Research on the Impact of Information-based Teaching in Urban and Rural Middle Schools on Students' Academic Performance

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Abstract: With the continuous advancement of educational informatization in China, the application of information technology in secondary school teaching is becoming increasingly common. However, there are still differences between urban and rural areas in terms of information infrastructure, resource utilization, and teacher information literacy, and their actual impact on students' academic performance urgently needs empirical testing. This article takes 331 urban and rural middle school classes as samples, constructs a multiple regression model, and explores the impact of information-based teaching on students' academic performance from four dimensions: the proportion of multimedia teaching, the degree of informationization in lesson preparation, the degree of informationization in teaching content, and the proportion of information-based self-directed learning. Heterogeneity effects are analyzed through teaching experience grouping. The research results indicate that multimedia teaching, lesson preparation informatization, and teaching content informatization all have a significant positive effect on students' academic performance, with the degree of lesson preparation informatization having the most prominent impact; The proportion of information-based self-directed learning has no significant impact on academic performance, indicating that the effectiveness of self-directed learning is constrained by students' self-discipline and usage patterns. Heterogeneity analysis shows that teachers with lower teaching experience have a more significant promoting effect on multimedia and content informatization, while the experience of homeroom teachers with higher teaching experience has a greater impact on academic performance improvement. This study provides empirical reference for promoting the balanced development of information technology in urban and rural education, enhancing teachers' information literacy, and regulating students' self-directed learning.

Keywords: Urban and Rural Middle Schools; Information-based Teaching; Academic Performance; Multiple Regression

1. Introduction

In recent years, rapid advancements in information technology have driven continuous improvements in educational modernization. Digital teaching has emerged as a vital means to enhance the quality of basic education and propel educational modernization. At the national level, policy documents such as the "Education Informatization 2.0 Action Plan" and the "14th Five-Year Plan for Education Informatization and Cybersecurity" have been issued, explicitly calling for "vigorous promotion of digital transformation in education." These initiatives aim to facilitate the sharing of high-quality educational resources and narrow educational disparities between urban and rural areas, regions, and schools. Against this backdrop, information technologies such as multimedia teaching, smart classrooms, and online learning platforms have seen increasing adoption in primary and secondary school classrooms, with information technology becoming increasingly integrated into curriculum delivery.

However, current circumstances reveal a significant gap in information-based education levels between urban and rural schools in China. Some urban schools have established mature systems in hardware facilities, teacher IT training, and digital resource applications; conversely, many rural schools lag in IT infrastructure development, require enhanced teacher IT competencies, and exhibit limited scope and depth of IT application in classrooms. This disparity not only hinders innovation in teaching methodologies but also impedes academic achievement and the realization of educational equity.

Investigating the impact of urban-rural IT-enabled teaching on student performance holds both significant policy implications and practical educational value. Such research provides empirical data to evaluate the effectiveness of national educational informatization policies while quantitatively analyzing the relationship between various aspects of IT-integrated teaching and student performance. Therefore, this paper employs panel data and fixed-effects methods to systematically examine the mechanisms through which IT-integrated teaching influences student achievement and the variations in these effects under different conditions. It aims to assist educational policymakers and school administrators in developing scientifically sound and rational strategies for educational informatization.

