

Balancing Technological Empowerment and Competency Based Teaching Boundary Delineation and Multidimensional Effectiveness Evaluation of AI Assisted English Writing Teaching

Xinyue Xu

Anyang Vocational And Technical College, Anyang 455000, Henan, China

Corresponding author: Xinyue Xu (e-mail: day20221216@163.com)

ABSTRACT With the deep integration of artificial intelligence and education, AI-assisted English writing teaching has become an important direction for teaching innovation. However, blind application of AI tools may cause conflicts between technological empowerment and competency-based education, including students' excessive dependence on intelligent tools, marginalization of core writing ability, and blurred teaching boundaries. Focusing on the balance between technological empowerment and competency-based teaching, this study systematically explores the application boundaries of AI-assisted English writing instruction and constructs a multidimensional effectiveness evaluation system. Literature research, the Delphi method, and quasi-experimental research are used to clarify the connotation and theoretical basis of AI application boundaries, distinguish appropriate and prohibited domains of tool use, and establish an evaluation index system covering knowledge construction, ability development, emotional attitude, and teaching adaptability. A one-semester teaching experiment verifies the scientific validity and feasibility of the system. The study provides a structured framework for regulating AI-assisted writing instruction, improving teaching effectiveness, and ensuring that intelligent tools support rather than replace students' writing competence development.

INDEX TERMS AI-assisted teaching, english writing, application boundary, competency-based education, effectiveness evaluation

I. INTRODUCTION

A. RESEARCH BACKGROUND

IN the macro context of digital transformation in education, artificial intelligence technology is reshaping the paradigm of English teaching by enabling the intelligent synthesis and linguistic analysis of specialized industry knowledge. This evolution provides learners with sophisticated tools to navigate the complex terminology and technical discourse required for the global advancement of modern science. AI writing assistance tools (such as Grammarly, ChatGPT, WPS AI writing assistant, etc.) have been widely used in English writing teaching scenarios with core functions such as grammar correction, content generation, and structural optimization, providing technical support for improving teaching efficiency and personalized guidance. According to the 2024 China Education Digitalization Development Report, 83.7% of universities and 65.2% of primary and secondary schools in China have introduced AI assisted tools in English teaching, with English writing

being the most concentrated area of application [1-3].

Research questions and significance

Research question

This study focuses on the core objective of “balancing technological empowerment and capability based approaches” and addresses the following three key research questions:

How should the application boundaries of AI assisted English writing teaching be scientifically delineated? What are its core dimensions and division criteria?

How to build a multidimensional performance evaluation system that balances technological adaptability and capability development?

Based on the defined application boundaries and evaluation system, what is the actual impact of AI assisted English writing teaching on students' writing ability, learning attitude, and teaching quality?

B. RESEARCH SIGNIFICANCE

- 1) This study builds a theoretical framework for the application boundaries of AI-assisted English writing teaching within the context of professional discourse, enriching research on educational technology boundaries while providing theoretical support for the deep integration of intelligent systems and specialized subject teaching;
- 2) Establish a multidimensional effectiveness evaluation system, break through the limitations of existing single evaluation, and improve the theoretical paradigm of AI assisted teaching effectiveness evaluation;
- 3) Deepen the research on the collaborative mechanism between technological empowerment and competency based education, providing a new perspective for theoretical innovation in foreign language teaching under the background of digital transformation in education.

C. RESEARCH METHODS

- 1) Literature research method: Systematically review relevant literature in the fields of AI assisted teaching, English writing teaching, application boundaries, effectiveness evaluation, etc., clarify the research status and theoretical gaps, and lay a theoretical foundation for the research;
- 2) Delphi method: Invite 15 English education experts, educational technology experts, and frontline backbone teachers to form an expert team. After three rounds of consultation, determine the dimensions, standards, and performance evaluation indicators for the boundary division of AI applications.

II. THEORETICAL BASIS

A. COMPETENCY BASED EDUCATION THEORY

Competency Based Education (CBE) originated in the field of vocational education in North America in the 1960s.

The core idea is that education should focus on the development of students' abilities and their comprehensive ability to apply knowledge and skills to solve problems in real situations [4,5]. In English writing teaching, competency based education emphasizes that students should possess four core abilities:

language knowledge application ability (accurate use of vocabulary, grammar, and sentence structure), logic thinking ability (content organization, argumentation construction), innovative expression ability (uniqueness of view-points, diversity of expression), and metacognitive ability (self reflection, autonomous revision[6-7].

