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A Study of the Path and Effectiveness of Intelligent Educational Tools to Promote Personalised Learning

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Abstract

This study explores the path and effectiveness of intelligent educational tools for personalised learning, and identifies three major problems: insufficient technology adaptability, difficulties in instructional design, and barriers to student independent learning. The study proposes three paths: improving technology adaptability, optimising instructional design methods, and building a system for cultivating students independent learning abilities. Empirical research shows that smart tools help intermediate and advanced students the most, but regional differences are obvious. The research results provide theoretical basis and practical guidance for the design of intelligent education platforms, teacher training and balanced deployment of resources.

Keywords

Intelligent Educational Tools; Personalised Learning; Adaptive Learning System; Learning Data Analysis; Balanced Educational Resources

1. Introduction

Intelligent educational tools are becoming a central force driving educational change, and their potential to support personalised learning has attracted widespread attention[1]. Current research suggests that smart technologies can customise learning paths, content and feedback according to learner characteristics, but they still face many challenges in practical application[2]. This study aims to explore the effective paths of smart educational tools for personalised learning and analyse their effectiveness and limitations in practice[3]. The article firstly comprehends the theoretical foundation of smart education tools, then analyses the three major problems of technology adaptation, instructional design, and students' independent learning in the implementation process, then proposes a systematic solution, and finally evaluates the effectiveness of the application through a multi-region empiri-

cal study, which provides a theoretical basis and a practical guide for the optimal design and effective implementation of smart education tools.

2. Theoretical foundations of smart education tools

The theoretical foundations of smart educational tools incorporate core concepts from multiple disciplinary fields. Constructivist theory emphasises the active construction of knowledge by the learner, whereby smart tools provide interactive environments to support self-directed enquiry[4]. Socio-cultural theory and the theory of the zone of nearest development guide intelligent systems to create optimal levels of challenge and enable socially interactive learning through virtual communities. Connectionism theory supports intelligent tools to build an open learning ecosystem to help learners make knowledge connections in complex information[5]. Cognitive load theory guides intelligent systems to optimise content presentation and difficulty adjustment to avoid wasting cognitive resources. Motivation theory provides design guidelines for intelligent tools to maintain learners' intrinsic motivation by satisfying psychological needs such as autonomy, competence and sense of belonging. Together, these theories form a theoretical framework for intelligent educational tools, guiding their technological development and pedagogical application to achieve personalised learning goals.

3. Problems with smart education tools for personalised learning

3.1 Insufficient technical adaptability

The current intelligent educational tools in practical application generally have the problem of insufficient technical adaptability, which makes it difficult to meet the diverse needs of educational scenarios. According to the data of the 2024 National Education Informatisation Survey, about 67% of teachers reflect that the intelligent system is unable to accurately identify the real ability level and cognitive state of students, leading to deviations between the recommended content and the actual needs of students[6]. The integration of technology and education is still at a shallow stage, with intelligent algorithms mostly based on simple correctness of answers and completion time, lacking in-depth analysis of the learning process and mindset. Many systems have poor compatibility between different devices, with nearly 40% of schools nationwide experiencing compatibility problems during use, and network bandwidth limitations in some schools in remote areas have also led to slow responses from intelligent systems, affecting the experience of using them. The rapid pace of updating and iteration of smart education tools makes it difficult for teachers and students to adapt, and the high cost of technological learning results in many functions being left unused and unable to maximise their effectiveness.

3.2 Difficulties in Instructional Design and Implementation

Intelligent educational tools face systematic difficulties in design and implementa-

tion in teaching practice, affecting their educational value. As shown in Figure 1, teachers face multiple challenges in the integration process, with insufficient training and mismatched evaluation systems being particularly prominent. National surveys show that only 23 per cent of teachers are able to effectively integrate smart tools into their curricula, with the majority viewing them as supplementary tools rather than the core of pedagogical change. The problem of technology-led design is serious, with only 28 per cent of education experts involved, leading to a disconnect between the function of the tool and its teaching objectives, and a lack of subject-specificity[7]. The teacher training system is lagging behind, with only 35% of teachers having received professional training, and 47% of them receiving short-term formal training without continuous support. 69% of teachers report that it is difficult to integrate the data of smart tools with traditional assessment indicators, which puts the application of smart education in a predicament of ‘using for the sake of use’, and makes it impossible to realise in-depth pedagogical change.

