

Artificial Intelligence Adaptive Learning Path and Middle School Students' English Academic Self-Efficacy: A Study on the Mediating Role of Perceived Autonomy Support

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Abstract: Objective: To explore the correlation mechanism between artificial intelligence adaptive learning path and junior high school students' English academic self-efficacy, and clarify the mediating effect of Perceived Autonomy Support. Method: Stratified sampling was adopted to select 512 junior high school students from 8 middle schools in Beijing, Zhejiang, and Sichuan provinces (cities). the validated "Middle School Students' English Academic Self-Efficacy Scale" (Cronbach's $\alpha = 0.886$) and the "Learning Environment Autonomy Support Scale" (Cronbach's $\alpha = 0.849$), which have been validated by the academic community, were used for research. Combined with objective data from the backend of iFlytek Intelligent Learning Network, correlation and mediation analyses were performed using SPSS 26.0 and Hayes' PROCESS macro (Model 4). Result: There was a significant positive correlation between the depth of artificial intelligence adaptive learning path usage and English academic self-efficacy ($r=0.397$, $P<0.01$); Perceived Autonomy Support played a partial mediating role, with an effect value of 0.142, accounting for 35.77% of the total effect. Conclusion: The adaptive learning path of artificial intelligence can directly or indirectly enhance students' English academic self-efficacy by strengthening Perceived Autonomy Support. It is recommended to optimize the autonomous support design of adaptive tools in English teaching.

Keywords: Artificial Intelligence Adaptive Learning Path, Middle School Students, English Academic Self-Efficacy, Perceived Autonomy Support, Mediating Role.

1. Introduction

After the implementation of the Action Plan for Education Informatization 2.0 and the Action Plan for Empowering Education Digitalization with Artificial Intelligence, the deep integration of artificial intelligence technology and basic education subject teaching continues to advance. The adaptive learning system, with its core characteristics of "precise diagnosis, personalized push, and dynamic optimization", has become a key technical carrier for breaking the bottleneck of "insufficient differentiation" in middle school English teaching. English academic self-efficacy is a specific extension of Bandura's self-efficacy theory in subject learning, which has a key impact on stimulating middle school students' English learning motivation, selecting learning strategies, and improving academic performance. According to the "2023 National Education Development Statistical Bulletin" released by the Ministry of Education, the digital teaching conditions in compulsory education schools in China continue to improve, and the coverage rate of smart classrooms has reached 45.7%. English subject adaptive learning tools have been promoted and applied in primary and secondary schools in many places. However, in practice, there are significant differences in the effectiveness of using such tools among different schools and student groups, and some students have problems such as resistance to use and lack of improvement in their sense of efficacy. Reviewing existing research, it has been found that the academic community has preliminarily explored the direct correlation between artificial intelligence adaptive learning and English academic self-efficacy, but the internal mechanism between them remains unclear. According to self-determination theory, autonomous

support is a core element in meeting individual autonomous needs and enhancing self-efficacy, and it is speculated that it may play a mediating role between the two [1]. Based on this, this study focuses on empirical research on the relationship between the three, providing empirical evidence and practical guidance for the targeted application of artificial intelligence technology in middle school English teaching and the improvement of students' learning psychological qualities.

1.1. literature Review

Existing studies have initially explored the correlations among core variables, but there is an obvious research gap in integrated exploration. Middle school English is a key stage for the advancement of language ability. The hierarchy of learning content (such as the construction of grammar system and the cultivation of discourse comprehension ability) and the developmental stage characteristics of students' cognitive development make the personalized adaptation needs of adaptive learning more prominent. In terms of artificial intelligence adaptive learning and middle school students' English academic self-efficacy, a meta-analysis on K-12 online learning environments confirmed that personalized technology intervention can improve students' academic performance and self-efficacy. However, although the study covers the basic education stage, it has not been refined to the skill dimension of middle school English subjects (such as the differential adaptation of listening, speaking, reading and writing), and the internal paths of action in the context of middle school English have not been clear [2].

The effect of perceived autonomy support has been verified in multiple dimensions: the macro framework of self-determination theory points out that the satisfaction of autonomous needs is the core link connecting the

environment and individual psychology [3]; The rapid development of middle school students' self-awareness makes the impact of perceived autonomy support on their learning psychology more sensitive. The latest meta-analysis further shows that autonomy support in the digital learning environment can significantly enhance students' intrinsic motivation and autonomy perception [4]. At the same time, studies have confirmed that perceived autonomy support exerts an indirect effect on academic outcomes via self-efficacy, but it has not been included in the relationship framework of "AI-powered adaptive learning paths - middle school students' English academic self-efficacy", nor has it focused on the subject specificity of middle school English [5].