2. Review of the Literature

2.1 Research on Information-based Teaching

Research on information-based teaching conducted by scholars both domestically and internationally has largely focused on areas such as teaching model innovation, teacher competency enhancement, and improvement of teaching effectiveness. Sun Dapeng integrated modern teaching theories to explore development pathways for information-based physical education in higher education. By analyzing physical fitness data and establishing models, he found that information-based methods play a positive role in optimizing teaching content and enhancing student physical fitness [1]. Li Xia and Liu Ming, using pre-service teachers as subjects, proposed a "dual-track integration" training model to enhance their information-based teaching capabilities. Empirical data demonstrated this model effectively improves pre-service teachers' information literacy and technological application skills [2]. From a teaching anthropology perspective, Zhu Fangchun and Xu Binyan analyzed secondary mathematics teachers' information-based instructional behaviors, highlighting that teachers' perceptions of technology significantly influence their adoption and innovative application of information technologies [3]. Zhang Hongyan and Wang Yun constructed an evaluation system for secondary chemistry teachers' information technology competencies, validating its scientific rigor and practicality through empirical data, thereby providing a tool for sustained teacher development [4]. Through classroom observations, Zhu Maoyong reflected on information-based teaching in secondary English education, advocating for integrating information technology with interactive teaching methods such as debates and role-playing to enhance classroom engagement and teaching effectiveness [5]. These studies provide diverse theoretical and practical references for information-based teaching across different disciplines and educational stages, laying the foundation for this paper's analysis of the effectiveness of information-based teaching in urban and rural secondary schools.

2.2 Research on Factors Influencing Academic Performance

Research by foreign scholars on factors influencing student performance has primarily focused on family, school, teacher characteristics, and individual student behavior. Hu Yongmei and Xu Meiqi, employing educational ecosystem theory and network analysis methods, found that parental educational expectations, parental involvement in school education, teacher quality, and students' allocation of extracurricular time significantly impact the academic performance of elementary and middle school students [6]. Xianfei Gu examined academic achievement disparities among secondary students across three dimensions-individual, family, and school-identifying learning habits, psychological state, family support, and classroom teaching quality as key determinants [7]. Zhang Zihan and Lei Wanpeng focused on disadvantaged students, finding that establishing positive emotional interactions between teachers and students and enhancing students' learning perseverance significantly improved academic performance. They also emphasized the importance of formative assessment [8]. Zhang Long et al., through a multiple mediation model analysis, discovered that physical exercise indirectly enhances secondary students' academic performance by improving their cognitive and non-cognitive abilities, with this indirect effect being greater than the direct one [9]. Liu Xinqiao and Wei Yi analyzed Beijing data using value-added models and multilevel linear models, revealing that teacher characteristics such as gender and status as a key teacher significantly impact student performance. They proposed establishing a categorized, multidimensional

teacher evaluation system [10]. These studies demonstrate that student academic achievement is influenced by multiple factors, encompassing both external conditions like family and social resources, as well as internal factors such as teacher quality and student individual characteristics.

2.3 Research on the Impact of Information-based Teaching on Student Academic Performance

Domestic and international literature on the impact of information-based teaching on student performance primarily focuses on aspects such as investment, the digital divide, urban-rural disparities, and underlying mechanisms. Based on data from primary schools in Nanjing, Ding Jing et al. found a correlation between the level of school information technology infrastructure and students' Chinese and mathematics scores [11]. Ma Hongmei et al., utilizing PISA-2018 global data, highlighted significant disparities in school IT infrastructure between urban and rural areas as well as across regions. They noted that hardware and software provision positively influenced student performance, yet the digital divide remained pronounced [12]. Based on China Education Panel Survey (CEPS) data, Zhu Qiuming found that information technology can enhance rural students' performance, though this improvement is influenced by household economic conditions and the purpose of IT usage [13]. Tian Yahui et al. employed a multilevel linear model to analyze Nanjing junior high school data, revealing that the proportion of multimedia classrooms significantly boosts student performance and contributes to narrowing educational disparities [14]. Mbugua et al. empirically demonstrated that integrating information and communication technology (ICT) into teaching at Kenyan public secondary schools improves student performance by enhancing classroom interaction and knowledge visualization. However, implementation effectiveness is constrained by teachers' instructional strategies and execution capabilities. These studies indicate that technology-enhanced teaching holds potential to boost academic achievement across diverse contexts. Yet, due to variations in technological conditions, usage methods, and educational environments, the impact of such approaches exhibits considerable variability [15].