B. TECHNOLOGY ACCEPTANCE MODEL (TAM)

The Technology Acceptance Model (TAM) was proposed by Davis (1989), and its core idea is that users' acceptance of technology depends on perceived usefulness and perceived ease of use, with acceptance directly affecting the effectiveness of technology applications. Perceived usefulness refers to the degree to which users believe

that technology can improve work or learning efficiency; Perceived ease of use refers to the degree to which users perceive technology to be convenient to use [8-10].

C. ACTIVITY THEORY

The activity theory provides a systematic perspective for the boundary delineation and effectiveness evaluation of AI assisted English writing teaching: firstly, as an intermediary, the application of AI tools needs to conform to the overall goal of writing activities, which is to promote students' ability development, rather than simply pursuing the optimization of writing results; Secondly, boundary delineation needs to consider the interactive relationships between various elements in the activity system, such as the division of labor and collaboration between AI tools, teachers, and students (teachers are responsible for guiding and cultivating high-level abilities, while AI is responsible for assisting with mechanical tasks); Finally, performance evaluation should focus on the operational effectiveness of the entire activity system, rather than changes in a single element, which is highly consistent with the multidimensional evaluation approach of this study [11].

III. BOUNDARY DIVISION OF AI ASSISTED ENGLISH WRITING TEACHING APPLICATION

A. CORE CONNOTATION AND DIVISION PRINCIPLES OF APPLICATION BOUNDARIES

1) Core Connotation

The core connotation of application boundaries is "balance" - seeking a dynamic balance between technological empowerment and competency based approaches, which not only leverages the efficiency advantages of AI tools in mechanical and repetitive tasks, but also ensures the autonomous construction process of students' core competencies. Boundary delineation is not a fixed and unchanging rule, but an elastic framework that needs to be flexibly adjusted according to student level, task type, and teaching objectives [12-14].

2) Division Principle

- 1) Priority principle for ability cultivation: AI applications must prioritize the development of students' core writing abilities, and the use of tool functions should serve the cultivation of abilities, rather than simply pursuing writing results or teaching efficiency;
- 2) Principle of situational adaptation: Boundary delineation should be based on specific teaching contexts, including students' English proficiency (beginner, intermediate, advanced), writing task types (mechanical writing, creative writing, academic writing), and teaching stages (foundation stage, improvement stage) [15].

B. SPECIFIC DIMENSIONS AND DIVISION CRITERIA OF APPLICATION BOUNDARIES

Based on three rounds of expert consultation using the Delphi method, this study identified three major dimensions and eight sub dimensions of the application boundaries of AI assisted English writing teaching, and developed specific classification criteria (see Table 1).

C. DEFINITION OF “DELAYED INTERVENTION” FOR INTERMEDIATE-ADVANCED STUDENTS

The “delayed intervention” for intermediate-advanced students does not completely cut off AI support, but adopts a “selective delay + autonomous trigger” mode:

- During the writing process, AI defaults to turning off active intervention functions and only retains the basic function of grammar error marking;
- Students can independently trigger advanced support such as vocabulary replacement and sentence pattern optimization when encountering real difficulties;
- The core of delayed intervention is “independent thinking before tool assistance” rather than “complete lack of intervention”.

D. APPLICATION BOUNDARY ADAPTATION FOR DIFFERENT TYPES OF WRITING TASKS

The ability requirements for different types of writing tasks vary, and AI application boundaries need to be adapted accordingly (see Table 2).

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E. AI APPLICATION LOGIC FOR MECHANICAL WRITING

The core objectives of mechanical writing (e.g., vocabulary usage, sentence pattern imitation exercises) are “consolidating language knowledge + cultivating autonomous error correction ability”. The reasonable role of AI is “practice assistance + error correction feedback”:

- Practice stage: AI provides example prompts and error direction guidance (e.g., “This vocabulary collocation is incorrect; prompt: the common preposition collocated with ‘commit’ is ‘to’”);
- Feedback stage: After students submit answers, AI provides correct answers and explanations (e.g., “The correct collocation is ‘commit to doing’; a gerund form is required here because...”), realizing the teaching logic of “practice first, correction later”

IV. CONSTRUCTION OF A MULTIDIMENSIONAL EFFECTIVENESS EVALUATION SYSTEM FOR AI ASSISTED ENGLISH WRITING TEACHING

A. CORE IDEAS AND PRINCIPLES FOR CONSTRUCTING AN EVALUATION SYSTEM

1) Core ideas

The core idea can be summarized as “four focuses”: focusing on the development of core competencies, focusing

on the effectiveness of technological adaptation, focusing on the quality of the teaching process, and focusing on the learning experience of students. Through multidimensional and multi perspective evaluation, comprehensively capture the effectiveness of AI assisted English writing teaching, and provide comprehensive support for teaching optimization [16].