To sum up, the existing research lacks systematic empirical exploration on the relationship among the three. This study aims to fill this gap and provide more accurate theoretical support for technology-empowered middle school English teaching.

2. Definition of Related Concepts and Theoretical Basis

2.1. Definition of Core Concepts

The adaptive learning path of artificial intelligence relies on core technologies such as machine learning and big data analysis. By collecting multidimensional data such as students' English basic test results, learning task completion quality, and feedback on incorrect answers, it dynamically generates solutions that are suitable for individual cognitive levels and personalized learning needs. The core features are "precise adaptability" and "dynamic adjustment". Common application carriers include educational platforms such as iFlytek Intelligent Learning Network, which have been widely used in primary and secondary schools, to help achieve personalized teaching. Middle school students' academic self-efficacy in English refers to their ability and confidence level in completing specific learning tasks such as vocabulary accumulation, grammar application, listening, reading comprehension, and written expression. It is a concrete manifestation of academic self-efficacy in the field of English and directly affects learning engagement. Perceived Autonomy Support originates from self-determination theory, referring to the autonomy support provided by students' perceived learning environment (including technological tools, teacher guidance, peer interaction, etc.), specifically manifested as the autonomous decision-making space for selecting learning content, arranging learning time, and choosing learning methods [6].

2.2. Theoretical Basis

This study is supported by the self-determination theory and Bandura's self-efficacy theory. The self-determination theory proposes that autonomy, competence, and belonging are the three core psychological needs required for individual growth and development, among which the full satisfaction of autonomy needs can effectively stimulate intrinsic learning motivation, thereby positively enhancing self-efficacy; The adaptive learning path of artificial intelligence precisely satisfies students' competence needs through personalized content push, ensuring their autonomous needs through flexible and autonomous selection, and ultimately affecting their self-efficacy in English academic studies. Bandura's self-efficacy theory clearly states that direct experience is the

core source for the formation and improvement of self-efficacy, and the real-time learning feedback and visualization of progress results of adaptive learning paths can help students clearly perceive learning outcomes, continuously accumulate successful learning experience, and lay a solid foundation for the improvement of English academic self-efficacy. Previous studies have confirmed that the level of Perceived Autonomy Support can positively predict academic self-efficacy, providing a solid theoretical foundation for the hypothesis of mediating effects in this study [7].

3. Research Design and Methods

3.1. Research Hypothesis

Based on theoretical analysis and existing research, hypothesis H1 is proposed: AI adaptive learning path positively predicts middle school students' English academic self-efficacy; H2: Artificial intelligence adaptive learning path positively predicts students' Perceived Autonomy Support level; H3: Perceived Autonomy Support positively predicts junior high school students' English academic self-efficacy; H4: Perceived Autonomy Support plays a mediating role between the two.

3.2. Research Object

Stratified sampling was used to select middle school students from 8 middle schools (2 key urban schools, 3 ordinary urban schools, and 3 rural schools) in three provinces (cities): Beijing, Zhejiang, and Sichuan as the research subjects, all of whom used the "iFlytek Intelligent Learning Network" English adaptive module for at least one semester. A total of 560 questionnaires were distributed, and 512 valid questionnaires were collected, with an effective response rate of 91.43%. Sample composition: 252 males (49.22%) and 260 females (50.78%); 176 seventh-grade students (34.37%), 182 eighth-grade students (35.55%), and 154 ninth-grade students (30.08%).

3.3. Research Tools

The English Academic Self-Efficacy Scale for Middle School Students: Using a mature academic scale with 20 items, it is divided into two dimensions: ability self-efficacy and behavioral self-efficacy, with a 5-point Likert scale. After reliability and validity testing, the internal consistency reliability coefficient is 0.886 (test-retest reliability 0.823), which meets the standards of psychometrics; "Learning Environment Autonomy Support Scale" for Learning Environment: Referring to mature scales related to self-determination theory, 14 items were determined and adjusted for English learning scenarios, with a 5-point Likert scale. The internal consistency reliability coefficient was 0.849, and the reliability and validity met the standard [8]; Objective data: Indicators including average weekly usage time, number of completed personalized tasks, and weak point breakthrough rate were extracted from the backend of iFlytek Intelligent Learning Network as quantitative evaluation criteria.

3.4. Data Processing

Data were analyzed using SPSS 26.0 and Hayes' PROCESS macro (Model 4). Common Method Bias Test, descriptive statistics, Pearson correlation analysis, multiple regression analysis, and mediation effect test were conducted sequentially, with a significance level set at $\alpha = 0.05$ [9].