3. Theoretical Foundations and Assumptions

3.1 Theoretical Foundations

3.1.1 Theory of acceptance of educational technology

The Technology Acceptance Model, proposed by Davis, is primarily used to explain and predict whether individuals are willing to adopt and use new technologies. At the core of this model are "perceived usefulness" (the belief that the technology is beneficial) and "perceived ease of use" (the belief that the technology is easy to operate). These two factors influence technology adoption through "intention to use." In digital teaching environments, the acceptance levels of multimedia instruction, online learning platforms, and digital classroom resources by teachers and students determine how frequently and deeply these tools are utilized in the classroom. Disparities exist between urban and rural secondary schools in terms of technological resources, information literacy levels among teachers and students, and training support conditions. These gaps affect teachers' and students' "perceptions" of information-based teaching tools, which in turn influence the effectiveness of academic achievement improvement. Therefore, using the Technology Acceptance Model (TAM) as a framework can both explain the differences in the use of information-based teaching across different schools and groups, and reveal the potential mechanisms through which these differences may impact student academic performance.

3.1.2 Constructionist learning theory

Constructivist learning theory posits that learning is a process whereby learners actively understand and construct new knowledge based on their existing knowledge through interaction with the external environment. Information-based teaching leverages multimedia, online resources, and interactive platforms to provide students with rich learning contexts and opportunities for independent exploration, aligning closely with constructivism's principles of "student-centered learning" and "contextualized learning." Information technology not only transcends temporal and spatial constraints to deliver diverse authentic materials across urban and rural secondary education settings but also enables real-time interaction and collaborative inquiry between teachers and students, as well as among students themselves. This facilitates the development of

independent learning skills and deepens students' comprehension of knowledge. Furthermore, constructivism emphasizes individual learner differences, providing a theoretical foundation for analyzing variations in learning responses and academic performance among students from different regions and schools with varying levels of information technology integration.

3.2 Research Hypotheses

From the perspective of the Technology Acceptance Model (TAM), teachers' perception that multimedia is useful influences how they utilize it-such as through PowerPoint presentations, micro-videos, and interactive whiteboards-to make lessons more engaging and dynamic. These technological tools can visually represent complex concepts, reducing the difficulty of comprehension and thereby enhancing students' learning engagement and knowledge retention. From a constructivist perspective, multimedia resources create rich learning contexts that help students connect new knowledge with prior knowledge, enhancing their ability to transfer learning. Although urban and rural schools differ in hardware conditions and network environments, the judicious use of multimedia tools still holds significant potential to improve student performance. Based on this, we propose:

H1 Hypothesis: The higher the proportion of multimedia instruction, the better the student performance.

When teachers find digital tools useful during lesson preparation (e.g., online resource searches, intelligent question banks, cloud-based lesson planning platforms), they are more likely to design targeted instructional content. In both urban and rural secondary schools, digital lesson preparation enables teachers to access more comprehensive and innovative teaching resources. It also allows them to develop precise teaching plans based on student learning data, thereby improving classroom interaction and task assignments. From a constructivist perspective, information-based lesson preparation enables teachers to design learning scenarios better aligned with students' cognitive levels and interests, stimulating their capacity for self-directed learning and deep thinking. High-level information-based lesson preparation enhances the effectiveness of student learning. Based on this, we propose:

H2 Hypothesis: The higher the level of information-based lesson preparation, the better the students' academic performance.

"Teaching content that is perceived as useful and interactive" can enhance students' interest in learning. Constructivism holds that learning materials and real-world problem scenarios are crucial for students to grasp the meaning of knowledge. For instance, geography courses utilize digital maps and remote sensing imagery as data support, while physics courses employ simulation software. These tools break the physical constraints of traditional classrooms, enabling students to form deeper impressions of knowledge through multidimensional information. For rural schools with relatively scarce resources, high-quality digital teaching content can also compensate for deficiencies in experimental facilities and teaching staff. The deeper the digitalization of teaching content, the greater the potential for students to enhance their knowledge structure and overall competence. Based on this, we propose:

H3 Hypothesis: The higher the digitalization level of teaching content, the better students' academic performance.