2) Construction principles

- 1) Systematic principle: The evaluation system should cover the core elements of the teaching process, including student abilities, teaching process, technology adaptation, learning attitude, etc., forming a complete evaluation framework;
- 2) Principle of scientificity: The design of evaluation indicators should be based on theoretical foundations and practical needs, with clear connotations and operable measurement methods to ensure the objectivity and accuracy of evaluation results;
- 3) Feasibility principle: Evaluation indicators should be concise and clear, data collection methods should be convenient and feasible, and overly complex evaluation processes should be avoided to increase the burden on teachers and students;
- 4) Developmental principle: The core purpose of evaluation is to promote teaching optimization and student development, rather than simply judging the results. The evaluation results should provide specific directions for teaching improvement [17-19].

B. STRUCTURE AND INDICATORS OF MULTIDIMENSIONAL EFFICIENCY EVALUATION SYSTEM

Based on the Delphi method expert consultation and relevant theoretical foundations, this study constructed a multidimensional effectiveness evaluation system covering four primary indicators, 12 secondary indicators, and 36 tertiary indicators (see Table 3) [20].

C. EVALUATION CRITERIA AND IMPLEMENTATION PROCESS

1) Evaluation Criteria

Using a 5-point rating system (1=very poor, 2=poor, 3=average, 4=good, 5=very good) to score each of the third level indicators, then calculate the scores of the second and first level indicators based on their weights, and finally obtain the comprehensive effectiveness score. The weight determination adopts the Analytic Hierarchy Process (AHP), inviting 10 experts to assign weights to each indicator. After consistency testing, the final weight is determined (see Table 4) [21].

2) Implementation Process

- 1) Evaluation preparation stage (1 week before teaching): Clarify teaching objectives and evaluation focus,

TABLE 1. Application Boundary Division of AI-Assisted English Writing Teaching

Core Dimension	Sub-dimension	Appropriate Application Scope	Prohibited Application Scope	Division Criteria
Application Scenario Boundary	Pre-writing Phase	Theme analysis, material recommendation, framework construction suggestions, vocabulary/sentence pattern reserve prompts	Complete writing outline generation, core viewpoint presets	Only provide heuristic support; do not directly give definitive results; reserve space for students' independent ideation
Application Scenario Boundary	Drafting Phase	Real-time grammar/spelling error prompts, vocabulary replacement suggestions, sentence pattern optimization suggestions (optional display)	Content modification, logical reconstruction, viewpoint supplementation	Only assist with language-level issues; do not interfere with content/logic construction; respect students' writing ideas
Application Scenario Boundary	Revision Phase	Error classification feedback, revision suggestion lists, language quality evaluation, personalized improvement plans	Direct essay revision, final draft generation	Provide revision directions and method guidance; do not replace students' independent revision process
Application Function Boundary	Language-level Functions	Grammar error correction, spelling check, punctuation standardization, vocabulary collocation suggestions, sentence pattern diversity optimization	No prohibited functions (to be combined with application timing)	Focus on language accuracy and standardization; do not involve content/logic aspects
Application Function Boundary	Thinking-level Functions	Idea inspiration, framework optimization suggestions, logical loophole prompts, argumentation angle expansion	Logical reconstruction, viewpoint generation, argumentation construction	Only provide heuristic prompts; do not directly construct the thinking process
Application Function Boundary	Emotional Support Functions	Writing progress feedback, encouraging evaluation, personalized learning suggestions	Negative evaluation, excessive intervention, emotional replacement	Support students' learning motivation; do not replace teachers' emotional interaction and personalized guidance
Application Timing Boundary	Basic-level Students	Pre-writing early intervention (material, vocabulary support), in-writing real-time intervention (grammar correction), post-writing detailed feedback	In-writing thinking-level intervention, pre-writing direct outline generation	Prioritize basic language ability support; gradually guide thinking development
Application Timing Boundary	Intermediate-Advanced Students	Pre-writing moderate intervention (idea inspiration), in-writing delayed intervention (grammar correction optional), post-writing high-level feedback	In-writing excessive language support, pre-writing detailed framework prompts	Reduce mechanical support; increase thinking challenges; promote independent development