4. Research Results and Analysis

4.1. Common Method Bias Test

In order to accurately control the potential interference of common method bias on research conclusions, this study adopted targeted measures such as anonymous filling, randomized item order, and clear filling instructions during the questionnaire design stage. After the survey was completed, Harman single factor test was further used for post-hoc validation. All scale items were included in exploratory factor analysis, and 11 factors were extracted without rotation. The first factor explained 21.87% of the variance, far below the critical threshold of 40%, indicating that there was no significant common method bias in the study and the reliability of the data was fully guaranteed.

4.2. Descriptive Statistics and Correlation Analysis

The descriptive statistical results showed that the depth of use of artificial intelligence adaptive learning paths ($M=3.18$, $SD=0.83$), Perceived Autonomy Support ($M=3.36$, $SD=0.75$), and English academic self-efficacy ($M=3.27$, $SD=0.79$) were all at a medium to high level, and the distribution of scores for each variable was balanced, without obvious skewness or extreme values. Pearson correlation analysis showed that all three factors were significantly positively correlated (all

$P<0.01$), with a correlation coefficient of $r=0.397$ between pathway and self-efficacy, $r=0.462$ between pathway and Perceived Autonomy Support, and $r=0.498$ between Perceived Autonomy Support and self-efficacy. These significant correlations laid a solid foundation for subsequent mediation effect testing.

4.3. Mediation Effect Test

Using the classic Model 4 in the PROCESS macro program developed by Hayes, this study examines the mediating effect of Perceived Autonomy Support [10]. The results showed that after controlling for demographic covariates such as gender, grade, and school type, the adaptive learning path had a significant direct predictive effect on English academic self-efficacy; At the same time, it also had a significant positive predictive effect on Perceived Autonomy Support; After incorporating both into the regression equation, the prediction of Perceived Autonomy Support remained significant, and the path prediction coefficient decreased to 0.098 ($t=2.345$, $P<0.05$). The mediation effect value is 0.142, with a corresponding 95% confidence interval of [0.095,0.193] (excluding 0), indicating that Perceived Autonomy Support played a partial mediating role, and the mediation effect accounts for 35.77% of the total effect. The specific test results are shown in Table 1, and the above series of results further verify the reliability of the data and the robustness of the conclusions.

Table 1. Results of the Mediating Effect Test on Perceived Autonomy Support

Regression Path	Independent variable	Dependent variable/mediator variable	β value	T-value	P value	95% confidence interval
Direct Path 1	Artificial Intelligence Adaptive Learning Path	English Academic Self-Efficacy	0.253	6.517	<0.001	[0.178, 0.328]
Mediating Path 1	Artificial Intelligence Adaptive Learning Path	Perceived Autonomy Support	0.462	11.892	<0.001	[0.385, 0.539]
Mediating Path 2	Perceived Autonomy Support	English Academic Self-Efficacy	0.307	7.943	<0.001	[0.221, 0.393]
Direct Path 2 (Control Intermediary)	Artificial Intelligence Adaptive Learning Path	English Academic Self-Efficacy	0.098	2.345	<0.05	[0.015, 0.181]
Mediating effect	-	-	0.142	-	<0.01	[0.095, 0.193]

Note: 1. Control variables: gender, grade, school type; 2. The proportion of mediating effect to the total effect: 35.77%; 3. A confidence interval excluding 0 indicates a significant mediating effect.

5. Discussion

5.1. The Direct Impact of Artificial Intelligence Adaptive Learning Path on English Academic Self-Efficacy

The results of this study validate hypothesis H1 that adaptive learning paths can significantly positively predict middle school students' English academic self-efficacy. Platforms such as iFlytek Intelligent Learning Network use algorithms to accurately diagnose weak areas in English, such as grammar and vocabulary gaps, and push learning content and exercises that are adapted to the difficulty level, effectively reducing the frustration caused by difficult tasks. This type of personalized adaptation model has been proven to help students overcome learning difficulties more efficiently in middle school English teaching practice. Concrete learning outcomes can strengthen students' confidence in their own English learning abilities, thereby

enhancing their self-efficacy [11]. At the same time, the real-time feedback function of the adaptive path allows students to timely grasp the learning progress and task quality, and a clear sense of process control strengthens the cognitive effectiveness of learning behavior, which conforms to Bandura's self-efficacy theory that "direct experience is the core pathway for the formation of self-efficacy".

5.2. The Mediating Role of Perceived Autonomy Support

The research results validate hypotheses H2, H3, and H4, confirming that Perceived Autonomy Support played a partial mediating role between the two [12]. The adaptive learning path breaks the limitations of traditional English teaching with "unified pace and content". Students can choose their own learning time, content progression order (such as breaking through vocabulary first and then strengthening grammar), and learning methods (such as video learning, specialized exercises, and simulation tests). The full autonomy of choice allows students to truly perceive the autonomous support of the learning environment. According to self-determination theory, satisfying autonomous needs can stimulate intrinsic learning motivation and encourage

students to actively engage in English learning. In English reading, students can independently choose topics of interest (campus life, cultural customs, technological development), and the platform dynamically matches the difficulty of the text. Personalized and autonomous experiences enhance learning participation and reading ability control, thereby improving English academic self-efficacy. This conclusion is consistent with existing research on self-supporting education and further confirms the rationality of the mechanism of action.