From a constructivist perspective, self-directed learning is a crucial pathway for students to explore and construct knowledge meaning through self-motivation. Digital tools provide timely feedback, vast resources, and personalized learning paths for such autonomy. The Technology Acceptance Model (TAM) emphasizes that students' perceptions of tools as "useful and easy to use" during digital self-directed learning significantly impact learning quality. However, the effectiveness of self-directed learning is greatly influenced by students' self-management abilities, learning motivation, and the purpose of technology use. For instance, some students may use digital tools for entertainment rather than learning, which not only wastes time but also distracts them. Furthermore, differences in family education and self-discipline between urban and rural students can lead to varying outcomes in self-directed learning. Despite these risks, a reasonable proportion of digital self-directed learning may still positively impact academic performance. Based on this, we propose:

H4 Hypothesis: The greater the proportion of information-based self-directed learning, the better the student performance.

4. Empirical Analysis

4.1 Research Design

4.1.1 Sample and data sources

The research sample for this study was derived from questionnaire surveys and academic performance data compiled from urban and rural secondary school classes, covering a full academic year. The final valid sample comprised 331 class observations, representing diverse teaching contexts across urban and rural areas and multiple subjects, ensuring strong representativeness. Student academic performance data utilized the average scores across subjects from each class's most recent final exams to reflect overall class academic proficiency. Variables related to information-based teaching (such as the proportion of multimedia instruction and the degree of digital lesson preparation) were derived from teacher and student questionnaires. Control variables (including class size, teacher experience, and number of class periods) were sourced from school administrative system records. For data processing, we first removed missing information. Then, for scaled variables requiring scoring, we standardized them using a 1–5 point scale to ensure consistent variable definitions and comparability.

4.1.2 Variable selection

This study constructed a system of dependent variables, independent variables, and control variables based on class-level data, as shown in Table 1.

Table 1. Variable Definition Table

Variable Type	Variable Name	Variable Symbol	Variable Definition
Dependent variable	Academic Performance	score	The average score for all subjects in this class on the most recent final exam
Independent variable	Proportion of Multimedia Instruction	media	The proportion of multimedia instruction hours to total instruction hours across all subjects in this class
	Level of Information Technology Integration in Lesson Preparation	prepi	The proportion of total lesson preparation time spent by teachers in this class using information technology tools
	Level of Information Technology Integration in Teaching Content	conti	The proportion of information technology content in the teaching content of this class relative to the total teaching content
	Proportion of self-directed learning in information technology	selfie	The proportion of total learning time spent by students on self-directed learning using information technology tools in or outside of class
Control Variables	Total Class Enrollment	size	Total number of students in the class
	Teaching experience of homeroom teacher	tage	Total years of teaching experience for the homeroom teacher
	Average teaching experience of instructors	texp	Average teaching experience of all subject teachers for this class
	Total Weekly Class Hours	wless	Total number of class periods per week
	Completion Rate of Assignments	hwfin	Average homework completion rate for the semester
	Proportion of males	male	Percentage of male students in the class
	Extracurricular Subject Tutoring Ratio	tutor	Percentage of students participating in extracurricular subject tutoring