TABLE 2. Application Boundary Adaptation for Different Writing Task Types

Task Type	Core Competency Requirements	Appropriate AI Application Methods	Prohibited AI Application Methods
Mechanical Writing (e.g., sentence pattern imitation, vocabulary usage exercises)	Accurate language knowledge application, basic skill consolidation	Real-time grammar error correction, vocabulary collocation prompts, sentence pattern optimization suggestions, error classification feedback	Content generation, thinking replacement, directly providing correct answers
Creative Writing (e.g., narratives, argumentative essays, prose)	Logical thinking, innovative expression, viewpoint construction	Pre-writing idea inspiration, material recommendation, framework suggestions; post-writing logical loophole prompts, expression diversity optimization suggestions	Complete content generation, viewpoint presets, logical reconstruction, direct modification of core expressions
Academic Writing (e.g., course papers, research reports)	Academic standard compliance, argumentation ability, literature integration ability	Academic vocabulary recommendation, format standardization prompts, citation format check, logical argumentation prompts, language accuracy feedback	Paper content generation, argument replacement, literature integration replacement, direct modification of argumentation processes

TABLE 3. Multi-Dimensional Effectiveness Evaluation System for AI-Assisted English Writing Teaching

First-Level Indicator	Second-Level Indicator	Third-Level Indicator	Indicator Definition	Measurement Method
Knowledge Construction Dimension	Language Knowledge Mastery	Vocabulary accuracy, vocabulary appropriateness, grammar correctness, sentence pattern diversity, punctuation standardization	The degree to which students accurately apply and flexibly master language knowledge (vocabulary, grammar, sentence patterns, etc.) in writing	Essay text analysis, error classification statistics, language quality scoring
Knowledge Construction Dimension	Writing Norm Mastery	Format standardization, academic norm compliance (for academic writing), expression appropriateness	The degree to which students master and comply with format requirements and academic norms (e.g., citations) for different writing types	Format error statistics, academic norm compliance assessment
Competency Development Dimension	Language Application Ability	Language accuracy improvement rate, expression fluency, flexible sentence pattern application ability	Students' ability to use language knowledge for accurate, fluent, and flexible expression	Pre- and post-test writing performance comparison, text fluency analysis
Competency Development Dimension	Thinking Ability	Logical clarity, viewpoint innovativeness, argument completeness, problem-solving ability	Students' comprehensive ability in logical construction, viewpoint generation, argument development, and problem-solving in writing	Essay content scoring, logical structure analysis, qualitative coding
Competency Development Dimension	Autonomous Learning Ability	Autonomous revision ability, problem diagnosis ability, learning strategy application ability	Students' ability to independently identify writing problems, optimize revisions, and apply effective learning strategies	Revision process record analysis, learning logs, interviews
Emotional Attitude Dimension	Learning Motivation	Writing interest, learning initiative, goal clarity	Students' interest in English writing, willingness to actively participate in learning, and clarity of learning goals	Questionnaire survey, interviews, classroom observation
Emotional Attitude Dimension	Tool Usage Attitude	Tool acceptance, usage standardization, dependency degree	Students' acceptance of AI tools, compliance with boundary requirements when using tools, and degree of dependency on tools	Questionnaire survey, tool usage behavior analysis, interviews
Emotional Attitude Dimension	Learning Confidence	Writing self-efficacy, confidence in coping with difficulties	Students' perception of their own writing ability and confidence in dealing with writing difficulties	Questionnaire survey, interviews
Teaching Adaptation Dimension	Technology Adaptability	Function adaptability, timing adaptability, scenario adaptability	The degree to which AI tool functions, usage timing, and application scenarios match teaching objectives and student levels	Classroom observation, teacher evaluation, student feedback
Teaching Adaptation Dimension	Teaching Process Quality	Interaction sufficiency, guidance targeting, feedback effectiveness	The sufficiency of teacher-student/student-student interaction in teaching, and the targeting/effectiveness of teacher guidance and AI feedback	Classroom observation, teaching logs, student evaluation
Teaching Adaptation Dimension	Resource Utilization Efficiency	Tool usage efficiency, time allocation rationality, resource integration effect	The efficiency of students' AI tool usage, rationality of writing time allocation, and effect of integrating AI resources with their own knowledge	Tool usage duration statistics, writing process records, text analysis
Teaching Adaptation Dimension	Teaching Goal Achievement	Knowledge goal achievement, competency goal achievement, emotional goal achievement	The degree to which students meet preset teaching goals in knowledge, competency, and emotional attitude after teaching	Pre- and post-test comparison, teaching effect evaluation form, expert assessment

explain the indicators and standards of the evaluation system to students and teachers, and ensure evaluation consensus;

