paragraph 4 is difficult, and it can be understood after splitting”. Finally, the behavioral trajectories are automatically recorded. The platform automatically collects students' reading time, dwell time, jump trajectory and other behavioral data synchronously. If a student repeatedly stays in a paragraph without annotating much, it may mean that it has difficulties in conceptual understanding.

5.2.2 Example of Ai-based Intelligent Analysis

After completing the data collection, integrate interpretation with the help of AI technology: if the student lacks attention to the core target phrase such as “prevent the loss of cultural relics”, but frequently marks digital details such as “$80 million” in the full text, it means that the student's reading is still only a simple extraction of details and has not yet formed the ability to integrate the topic. The AI system will classify this phenomenon as a deviation in the extraction focus. If the student‘s analysis of the text logic chain only stays at the level of “building dams - demolishing monuments” and fails to identify the target logical path of “dam construction - flooding monuments - international collaboration - migration of monuments”, AI can judge that there is a break in causal reasoning or chapter structure integration, and generate hints for missing logic chain; If the student mentions in the log “I found that I misunderstood paragraph 3, so I returned to the title to re-judge the topic”, it can be regarded as strong metacognitive monitoring; while if the student only writes “This paragraph is too difficult”, it may indicate that although it is difficult to perceive, it lacks strategic adjustment.

AI can also integrate behavioral data to identify the source of students' potential difficulties. For example, students stay on the passive voice sentence of paragraph 4 of the text “temples and other cultural sites were taken down piece by piece by piece” for a long time and read it repeatedly, but the correct rate of logical questions is not bad, so the problem may be more due to language form barriers than insufficient cognitive ability.

5.2.3 Example of Thinking Visualization

In order to solve the long-term dilemma of invisible thinking in English reading teaching, this study generates two types of visualization results on the basis of AI analysis.

AI generates a hierarchical mind map based on the semantic analysis of students' annotations and log contents. The map takes “Problem–Conflict–Solution–Outcome” as the main axis, presenting students' understanding of the overall structure of the text. For example, for students who can fully identify the “Aswan Dam Construction Causes Cultural Crisis - United Nations Global Cooperation - Monument Migration - Win-Win”, the mind map structure is usually clear; And the map of students who break the logic chain may miss one or some nodes. Teachers can quickly find group problems by comparing different mind maps.

AI combines emotional words (such as difficult, confused, interesting) and behavioral stagnation characteristics in the reading log to mark the key areas that trigger high-frequency emotional reactions in the text in the form of emotion heat maps. For example, if there is a high-frequency confusion prompt in the complex passive sentence area of paragraph 4, the teacher can focus on the explanation in the follow-up class.

5.2.4 Example of Instructional Intervention Strategies

In the instructional intervention stage, teachers carry out targeted instructional interventions based on AI analysis results and visualization mind map.

In response to the problem of information extraction deviation, teachers can carry out core information positioning training, provide accurate attribution and adjustment suggestions, and design a positive feedback mechanism, such as giving students who have successfully sorted out the international collaboration process the title of “ Logic Organizer Award” to enhance their reading self-efficacy.

In response to the problem of logical hierarchy chaos, teachers can design the task of “ discourse logic reconstruction”, requiring students to rely on the visual map to re-sort the text logic steps in the article From Problems to Solutions, and explain the relationship between each step, so as to strengthen students' causal reasoning and structural awareness.

In response to the problem of insufficient metacognition, teachers can guide students to review their thinking path and ask them to explain orally or in writing “how they initially understood, where there were deviations, and how to correct them later”. This process can truly transform AI feedback into self-monitoring ability.

5.2.5 Personalized Feedback and Iterative Optimization

After the teaching, AI generates a customized feedback report for each student, including reading advantages, core issues, strategic suggestions and follow-up tasks. For example, for students with strong logical thinking but not detailed information extraction, the system may suggest that they strengthen keyword positioning; For students who can identify difficulties but lack strategic adjustment, it is recommended to increase the reading reflection task; for students who have positive emotional experience but weak self-monitoring, it is recommended that they self-check for thinking loopholes according to the standard mind map after reading; For students whose reading is blocked due to weak grammar foundation, it is recommended that they do special grammar exercises.

At the same time, teachers reflect on the instructional pathway of this round in combination with classroom observation, student interviews and learning results. For example, if it is found that the mind map hierarchy is too complicated and the cognitive load of some students is too high, the mind map can be simplified in the next round; If it is found that students rely more on emotional prompts, emotional reflection links can be added to ensure that the instructional pathway continues to adapt to students' needs and teaching reality.