4.1.3 Model specifications

This study employs an ordinary least squares (OLS) regression model to conduct a benchmark regression analysis on the data, examining the impact of independent variables on the dependent variable (student academic performance). The regression model is as follows:

$$score_i=\alpha+\beta_1 media_i+\beta_2 size_i+\beta_3 tage_i+\beta_4 texp_i+\beta_5 wless_i+\beta_6 hwfin_i+\beta_7 male_i+\beta_8 tutor_i+\varepsilon_i \quad (1)$$

$$score_i=\alpha+\beta_1 prepi_i+\beta_2 size_i+\beta_3 tage_i+\beta_4 texp_i+\beta_5 wless_i+\beta_6 hwfin_i+\beta_7 male_i+\beta_8 tutor_i+\varepsilon_i \quad (2)$$

$$score_i=\alpha+\beta_1 conti_i+\beta_2 size_i+\beta_3 tage_i+\beta_4 texp_i+\beta_5 wless_i+\beta_6 hwfin_i+\beta_7 male_i+\beta_8 tutor_i+\varepsilon_i \quad (3)$$

$$score_i=\alpha+\beta_1 selfi_i+\beta_2 size_i+\beta_3 tage_i+\beta_4 texp_i+\beta_5 wless_i+\beta_6 hwfin_i+\beta_7 male_i+\beta_8 tutor_i+\varepsilon_i \quad (4)$$

Where i represents the teacher, a denotes the constant term, $\beta_1 \sim \beta_n$ signifies the variable coefficient, and ϵ_{it} is the random disturbance term.

4.2 Empirical Findings

4.2.1 Descriptive analysis

Table 2 shows that this study collected observations from 331 classes, with all variables falling within the predefined measurement scales. As shown in Table 2, the mean score for the dependent variable "academic achievement (score)" was 2.616, with a standard deviation of 1.340, indicating varying academic performance across different classes. The means for the four core independent variables are as follows: proportion of multimedia instruction (media) 2.776, level of information technology integration in lesson preparation (prepi) 2.568, level of information technology integration in teaching content (conti) 2.477, and proportion of information technology-based independent learning (selfi) 2.372. Among these, the mean for the proportion of information technology-based independent learning is the lowest, indicating that the application of information technology is more prevalent in classroom teaching segments than in student independent learning segments.

Table 2. Descriptive Analysis

Variable	Obs	Mean	Std.dev.	Min	Max
score	331	2.616	1.340	1	5
media	331	2.776	1.481	1	5
prepi	331	2.568	1.240	1	5
conti	331	2.477	1.310	1	5
selfie	331	2.372	1.218	1	5
size	331	2.221	1.148	1	4
tage	331	2.498	1.417	1	5
texp	331	2.335	1.364	1	5
less	331	2.320	1.117	1	4
hwfin	331	2.215	1.064	1	4
male	331	2.326	1.105	1	4
tutor	331	2.260	1.309	1	5

Regarding control variables, the mean class size (size) was 2.221, and the mean weekly total class hours (wless) was 2.320, indicating moderate differences in class size and scheduling across the sample classes. The means for homeroom teacher experience (tage) and subject teacher average experience (texp) were essentially identical, reflecting that both homeroom and subject teachers possessed roughly equivalent levels of teaching experience.

4.2.2 Correlation analysis

Table 3 indicates that academic performance (score) exhibits significant positive correlations ($p<0.05$ or $p<0.01$) with multimedia teaching proportion (media), lesson preparation informatization level (prepi), teaching content informatization level (conti), class size (size), and homeroom teacher's years of experience (tage). This demonstrates a clear positive association between these factors and student performance, with high reliability.

The correlation coefficient between the proportion of information-based self-directed learning (selfi) and academic performance is negative but not significant. This suggests that the positive impact of information-based self-directed learning on academic performance depends on students' self-discipline and proper usage methods; otherwise, it may fail to produce positive outcomes. The homeroom teacher's years of experience (tage) positively correlated with the total class size (size). The average teaching experience of subject teachers (texp) negatively correlated with the proportion of multimedia instruction (media), suggesting that more experienced teachers are not necessarily more inclined to use multimedia teaching methods. The homework completion rate (hwfin) showed a significant negative correlation with the number of weekly class hours (wless), indicating that overly tight class schedules may compromise the quality of students' homework completion.

Furthermore, the correlation coefficients between all variables are below 0.2, indicating no severe multicollinearity issues that would compromise the regression analysis results.