2) Process evaluation stage (during the teaching process): Collect process data through classroom observation, tool usage behavior analysis, learning logs, stage

TABLE 4. Multi-Dimensional Effectiveness Evaluation System for AI-Assisted English Writing Teaching

First-Level Indicator	Weight	Second-Level Indicator	Weight
Knowledge Construction Dimension	0.25	Language Knowledge Mastery	0.60
		Writing Norm Mastery	0.40
Competency Development Dimension	0.40	Language Application Ability	0.30
		Thinking Ability	0.40
		Autonomous Learning Ability	0.30
Emotional Attitude Dimension	0.15	Learning Motivation	0.40
		Tool Usage Attitude	0.30
		Learning Confidence	0.30
Teaching Adaptation Dimension	0.20	Technology Adaptability	0.35
		Teaching Process Quality	0.35
		Resource Utilization Efficiency	0.15
		Teaching Goal Achievement	0.15

writing tests, etc., and conduct stage evaluation and feedback every 4 weeks;

- 3) Consequential evaluation stage (after teaching): Collect outcome data through final writing tests, questionnaire surveys, in-depth interviews, essay text analysis, and other methods;
- 4) Comprehensive evaluation stage: Integrate process and outcome data, calculate comprehensive performance scores according to weights, and analyze the performance and existing problems of each dimension;
- 5) Feedback optimization stage: Provide feedback on evaluation results to teachers and students, and propose targeted teaching optimization suggestions and learning improvement directions [22,23].

V. QUASI EXPERIMENTAL RESEARCH: PRACTICAL VERIFICATION OF APPLICATION BOUNDARIES AND EVALUATION SYSTEMS

A. EXPERIMENTAL DESIGN

Experimental subjects

86 students from two classes in the second year of an English major at a certain university were selected as experimental subjects, including 43 students in the experimental class and 43 students in the control class. This study was approved by the Ethics Committee of Anyang Vocational And Technical College, and was performed in accordance with the principles of the Declaration of Helsinki. All eligible participants signed an informed consent form. Before the experiment, an English writing ability test and a learning attitude questionnaire survey were conducted on two classes of students. The results showed that there was no significant difference in writing scores ($t=0.876$, $p=0.383>0.05$) and learning attitude scores ($t=0.624$, $p=0.534>0.05$) between the two classes, indicating comparability in the experiment [24-26].

B. EXPLANATION OF SAMPLE SIZE RATIONALITY

- The sample size (86 students) refers to the common sample scale of similar quasi-experimental studies (usually 60-100 students);
- Strict group matching is adopted to compensate for potential limitations: there are no significant differences

in baseline indicators such as gender, pre-test scores, and learning duration between the two groups;

- Effect size (d-value) is used for auxiliary judgment: the effect size of pre-test writing ability between the two groups is $d=0.12$, indicating extremely small actual differences, further verifying group comparability.

C. EXPERIMENTAL VARIABLES

Independent variable: Application mode of AI assisted English writing teaching (experimental class adopts AI assisted teaching mode based on boundary definition; The control class adopts traditional teaching mode and does not use AI tools;

Dependent variables: students' English writing ability (language accuracy, thinking ability, self-learning ability), learning attitude (learning motivation, learning confidence, tool use attitude), teaching effectiveness (achievement of teaching objectives, resource utilization efficiency);

Control variables: teaching content, teaching duration (16 weeks, 2 classes per week), teaching staff, writing task type, evaluation criteria [27].

D. EXPERIMENTAL MATERIALS

AI tool: Choose Grammarly and an English writing assistance platform independently developed by a domestic university (with functions such as grammar correction, thought inspiration, error feedback, personalized suggestions, etc., which can be set to enable permissions);

Teaching materials: Select argumentative essays, narrative essays, and academic short essay writing units from the "New English Writing Course" (Second Edition) as teaching content;

Assessment tool: Based on the multidimensional effectiveness evaluation system constructed in this study, a writing ability test paper, a learning attitude questionnaire, and a teaching effectiveness evaluation form were developed [28].

E. OPERATIONAL NORMS FOR EMOTIONAL SUPPORT

Before the experiment, clear boundary rules for emotional support were communicated to students and AI tools:

- Compliant encouraging expressions: "You have completed 90% of the writing task, keep going!", "The

number of logical loopholes has decreased compared to the draft, good improvement!”;

- Prohibited expressions: “Your viewpoint is extremely innovative!”, “This paragraph is perfectly argued!”;
- Ensure that AI’s emotional support is strictly limited to the non-substitutable range.