5.3. Educational Implications

Based on the research findings, three suggestions are proposed to improve the practical application of adaptive learning paths in middle school English teaching: firstly, tool development enterprises need to strengthen the design of autonomous support functions, increase the space for personalized selection of learning content, such as providing multi-topic and multi-difficulty resources, and allowing students to independently formulate learning plans; Secondly, English teachers should play a guiding role in integrating "technology+teaching", guiding students to use adaptive paths reasonably, interpreting the advantages of personalized learning, paying attention to the perception of Perceived Autonomy Support, and adjusting guidance strategies in a timely manner; Thirdly, education management departments need to strengthen the allocation of artificial intelligence teaching equipment and teacher training in rural middle schools, narrow the gap between urban and rural applications, enable more students to benefit from technological empowerment, and enhance their English academic self-efficacy.

6. Research Shortcomings and Prospects

6.1. Research Limitations

Based on the research process and results, there are three significant shortcomings in this study. Firstly, the cross-sectional survey design can only reveal the correlational relationship between variables rather than causal links, and cannot clarify the causal relationship and long-term dynamic evolution of the three [13]. Issues such as whether the long-term use of adaptive learning paths can continuously improve English academic efficacy and whether the mediating role of Perceived Autonomy Support changes with learning stages are not yet clear. Therefore, a follow-up survey design is needed to conduct a 2-year longitudinal survey to further explore the dynamic mechanism between variables [14]; Secondly, there are limitations in the geographical coverage of the research sample. Although it has covered the three major regions of North China, East China, and Southwest China, schools in Northeast China, Northwest China, and other areas have not been included. The representativeness of the sample needs to be improved, and the research subjects are only limited to junior high school students, without involving senior high school students, which limits the applicability of the research conclusion; Thirdly, potential moderating variables such as students' basic English proficiency, learning styles, and teachers' technical application abilities were not considered, which may have an impact on the association between adaptive learning paths and English academic efficacy.

6.2. Research Prospects

In response to the shortcomings of this study, future research can be promoted from three aspects: firstly, adopting experimental research design, setting up an experimental group (continuously using adaptive learning path) and a control group (traditional learning mode), clarifying the causal effects of adaptive learning path on English academic performance through intervention experiments, and enhancing the persuasiveness of research conclusions; The second is to expand the sample coverage by including schools and senior high school students from Northeast, Northwest and other regions in the survey, while introducing moderating variables such as English proficiency and learning style to explore their moderating effects and enrich the universality of research conclusions; The third is to integrate qualitative research methods, using semi-structured interviews, classroom observations, learning log analysis and other means to deeply explore students' subjective experiences in using adaptive learning paths, clarify the specific formation process of Perceived Autonomy Support, and provide more detailed basis for the design optimization and application practice of adaptive learning tools. In addition, in the future, the differences in the impact of different types of adaptive learning algorithms on students' Perceived Autonomy Support and English academic efficacy can be explored, providing more accurate direction guidance for technology research and development.

7. Conclusion

This study is based on self-determination theory and Bandura's self-efficacy theory. Through empirical research, it explores the relationship between artificial intelligence adaptive learning path, Perceived Autonomy Support, and junior high school students' English academic self-efficacy. The core conclusions are as follows: firstly, there is a significant positive correlation between artificial intelligence adaptive learning path and junior high school students' English academic self-efficacy, which can directly improve the latter; Secondly, Perceived Autonomy Support plays a partial mediating role between the two, that is, the pathway can indirectly enhance efficacy by enhancing autonomous support. The academic value of this study lies in clarifying the mediating role of autonomous support, filling the research gap in their mechanisms of action, verifying the applicability of self-determination theory in technology-enabled teaching, and enriching research on the application of artificial intelligence education and student learning psychology. On a practical level, the conclusion provides clear guidance for the effective application of artificial intelligence adaptive tools in middle school English teaching: optimizing the tool's autonomous support function and strengthening teacher integration guidance can fully leverage the advantages of technology empowerment to enhance students' sense of efficacy. It should be noted that this study has limitations in sample area and cross-sectional design. In the future, it will need to be improved through longitudinal tracking, sample expansion, and the integration of qualitative and quantitative methods. Exploring the interactive mechanism between artificial intelligence and students' learning psychology in the context of digital transformation of education is of great significance for promoting the high-quality development of middle school English teaching and cultivating students' core competencies.

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