5.3 Analysis of Expected Outcomes

In order to investigate the implementation effect of AI-enabled instructional pathway for thinking visualization in senior high school English reading, this study intends to evaluate in a combination of quantitative and qualitative. Based on the framework of Yang Xiaohu and Zhang Wenpeng's (2002) *Metacognitive Knowledge Questionnaire*, the scale is adapted and modified in combination with the teaching characteristics of generative AI and thinking visualization to form the "AI-enabled English Reading Strategy Cognitive Scale for High School Students" applicable to this study. The scale mainly includes three dimensions: first, self-monitoring and emotional regulation cognition, which is used to examine students' ability to plan, monitor, reflect and regulate emotions with the support of AI feedback; The second is the cognition of reading strategies, which is used to examine students' mastery of strategies such as title prediction, logical organization, word and sentence understanding, critical evaluation and thinking review; The third is task adaptation cognition, which is used to examine whether students can choose appropriate AI-assisted strategies according to different text types and reading goals. In order to ensure the scientificity of the scale, relevant teachers and researchers will be invited to review the content validity of the questions before the official test, and their internal consistency and structural rationality will be tested through pre-testing. The data collection will be carried out by three uniformly trained high school English teachers. All scales will be distributed and recycled in the classroom, and the whole process will be completed within 60 minutes.

6. Discussion and Conclusion

This research builds a generative AI-enabled high school English thinking during reading visualization instructional pathway around "data collection-AI-based intelligent analysis-dynamic visualization-emotional support-instructional intervention", and makes a preliminary exploration of its implementation process through instructional cases. With the help of AI, this study transforms annotations, logs and behavioral trajectories into a viewable spectrum, which helps to a certain extent the concretization and externalization of the metacognition process. On the other hand, this study emphasizes the dynamic tracking of the formation process of thinking during reading by AI, which can help teachers more accurately identify the specific difficulties of students in higher-order thinking activities, so as to improve the relevance of instructional intervention. In terms of teaching practice, this study can also provide a certain practical path reference for senior high school English reading instruction.

There are still certain limitations in this study. The research mainly focuses on the construction of instructional pathways and case design. Large samples and long-term empirical tests have not been carried out, and the relevant conclusions need to be further verified. At the same time, some schools have insufficient digital equipment and limited platform functions, and the adaptability of the path needs to be optimized. In the future, we can expand the scope of research, carry out a longer cycle of empirical research, optimize tools and processes in combination with different teaching conditions, improve the applicability of the path, and further enrich the relevant research on AI-enabled thinking visualization teaching.

References

[1] Jin, S., Tian, J., & Xu, X. (2018). Instructional design for junior high school English reading based on thinking visualization. *Modern Primary and Secondary Education, 34*(5), 43–46.

[2] Lin, X. (2019). Constructing thinking visualization classrooms from a multimodal perspective: A case study of senior high school English reading instruction. *Teaching and Research for Primary and Secondary School English*, (4), 18–23.

[3] Yu, G., Li, F., & Teng, W. (2024). AI plus education: Upgrading and transforming teaching models in the age of artificial intelligence. *Social Sciences in Ningxia*, (2), 191–198.

[4] Dong, Y., Yu, X., Alharbi, A., & Ahmad, S. (2022). AI-based production and application of English multimode online reading using multi-criteria decision support system. *Soft Computing, 26*(17), 10927–10937.

[5] Flavell, J. H. (1979). Metacognition and cognitive monitoring: A new area of cognitive-developmental inquiry. *American Psychologist, 34*(10), 906–911.

[6] Wang, L., & Guo, D. (2000). The nature and components of metacognition. *Acta Psychologica Sinica, 32*(4), 458–463.

[7] Yang, X., & Zhang, W. (2002). Metacognition and English reading comprehension among Chinese college students. *Foreign Language Teaching and Research, 34*(3), 213–218.

[8] Gao, A. (2022). An analysis of thinking visualization strategies in primary school English reading instruction. *Journal of Fujian Institute of Education*, (12), 91–94.

[9] Xiang, Y., & Fang, C. (2024). Artificial intelligence-empowered multimodal college English reading instruction: An exploration of instructional models. *Anhui Education Research*, (30), 76–78.

[10] Zhang, D. (2009). Exploring an integrated theoretical framework for multimodal discourse analysis. *Chinese Foreign Languages, 6*(1), 24–30.

[11] Zhu, Z., Rao, Y., Wu, Y., Qi, J., & Zhang, Y. (2019). Research progress on attention mechanisms in deep learning. *Journal of Chinese Information Processing, 33*(6), 1–11.

[12] Shao, S. (2025). The role of AI tools on EFL students' motivation, self-efficacy, and anxiety: Through the lens of control-value theory. *Learning and Motivation, 91*, 102154.

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Conflicts of Interest

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