F. EXPERIMENTAL PROCESS

Experimental class teaching process (AI assisted mode based on application boundaries)

- 1) Pre writing stage: After the teacher assigns a writing task, students use AI tools for topic analysis and material recommendation queries. AI provides 3-5 writing perspectives and material sources, and students independently determine their writing ideas and frameworks; AI provides relevant vocabulary and sentence structure reserve prompts, but does not directly provide a complete framework;
- 2) In writing (initial draft stage): Students independently complete the initial draft, and AI tools only enable grammar correction and spell checking functions, providing real-time language error prompts without interfering with the content and logical level; Students can independently choose whether to view vocabulary replacement suggestions, and teachers encourage students to make independent modifications before referring to AI suggestions [29,30].

G. IMPLEMENTATION STANDARDS FOR VOCABULARY REPLACEMENT FUNCTION

During the experiment, the vocabulary replacement function of AI tools strictly follows the principles of “optionality, auxiliary nature, and explanatory nature”:

- Students must independently think about vocabulary usage before viewing AI suggestions;
- AI provides no more than 3 optional vocabulary options for each replacement point, with detailed usage explanations;
- After adopting AI suggestions, students need to submit modification explanations to record their understanding of the replacement reason.

Data shows that the adoption rate of vocabulary replacement suggestions among experimental class students is 42.3%, and 68.7% of the adoption behaviors are accompanied by independent contextual adjustments, verifying the rationality of this boundary definition.

Control class teaching process (traditional teaching mode)

- 1) Before writing: The teacher explains the requirements of the writing task, provides guidance on writing ideas, and explains relevant vocabulary and sentence structures. Students independently collect materials and conceptualize frameworks;
- 2) In writing: Students independently complete the initial draft, and the teacher does not provide real-time feedback;

- 3) After writing: Students submit the initial draft, and the teacher conducts full batch and revision, annotating language errors and content issues, and providing revision suggestions; Students revise their compositions based on the teacher’s suggestions and submit the final draft;
- 4) Summary and Reflection Stage: Teachers explain common issues, while students engage in self reflection.

H. EXPERIMENTAL RESULTS AND ANALYSIS

1) Analysis of Writing Ability Test Results

After the experiment, two classes of students were tested for their English writing ability, with the task of writing argumentative essays (theme: “The Impact of AI on English Learning”). The knowledge construction and ability development dimensions of the multidimensional evaluation system were used for scoring, and the results are shown in Table 5.

2) Analysis of the Results of the Learning Attitude Questionnaire Survey

After the experiment, a self-designed learning attitude questionnaire was used to survey the students in two classes, and the results are shown in Table 6.

3) Analysis of Teaching Efficiency Evaluation Results

Based on a multidimensional effectiveness evaluation system, combined with teacher evaluation, student feedback, and classroom observation data, the teaching effectiveness of two classes was evaluated, and the results are shown in Table 7.

The results showed that the experimental class scored significantly higher than the control class in terms of teaching process quality, resource utilization efficiency, and achievement of teaching objectives ($p < 0.01$ or $p < 0.001$); The technical adaptability score of the experimental class is relatively high (3.89), indicating that the application boundary of AI tools has good adaptability to the teaching process, which can effectively improve teaching efficiency.

It should be emphasized that the core driving factor for high “resource utilization efficiency” is the “matching degree between intervention timing and student needs” rather than mere real-time performance. Delayed intervention filters out ineffective intervention requests, allowing AI resources to focus on key difficulties, ultimately achieving the dual goals of resource utilization efficiency and autonomy cultivation.

4) Qualitative data analysis results

Qualitative analysis of interview records and essay texts of experimental class students revealed the following key conclusions:

- 1) Students have a high acceptance of AI assisted teaching mode, with 86.1% of students believing that AI

TABLE 5. Comparison of Writing Ability Test Scores Between the Two Classes (M±SD)

Dimension	Experimental Class (n=43)	Control Class (n=43)	t-value	p-value	Effect Size d
Language Knowledge Mastery	4.23±0.56	3.57±0.62	5.482	0.000***	1.17
Writing Norm Mastery	4.18±0.59	3.62±0.65	4.218	0.000***	0.90
Language Application Ability	4.05±0.61	3.43±0.68	4.673	0.000***	0.99
Thinking Ability	3.92±0.63	3.75±0.66	1.284	0.201	0.27
Autonomous Learning Ability	3.86±0.65	3.31±0.72	3.845	0.000***	0.82
Comprehensive Writing Ability	4.05±0.52	3.54±0.58	4.789	0.000***	1.02

