

Research on the Practice of AI-Enabled Student Development Guidance Based on Subject Teaching

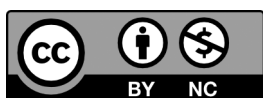
— A Case Study of Precision Teaching in High School Physics Circuit Review

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Abstract: Under the dual context of the digital transformation of education and the deepening of student development guidance, high school physics teaching must break away from the traditional positioning of “being dominated by knowledge transmission” and assume a new mission of “taking disciplines as the foundation and fostering students’ all-round development”. Taking the review teaching of the “Constant Current” unit in high school physics as a practical vehicle, this paper constructs a closed-loop student development guidance framework based on data-driven methodologies and AI technology, characterized by “pre-class diagnosis to pinpoint development bottlenecks — in-class hierarchical intervention to boost development — post-class verification to assess development outcomes”. Grounded in physics disciplinary knowledge, this study focuses on the role of AI technology in accurately aligning with students’ needs, cultivating core competencies, and facilitating personalized development, thereby verifying the feasibility of the student development guidance pathway within the context of disciplinary teaching. Practical results demonstrate that this model significantly enhances indicators such as students’ autonomous learning participation rate and the accuracy of tasks related to logical thinking. Most students can clearly perceive the improvement of their own abilities, providing a replicable “technology + discipline” integration paradigm for student development guidance.

Keywords: Data-driven; AI-powered; High school physics; Student development guidance



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1 Introduction

Student development guidance is one of the core issues in education in the new era. Its essence lies in “student-centeredness”, accurately matching the needs of different students for ability improvement, emotional growth, and personalized development (Zhang, 2024). Currently, the education field faces the problem of “obvious utilitarianism of score-only evaluation, neglecting students’ individuality and evaluating students with a single standard”. This leads to the lack of students’ learning autonomy, suppressed intrinsic motivation, and even mental health risks (Qiao, 2024). The core pain points of current student development guidance are twofold: first, vague demand identification, which mostly

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relies on teachers' experience to judge students' development shortcomings, lacking precise positioning supported by data; second, homogeneous support strategies, which are difficult to provide differentiated guidance for students with different ability levels and learning styles, and are easily separated from subject teaching, resulting in "disconnected development guidance".

As a discipline with both logicity and applicability, high school physics teaching naturally undertakes the functions of "ability training" and "thinking cultivation". For example, circuit analysis requires step-by-step reasoning, which can train logical thinking; experimental design requires independent inquiry, which can improve problem-solving ability. This provides a natural foundation for "taking disciplines as the foundation and integrating student development guidance", aligning with the core view that "the fundamental path of student development guidance lies in the cultivation of subject learning ability and active experience and inquiry" (Zhang, 2024). Previously, the author carried out AI-enabled precision teaching practice in high school physics with the review teaching of the "Constant Current" unit as the entry point, accumulating basic materials such as student learning data and teaching intervention strategies. Based on this, this study further takes physics as the background, focuses on the core question of "how subject teaching can serve student development", and explores the implementation path of AI-enabled teaching innovation practice in student development guidance.

In existing research, Shi (2020) pointed out that traditional physics review classes are "overly teacher-led and lack sufficient student participation" (Shi, 2020), which essentially reflects the teaching tendency of "valuing knowledge over development"; Ren & Wang (2025) proposed "backward design" which emphasizes goal orientation (Ren & Wang, 2025), providing ideas for "deriving teaching strategies from student development goals"; Wang Mei's "data-driven precision teaching" verified the supporting role of technology in teaching optimization (Wang, 2025). Building on these studies, this research expands the application scenario of "data and technology" from "subject knowledge teaching" to "student development guidance", forming a more targeted practical path.

2 Core Philosophy: Three Logics of AI-Enabled Student Development Guidance

Based on the core goal of "taking disciplines as the foundation and promoting student development", this study constructs a logical framework of "data-driven — evidence-based support — AI empowerment" for student development guidance, upgrading the integration point of AI technology and physics teaching from "subject tool assistance" to "core of development support".