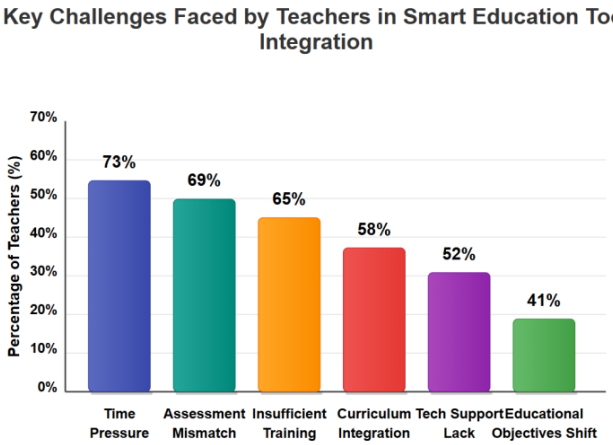

Figure 1. Main challenges faced by teachers in the process of integrating smart education tools

3.3 Barriers to student self-directed learning

Although smart education tools help personalised learning, students face multiple barriers to independent learning. According to the research, more than 60% of primary and secondary school students lack effective learning strategies and time management skills, making it difficult for them to stay focused in an environment without direct supervision. The problem of dependency is prominent, with about 52% of students overly trusting the system's recommendations and less independent thinking, and preferring to accept the system's answers rather than thinking about the reasons for discrepancies when they encounter inconsistent situations. Disparities in digital literacy are evident, with about 45 per cent of students not knowing how to resolve technological barriers when they encounter them, especially in lower grades and in rural areas[8]. Long-term use may lead to the phenomenon of ‘algorithmic comfort zone’, in which students are satisfied with the content recom-

mended by the system and lack the motivation and ability to explore uncharted territories, limiting the breadth and depth of their learning, and weakening the cultivation of innovative thinking and critical thinking skills.

4. Path analysis of smart education tools for personalised learning

4.1 Strategies to improve the adaptability of technology

To improve the technical suitability of intelligent educational tools, a multi-dimensional integration strategy should be adopted to optimise the whole process from technical design to implementation and application. Intelligent algorithms should be deeply integrated with educational theories, develop multi-dimensional evaluation models based on cognitive science and learning analytics theories, go beyond the single correct rate and speed indicators, and build a comprehensive evaluation system that includes cognitive processes, learning styles and thinking styles[9]. In terms of technical architecture, modular design and microservice architecture are adopted to enable the system to flexibly adapt to different teaching scenarios and hardware environments, and reduce equipment dependency. For the specificity of the educational environment, a lightweight application version is developed, and the dependence on network bandwidth is reduced through edge computing technology to ensure smooth operation even in areas with poor network conditions. In terms of user experience, the interface design of educational tools should follow the principle of intuition, lower the threshold of teachers and students, and realise ‘ready-to-use’, while developing progressive learning functions, so that users can start from basic functions and gradually master advanced features. System updates should adopt a smooth transition strategy, retaining the core functions that users are accustomed to, and adding new functions in accordance with the principle of minimal interference, so as to avoid adaptation difficulties caused by frequent and drastic changes.

4.2 Optimising instructional design and implementation methods

Optimising the pedagogical design and implementation of smart education tools lies in the construction of an integration framework oriented to educational objectives. Teaching design should adopt the integrated design mode of ‘goal-content-activity-evaluation’, and the selection of intelligent tools must serve the clear teaching goal rather than the technology itself. An interdisciplinary teamwork mechanism should be introduced at the early stage of curriculum design, with the participation of education experts, subject teachers, technicians and learning designers, to ensure the in-depth integration of technology and teaching. The teacher training system needs to shift to an ‘immersive and continuous’ mode, helping teachers to master the core concepts and operational skills of smart education through case studies, situational simulations and practical exercises, and estab-

lishing an in-school technology mentor system to provide continuous support[10]. The implementation of teaching and learning adopts a progressive integration strategy, ranging from unit teaching pilots to curriculum reconstruction, giving teachers ample room for adaptation and innovation. Reconstruction of the evaluation system is the key link, developing diversified evaluation standards, organically combining process data generated by the intelligent system with traditional academic evaluation, and constructing a comprehensive competence-oriented evaluation system. A design-based research mechanism has been established to continuously collect feedback on implementation, forming a cyclic improvement process of 'design-implementation-assessment-optimisation' and promoting the continuous optimisation of teaching design and implementation methods.

4.3 Cultivate students' independent learning ability

Cultivating students' independent learning ability is the key to the success of the application of intelligent educational tools, and a multi-level ability cultivation system needs to be constructed. The intelligent system should be embedded with a metacognitive training module to help students master the methods of planning, monitoring and adjusting their own learning process through the guidance of learning strategies, self-monitoring prompts and reflection guidance. The system design adopts a 'scaffolding learning path', dynamically adjusting the support according to the level of students' autonomy, providing detailed guidance and structured tasks at the initial stage, and gradually reducing the external support and increasing the space for independent decision-making as the ability improves, so as to realise a smooth transition from self-discipline to self-regulation. Stimulating intrinsic motivation is the source of motivation for lasting independent learning. The intelligent system applies the principles of gamification design to set up moderate challenges, immediate feedback and achievement systems, and at the same time pays attention to the construction of meaning, helping students to understand the connection between the learning content and their personal goals and the real world. A learning partner mechanism is established to create a peer-supportive environment through virtual learning communities and collaborative projects to cultivate social learning skills. Aiming at the common obstacles in the learning process, an intelligent support system is developed to provide stuck-point analysis and personalised solutions to help students overcome difficulties, build up their learning resilience and problem-solving abilities, and form a virtuous cycle of independent learning.