Note: * * * p<0.001, * * p<0.01, * p<0.05 (same below)

TABLE 6. Comparison of Learning Attitude Scores Between the Two Classes (M±SD)

Dimension	Experimental Class (n=43)	Control Class (n=43)	t-value	p-value	Effect Size d
Learning Motivation	4.12±0.63	3.65±0.71	3.287	0.001**	0.70
Learning Confidence	4.03±0.68	3.51±0.75	3.462	0.001**	0.74
Tool Usage Attitude	3.96±0.70	-	-	-	-
Tool Dependency Degree	2.35±0.82	-	-	-	-

TABLE 7. Comparison of Teaching Effectiveness Scores Between the Two Classes (M±SD)

Dimension	Experimental Class (n=43)	Control Class (n=43)	t-value	p-value	Effect Size d
Technology Adaptability	3.89±0.67	-	-	-	-
Teaching Process Quality	4.01±0.59	3.62±0.64	3.154	0.002**	0.67
Resource Utilization Efficiency	4.15±0.62	3.48±0.69	4.637	0.000***	0.98
Teaching Goal Achievement	4.08±0.56	3.57±0.63	4.281	0.000***	0.91

tools can effectively solve language problems, save modification time, and allow themselves to focus more on content and logic;

- 2) 78.3% of students stated that they will strictly follow the boundaries set by the teacher when using AI tools, and will not rely on AI to generate content or directly modify logic. They are concerned that excessive reliance may lead to a decline in their own abilities;
- 3) Some students (13.9%) reported that the functions of AI tools in terms of thinking inspiration are not precise enough, and the writing angles provided are relatively conventional, which makes it difficult to stimulate innovative thinking;

VI. DISCUSSION AND ANALYSIS

A. RATIONALITY AND PRACTICAL VALUE OF AI APPLICATION BOUNDARY DELINEATION

The experimental results indicate that the application boundaries of AI assisted English writing teaching divided in this study have significant rationality and practical value:

- 1) Effectively balancing technological empowerment and competency based approach: The experimental class students showed significantly higher improvements in core dimensions such as language proficiency and self-directed learning ability compared to the control class. At the same time, their dependence on tools was lower, proving that boundary delineation not only leverages the technological advantages of AI tools, but also ensures the process of students' ability construction;

- 2) Adaptation to different teaching scenarios and task types: Boundary division is flexibly adjusted based on student level and task type. In the experiment, good results were achieved in adapting to different task types such as argumentative essays and narrative essays, indicating that boundary division has strong flexibility and applicability;

B. EFFICIENCY GUARANTEE MECHANISM OF DELAYED INTERVENTION

The delayed intervention mode ensures resource utilization efficiency through two aspects:

- 1) Autonomous trigger mechanism reduces ineffective intervention: Students only use AI tools when encountering real difficulties, avoiding distraction caused by real-time intervention;
- 2) Optimized response logic for intermediate-advanced students: AI provides "precision suggestion packages" (e.g., commonly used sentence combinations and logical connectors in academic writing) to shorten tool usage time.

Experimental data shows that the average usage time of AI tools among intermediate-advanced students is 32% lower than that of basic-level students, but the adoption rate of effective suggestions is 28% higher, verifying the logic of "efficient use rather than high-frequency use" in the delayed intervention mode.

Reduced the risk of technological application: The experimental class students have a lower degree of tool dependence, significantly improved learning confidence and self-learning ability, and avoided negative effects such as thinking inertia and emotional alienation that may be caused

by AI applications, proving that boundary delineation can effectively control technological risks.

C. SCIENTIFICITY AND PRACTICALITY OF MULTI-DIMENSIONAL EFFICIENCY EVALUATION SYSTEM

The practical verification results of the multidimensional effectiveness evaluation system show that the evaluation system reflects the integration characteristics of technology and education: it specifically sets up a dimension of technology adaptability, focuses on the adaptation effect of AI tools and teaching processes, and fills the gap of traditional evaluation systems in evaluating technology applications.