2.1 Data-Driven: From "Subject Knowledge Diagnosis" to "Student Development Profiles"

Data collection in current physics teaching mostly focuses on "knowledge mastery" (such as knowledge point accuracy rate and error types). In contrast, data collection in this study is based on physics discipline assessment and places more emphasis on "development-related indicators". Three types of student data are collected through the digital teaching platform: first, learning behavior data (such as answering time and the number of answer modifications in pre-class circuit tests), reflecting students' willingness for autonomous learning and inquiry habits; second, task performance data (such as real-time note-taking trajectories and the logicity of experimental design schemes in class), mapping students' logical thinking and innovative abilities; third, feedback and interaction data (such as the number of student speeches and task completion rate), reflecting students' learning confidence and participation. Based on these three

types of data, AI tools are used for analysis to not only locate physics knowledge gaps but also explore the underlying student development pain points. Furthermore, AI tools are used to integrate multi-dimensional data to generate student development profiles including “ability level (basic/advanced/innovative), learning style (active inquiry/passive acceptance), and development needs (confidence improvement/ability breakthrough/habit formation)”, providing precise basis for subsequent guidance strategies and realizing “promoting personalized school education centered on students”.

2.2 Evidence-Based Support: From “Subject Teaching Intervention” to “Development Demand Adaptation”

The core of “evidence-based support” is “designing targeted teaching strategies based on students’ development pain points”. In teaching practice, physics discipline tasks are used as the implementation carrier to develop students’ abilities while solving real problems. For example, for students with “weak logical thinking” in the development profile, instead of directly explaining the knowledge itself, thinking training of “step-by-step reasoning” is embedded based on subject tasks — first guiding students to cultivate information extraction ability, then establishing orderly thinking habits, and finally strengthening self-verification awareness; for students with “insufficient learning confidence”, instead of rushing to promote complex subject tasks, starting with simple and basic subject knowledge questions, and through AI real-time feedback of affirmative information such as “correct answer”, helping students accumulate successful experiences, gradually build confidence, and improve students’ self-efficacy through achievement experiences.

This “evidence-based” logic breaks through the limitation of “subject knowledge centrism”: physics tasks are the “basic carrier”, and student development is the “ultimate goal”. Through hierarchical subject tasks, students’ “ability to transform needs into solutions” is cultivated, realizing the synchronous advancement of “subject knowledge learning” and “problem-solving ability development”, and promoting personal development through subject experience.

2.3 AI Empowerment: From “Subject Tool Assistance” to “Development Support Upgrade”

The application of AI technology in this study is no longer just auxiliary tools such as “virtual simulators for physical experiments” and “error question generators for knowledge points”, but the “core support for student development guidance”, mainly reflected in three functions: first, dynamic matching function — based on student development profiles, AI automatically pushes adaptive learning resources and tasks, realizing precise connection between “development needs and guidance strategies” and personalized intervention in students’ development problems; second, process visualization function — through AI tools, students’ thinking processes and ability changes are converted into visual charts, allowing students to intuitively perceive their own development progress, strengthen self-planning awareness, and help students form personal career goals; third, personalized feedback function — the feedback generated by AI is no longer only about “how to understand and apply subject knowledge”, but about “being able to extract key conditions in analyzing subject problems, but needing to pay attention to the reasoning order from overall to local to solve more complex subject problems”, extending subject feedback to general ability development guidance.

3 Practical Path: Implementation of Student Development Guidance with “Constant Current” Review as the Carrier

Taking the review of the “Constant Current” unit as the subject carrier, and according to the theory that “subject

learning is the fundamental path of student development guidance” (Fan & Qiao, 2017), the student development guidance is integrated into all links of physics teaching in accordance with the closed-loop process of “pre-class diagnosis — in-class intervention — post-class verification”. The specific implementation is as follows.