5.Evaluation of the Effectiveness of Intelligent Educational Tools for Personalised Learning

5.1 Case Background and Study Population

This study selected six schools in three different developmental regions of China, covering the eastern, central and western regions, involving 36 classes, 1,458 stu-

dents and 72 teachers, with students aged 9-16 years old. The study applied three types of intelligent educational tools: the adaptive learning system ‘ZhiXueYun’, the intelligent assessment tool ‘Learning Assistant’, and the virtual experimental platform ‘Inquiry Space’, and observed their effects on personalised learning in four subjects: Mathematics, Language, English and Science. The study lasted one academic year and focused on analysing the differences and common features of the application of smart tools in different regions and subject contexts.

5.2 Implementation process and methodological design

The study adopted a mixed research methodology, combining quantitative and qualitative methods to assess the effectiveness of the application of smart education tools. The implementation is divided into three phases: the pre-preparation phase (July-August 2023) to conduct teacher training and student baseline testing, with each teacher receiving 36 hours of professional training; the implementation phase (September 2023-June 2024) with teachers using the smart tool at least three classroom hours per week, and the research team's monthly observation and data collection; and the evaluation phase (June-July 2024) to conduct comprehensive data collection and analysis. Data collection methods included learning achievement pre- and post-test comparisons, questionnaires, classroom observations (216 sessions), semi-structured interviews (108 students, 36 teachers) and system log analysis. The research design adopted a quasi-experimental approach, dividing the parallel classes in each school into experimental and control groups to ensure the comparability of the underlying conditions of the two groups and to scientifically assess the actual effectiveness of the tool.

5.3 Evaluation of effectiveness and data analysis

The results of the study show that the smart education tool had a positive but differentiated impact on promoting personalised learning. As shown in Table 1, students in the experimental group made significant progress across multiple dimensions, with an average improvement in academic achievement of 8.6 points (in percentage), significantly higher than the 4.3 point improvement in the control group. The analysis of student stratification is even more important, as the data show that middle and backward students benefit the most, with the average achievement of the latter third of the students improving by 12.4 points, the middle segment improving by 8.7 points, and the first third of the students improving by only 5.2 points, which indicates that the smart tool has a positive effect on narrowing the learning gap.

Table 1. Comparison of changes in students' dimensions before and after the application of smart educational tools

Evaluation Dimension	Experimental Group Improvement	Control Group Improvement	Difference

Academic Performance (Out of 100)	8.6	4.3	4.3
Learning Interest (Out of 5)	0.94	0.38	0.56
Learning Time Investment (Minutes/Week)	96	32	64
Learning Planning Ability (Out of 5)	0.82	0.31	0.51
Problem-Solving Ability (Out of 5)	0.76	0.29	0.47
Collaborative Learning Ability (Out of 5)	0.65	0.42	0.23

Regional comparative data show that there are obvious regional differences in the effectiveness of the application, as shown in Table 2, schools in the eastern region have the most significant effect, with an average improvement of 10.3 points in students' performance, while in the central region it is 7.9 points and in the western region it is 6.8 points, reflecting the influence of resource conditions and implementation capacity on the effectiveness. Analysed in terms of subject dimensions, Mathematics and English subjects showed the most significant improvement, reaching 9.7 and 9.4 points respectively, while language subjects showed a relatively low improvement of 6.8 points, which may be related to the knowledge structure and learning characteristics of different subjects. Teachers' teaching behaviours also changed significantly, with classroom observation data revealing that teachers in the experimental group increased their time for individualised instruction by 18.7%, and the openness of classroom questioning by 25.3%. System log analysis reveals the evolution of students ‘ usage patterns, with only 31.2% of students being able to purposefully choose what to learn at the beginning of the implementation period, while this percentage rises to 73.5% at a later stage, suggesting that there is a significant increase in students’ ability to learn on their own.

Table 2. Comparison of the effectiveness of the application of smart education tools in different regions

Region	Academic Performance Improvement	Self-Learning Ability Improvement	Teacher Teaching Behavior Change	System Usage Depth
Eastern Region	10.3	0.91	27.50%	High
Central Region	7.9	0.73	19.20%	Medium
Western Region	6.8	0.58	12.30%	Low

6. Conclusion

Research on smart education tools for personalised learning has shown that technology adaptation, instructional design, and student capacity development are key pathways to effective application. Empirical research confirms that smart tools are effective in improving learning achievement, interest and autonomy, especially for middle and lower-income students, and help to narrow the learning gap. However, there are significant differences in the effectiveness of implementation in different

regions, reflecting the problem of uneven allocation of educational resources. Future research should focus on the in-depth integration of smart technologies and education theories, develop a more inclusive smart education ecosystem, promote the simultaneous improvement of education equity and quality, and realise technology-enabled education change.

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