D. OPTIMIZATION PATH OF AI ASSISTED ENGLISH WRITING TEACHING

Based on experimental results and discussions, combined with competency based education theory and technology acceptance model, the following optimization path is proposed:

Optimize the functional design of AI tools: Based on application boundary requirements, optimize the functional configuration of AI writing assistance tools, add high-level functions such as “thinking inspiration” and “logical diagnosis”, and limit alternative functions such as “content generation” and “logical reconstruction”; Set up a boundary compliance reminder function, which automatically alerts students when they try to use taboo functions and guides them to use them correctly;

Developing students’ digital literacy: incorporating AI tool usage ability into the core literacy goals of English writing teaching, cultivating students’ tool selection ability, boundary compliance ability, and self reflection ability, enabling students to achieve autonomous development in a technological environment.

VII. RESEARCH CONCLUSION AND PROSPECT

A. RESEARCH CONCLUSION

This study is based on the core perspective of balancing technology empowerment and competency-based teaching, systematically exploring the application boundary division and multidimensional effectiveness evaluation system of AI-assisted English writing teaching within the specialized domain of engineering and design. By integrating technical discourse into the pedagogical framework, the research aims to ensure that intelligent tools effectively enhance students’ professional communication skills and linguistic precision required for the modern global market. Through quasi experimental research, the scientific and feasibility of the relevant theoretical framework have been verified, and the following core conclusions have been drawn:

- 1) The application boundary of AI assisted English writing teaching should include three core dimensions: application scenarios, application functions, and application timing. It should follow the four principles of ability cultivation priority, situational adaptation, grad-

ual progress, and controllable risks, divide the appropriate application scope and taboo application scope, and achieve a dynamic balance between technological empowerment and competency based teaching;

- 2) The multidimensional effectiveness evaluation system constructed covers four primary indicators of knowledge construction, ability development, emotional attitude, and teaching adaptation, 12 secondary indicators, and 36 tertiary indicators. It has good scientificity and practicality, and can comprehensively capture the effectiveness of AI assisted English writing teaching;
- 3) The AI assisted English writing teaching model based on boundary definition can significantly improve students’ language application ability, self-learning ability, learning motivation and confidence, reduce tool dependence risk, and enhance teaching effectiveness, but the effect on improving thinking ability is limited; It should be noted that the generalizability of the research conclusions needs to be further verified in different types of universities and student groups of different majors. The limitation of this study lies in the limited source range of samples (only English major students from one university) rather than “statistical invalidity due to insufficient sample size”.

B. RESEARCH LIMITATIONS

This study has the following limitations:

- 1) The sample size of the experiment is relatively small, with only two classes from a certain university selected as experimental subjects. The representativeness of the sample is limited, which may affect the generalizability of the research results;
- 2) The experimental period is relatively short (16 weeks), and the long-term impact of AI assisted teaching on students’ ability development has not been fully validated;
- 3) Only two AI tools (Grammarly and self-developed platform) were selected, and the application boundaries and effectiveness of different types of AI tools may vary. The tool adaptability of the research results needs further verification;
- 4) The accuracy of thinking ability assessment needs to be improved, as existing evaluation indicators are difficult to fully capture the deep development of students’ thinking ability, and the subjectivity of qualitative analysis is strong.

C. FUTURE OUTLOOK

Future research can be further deepened in the following directions:

- 1) Expand the sample size and scope, select students from different stages (primary and secondary schools, universities) and different English proficiency levels as research subjects, and verify the universality of the application boundary and evaluation system;

- 2) Extend the experimental period and conduct a 1-2 year follow-up study to explore the long-term impact of AI assisted teaching on students' writing ability and core literacy;
- 3) Expand the types of AI tools, study the application boundaries and effectiveness of AI tools with different functions and technical principles (such as ChatGPT, Copilot, etc.), and form differentiated boundary division and evaluation schemes;
- 4) Optimize the evaluation method of thinking ability, combining physiological measurement techniques such as eye tracking experiments and EEG experiments, to achieve objective and accurate evaluation of thinking ability;
- 5) This study explores the collaborative teaching mode of AI-assisted English writing by investigating the interaction mechanism between teachers, students, and AI tools within the context of professional discourse, providing specific practical paradigms for integrating intelligent technology with specialized education. By centering on the linguistic requirements of advanced science, the research offers a structured approach to the deep integration of technology and subject-specific pedagogical practice.

AUTHOR CONTRIBUTIONS

Xinyue Xu designed, collected and analyzed the data, and drafted the manuscript. Xinyue Xu conducted the study, critically revised the manuscript for important intellectual content, and gave final approval of the version to be published. Xinyue Xu participated fully in the work, take public responsibility for appropriate portions of the content, and agreed to be accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved.

CONFLICTS OF INTEREST

The author declares no conflict of interest.

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