3.1 Pre-Class: AI Diagnosis — Pinpointing Students’ Development Pain Points

3.1.1 Introduction to the Subject Knowledge Carrier

The “Constant Current” unit is selected as the carrier for three core reasons related to its knowledge characteristics: first, “circuit analysis” requires students to have systematic thinking and conduct step-by-step reasoning, which can carry “logical thinking training”; second, “circuit design” can be combined with real-life scenarios (such as automatic street lights and anti-theft alarms), which can stimulate “inquiry awareness and problem-solving ability”; third, the knowledge difficulty is clearly hierarchical (from basic Ohm’s law to complex dynamic circuits), which can adapt to the needs of students at different development levels.

3.1.2 Design and Implementation of AI Diagnosis

Based on student development goals, “pre-class diagnostic tasks for Constant Current” are designed on the basis of physics discipline assessment, including three types of questions: first, basic operation questions (such as connecting simple series circuits), corresponding to the goal of “building learning confidence”; second, logical analysis questions (such as the impact of changes in sliding rheostat resistance on current in dynamic circuits), corresponding to the goal of “logical thinking training”; third, open design questions (such as “how to make street lights turn on automatically at dusk”), corresponding to the goal of “innovation and problem-solving ability”. Tasks are pushed through the digital platform, and AI tools collect data such as “answering time, step completeness, and scheme innovation”.

3.1.3 Diagnostic Output: “Student Development Pain Point Analysis Report”

AI tools analyze the collected data, focusing on development pain points with reference to physics knowledge mastery, and form core conclusions:

Ability pain points: 45% of students have the problem of “disordered logical reasoning”. For example, in dynamic circuit analysis, students skip “total resistance change” and directly judge local current; 30% of students have “weak inquiry awareness”. For example, only about 20% of students propose specific schemes for open design questions, while the rest give up directly.

Demand differences: Based on the data that the accuracy rate of basic questions is 88.9% but the schemes of open questions are single, the excellent group (top 24.1%) is determined to need “innovation ability expansion”; based on the data that the accuracy rate of basic questions is 77.8% and the accuracy rate of logical questions is only 40%, the intermediate group (51.7%) is determined to need “logical thinking strengthening”; based on the data that the accuracy rate of basic questions is 61.1% but the average number of answer modifications is 3 times, mostly showing “daring not to submit”, the weak group (24.1%) is determined to need “learning confidence building”.

Habit shortcomings: 60% of students do not check steps after answering, leading to simple calculation errors and a lack of “self-verification habits”, reflecting the development problem of “weak metacognitive ability”.

The diagnostic results accurately show problems such as “lack of sense of achievement, low self-efficacy, and insufficient autonomy” among some students.

3.2 In-Class: AI Intervention — Hierarchically Promoting Student Development

Based on the development pain points identified in pre-class diagnosis, an in-class process of “situational introduction — hierarchical tasks — real-time support” is designed. With physics circuit tasks as the basic carrier, the core goal is to promote student development. The specific implementation is as follows.

3.2.1 Situational Introduction: Stimulating Inquiry Awareness with Real-Life Scenarios

Taking the “light control principle of automatic street lights” as the introductory scenario, the real-life phenomenon of “dusk → street lights on” is displayed, and the question “how to realize this function with a circuit?” is raised. Here, with physical principles as the background, students are guided to think about “what conditions are needed to realize ‘street lights on at dusk’” (such as “components for sensing light changes” and “switches for controlling circuit on/off”), encouraging students to put forward guesses and cultivating the inquiry awareness of “from real-life phenomena to problem-solving”. Digital tools record students’ guesses in real time as the basis for subsequent personalized support.

3.2.2 Hierarchical Tasks: Connecting Physical Carriers with Development Goals

AI tools are used to design three types of hierarchical tasks. Each type of task is based on “physical circuits” as the basic carrier, but it points to different development goals, and adaptive tasks are pushed according to student development profiles.

Basic-level tasks (adapting to the weak group): “Connect a simple series circuit using the virtual experiment platform to make the light bulb light up”. The task is based on physical operation skills. Through real-time feedback of “correct” from the virtual software platform after successful operation and prompts of “check wire connection” when steps are wrong, it helps students accumulate successful experiences and build learning confidence.

Advanced-level tasks (adapting to the intermediate group): “Analyze the change process of current in the circuit when the resistance of the sliding rheostat changes, and record the analysis steps in words”. The task is based on dynamic circuit knowledge. By pushing “step-by-step reasoning prompts” (such as “Step 1: Judge the change of total resistance; Step 2: Judge the change of total current according to Ohm’s law”), it trains students’ “orderly thinking”.

Innovative-level tasks (adapting to the excellent group): “Design a door and window anti-theft alarm circuit, and explain the principle of ‘door opened → alarm sounds’”. The task is based on circuit design knowledge. The focus is not on “the correctness of circuit design”, but on encouraging students to put forward diversified schemes (such as “using a reed switch as a switch” and “using a photoresistor to detect light in the door gap”). Teachers display different students’ schemes through the digital platform and mark “innovation points” (such as “this scheme uses common components in life and has strong practicality”), cultivating students’ innovative thinking and expression ability.

3.2.3 Real-Time Support: AI Dynamically Adjusting Development Guidance Strategies

During the class, the digital platform collects students’ task participation data throughout the process (such as operation time, step completeness, and number of speeches) and dynamically adjusts support strategies. For example, for students who “get stuck in operation for more than 5 minutes”, push “simplified task decomposition” (such as splitting “designing an alarm circuit” into “determining switch components → connecting power supply and alarm → testing functions”) to avoid damaging confidence due to excessively difficult tasks; for students who “speak less but have complete step records”, prompt teachers to “invite the student to share ideas” through the teacher terminal, encouraging

them to express themselves and enhance participation confidence; for students who “have highly innovative schemes but logical loopholes”, push “logical verification prompts” (such as “in your scheme, how does the switch ensure the alarm continues to sound after the door is opened?”), guiding them to self-improve and strengthen their metacognitive ability.

3.3 Post-Class: AI Verification — Focusing on Student Development Effects

Post-class verification refers to the quality of physics discipline task completion, designs verification dimensions around “student development goals”, collects data through the digital platform, and conducts comparative analysis with the help of AI tools.

3.3.1 Verification Dimensions and Data Collection

Three types of development effect verification indicators are designed, based on physical task performance and weakening disciplinary attributes:

Ability development indicators: Participation rate in autonomous learning (proportion of students who actively complete extended tasks after class), logical thinking performance (accuracy rate of “step-by-step reasoning questions” in non-physics disciplines), and problem-solving ability (number of submitted alarm circuit optimization schemes);

Emotional attitude indicators: Students’ confidence score (1-10 points, self-evaluation of “confidence in solving complex tasks”) and willingness to take active challenges (number of students registering for “interdisciplinary task design”);

Personalized breakthrough indicators: Improvement in the range of task completion quality of the weak group, and practicality improvement of innovative schemes of the excellent group.

AI tools analyze data collected from the post-class task platform and student questionnaire system, comparing changes before and after the course.

3.3.2 Verification Results: Significant Student Development Effects

After analyzing the data, AI tools generate the “Student Development Effect Comparison Report”, with core conclusions as follows (data are from 29 students in Class 10, Grade 10).

Ability development: The participation rate in autonomous learning increased from 30% before the course to 65%. 62.96% of students could completely record logical analysis steps (only 40% before the course), and the average number of alarm circuit optimization schemes submitted by the excellent group reached 2.3 versions (only 1 version before the course);

Emotional attitude: Students’ confidence score increased from 4.2 points before the course to 7.1 points. 82% of students stated in the questionnaire that “they could feel the progress of their problem-solving ability”, and 18 students actively registered for interdisciplinary tasks (only seven before the course);

Personalized breakthrough: The average quality of post-class task completion of the weak group improved by 37.04% (such as “being able to independently complete simple circuit analysis and record steps”) without relying on teachers’ prompts; 62.5% of the innovative schemes of the excellent group added “practical design” (such as “adding low-battery prompt function to the alarm circuit”). The comprehensiveness of problem-solving was significantly improved.

These results confirm the effectiveness of “promoting students’ autonomous development through subject experience”.

3.3.3 Student Feedback: Direct Evidence of Development Perception

In the post-class feedback collected by AI tools, many students mentioned the “help of subject tasks to general abilities”. For example: “By analyzing circuit steps, I now also disassemble steps first when doing math problems” (student from the intermediate group); “When designing the alarm circuit, both the teacher and AI praised my idea as interesting, and now I am more daring to try new things” (student from the weak group); “Seeing the comparison chart of my logical step records from ‘disordered’ to ‘complete’, I know I have really made progress” (student from the excellent group). These feedbacks further confirm the effectiveness of “student development guidance based on disciplines”.

4 Practical Effects and Reflections

4.1 Practical Effects: Three Breakthroughs in Student Development Guidance

Through the practice of “physics-based and AI-enabled” student development guidance, this study has achieved breakthroughs in three aspects:

More precise identification of development needs: Relying on AI tools to analyze collected data, breaking through the limitation of “teachers’ experience judgment”, accurately locating the development pain points of different students (such as “weak logic” and “lack of confidence”), making guidance strategies more targeted;

More integrated development support: Integrating student development guidance into the whole process of physics teaching, avoiding “disconnection between development guidance and subject teaching”, allowing students to naturally improve their abilities while completing subject tasks with higher acceptance;

More comprehensive verification of development effects: Establishing a multi-dimensional verification system of “ability + emotion + personalization”, not only focusing on “quantifiable ability improvement” but also attaching importance to “students’ subjective development perception”, comprehensively evaluating the guidance effect.

4.2 Practical Reflections: Two Directions for Optimization

Insufficient support for students with special needs: In practice, for students with “social anxiety and unwillingness to participate in group discussions”, only “individual tasks + AI feedback” are used for support, lacking more targeted social ability guidance strategies. In the future, it is necessary to combine AI’s “emotion recognition function” (such as judging students’ emotions through facial expressions and voices) to push “low-pressure social tasks”.

Insufficient collection of qualitative development data: Current data are mostly “quantitative data” (such as participation rate and accuracy rate), and there is insufficient collection of qualitative data such as “in-depth changes in students’ thinking processes” (such as the transformation of logical thinking from “passive acceptance” to “active construction”) and “long-term development of learning habits” (such as whether step-by-step reasoning methods are continuously used after class). In the future, it is necessary to optimize or select other digital tools to build a multimodal evaluation system for student development.

4.3 Future Outlook: From “Single Discipline” to “Interdisciplinary Integration”

In the future, the model of “student development guidance based on disciplines” will be further expanded. The

concept of “building a collaborative development guidance system” will be deepened (Qiao, 2024): first, expanding the scope of disciplines, applying the model to mathematics, chemistry and other disciplines to verify the generality of the model; second, deepening AI functions, introducing “AI growth files” to continuously track students’ interdisciplinary development changes and generate “personalized development suggestions”, implementing the goal of “helping students form career goals”; third, building a collaborative mechanism, integrating the “development guidance roles” of subject teachers, AI tools and students themselves, forming a collaborative system of “teachers set directions, AI adapts, and students drive themselves”, promoting student development guidance from “phased intervention” to “long-term support”.

5 Conclusion

Taking the review of the “Constant Current” unit in high school physics as the subject foundation, this study proves the feasibility of “deep integration of subject teaching and student development guidance”. By taking physics knowledge as the background, weakening the excessive explanation of specific details, and focusing on the supporting role of AI technology in students’ ability, emotional and personalized development, it can achieve the goal of “solving one circuit problem, practicing one thinking ability; attending one physics class, promoting one development progress”.

Student development guidance is “an urgent need to implement the fundamental task of moral education and a key to promoting students’ healthy growth” (Qiao, 2025). In the context of increasing attention to student development guidance, the path of “taking disciplines as the foundation and technology as the support” not only avoids the dilemma of “disconnected development guidance” but also gives play to the carrier value of subject teaching. In the future, with the deep integration of AI technology and education and teaching, the logic of “subject carrier — technology empowerment — student development” will provide reference for more disciplines, promoting student development guidance from “experience-driven” to “data-driven”, and from “homogeneous support” to “personalized empowerment”, ultimately enabling every student to form core literacy and achieve better development.

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