Table 3. Correlation Analysis

	score	media	prepi	conti	selfie	size	tage
score	1	-	-	-	-	-	-
media	0.126**	1	-	-	-	-	-
prepi	0.143***	-0.0360	1	-	-	-	-
conti	0.105*	-0.0350	0.0300	1	-	-	-
selfi	-0.0540	0.0380	-0.0560	-0.00500	1	-	-
size	0.156***	-0.0320	0.0610	-0.0360	-0.00200	1	-
tage	0.152***	-0.0120	-0.0100	0.0620	-0.0480	0.174***	1
texp	0.0110	-0.117**	-0.0630	0.0880	0.0510	-0.131**	0.0870

less	0.117**	0.113**	0.0670	-0.0280	0.0440	0.0350	-0.0590
hwfin	0.0240	-0.0100	-0.0580	-0.00600	0.0580	0.122**	0.00100
male	0.099*	0.100*	-0.0360	-0.0680	-0.0860	-0.0640	-0.0110
tutor	0.0240	0.0320	-0.108**	-0.143***	0.00200	0.00800	0.0350
-	-	-	-	-	-	-	-
-	texp	wless	hwfin	male	tutor	-	-
texp	1	-	-	-	-	-	-
less	0.0860	1	-	-	-	-	-
hwfin	0.00900	-0.208***	1	-	-	-	-
male	-0.0250	-0.0280	-0.0370	1	-	-	-
tutor	0	0.0150	-0.094*	-0.094*	1	-	-

4.2.3 Baseline regression analysis

Table 4 shows that the four models respectively analyzed the impact of different core independent variables on academic performance, with the specific results as follows:

Model (1) (Impact of Multimedia Instruction Proportion): The regression coefficient for multimedia instruction proportion (media) is 0.0999, passing the significance test at the 5% level ($p<0.05$). This indicates that, controlling for other factors, a one-point increase in the proportion of multimedia instruction correlates with an approximate 0.1-point rise in the class's average academic performance. This suggests multimedia instruction effectively enhances information presentation and increases classroom interactivity, positively influencing student achievement.

Model (2) (Impact of lesson preparation informatization): The coefficient for lesson preparation informatization (prepi) is 0.153, significant at the 1% significance level ($p<0.01$), and exceeds the coefficient for multimedia teaching proportion. This indicates that teachers' use of informatized tools during lesson preparation enables more targeted and efficient instruction, exerting a more pronounced effect on student performance than multimedia teaching.

Model (3) (Impact of Instructional Content Digitalization): The coefficient for instructional content digitalization (conti) is 0.124, significant at the 5% level ($p<0.05$). This indicates that the richness and visual appeal of digital instructional content aid student comprehension and knowledge transfer, thereby enhancing performance.

Model (4) (Impact of Proportion of Information-Based Self-Directed Learning): The coefficient for the proportion of information-based self-directed learning (selfi) is -0.0506 and is not significant. This suggests that information-based self-directed learning does not necessarily directly improve academic performance, potentially constrained by factors such as student self-discipline and learning preferences. If students cannot properly utilize information tools for learning, positive outcomes are unlikely to materialize.

Regarding control variables:-Class size (size), weekly total class hours (wless), and homeroom teacher's years of experience (tage) were significantly positive at the 5% confidence level across all models. This indicates that moderate class sizes, reasonable class schedules, and experienced homeroom teachers positively influence student performance. However, the average teaching experience of subject teachers (texp), homework completion rate (hwfin), and the proportion of extracurricular tutoring (tutor) showed no significant impact, failing to demonstrate a clear effect on academic performance in this sample. The male-to-female ratio (male) was significantly positive at the 10% or 5% level in some models, potentially related to boys' classroom participation, performance in academic competitions, and teacher-student interaction styles.

Furthermore, the F-statistics for all four models were significant at the 1% level, indicating strong overall explanatory power for each regression equation. Collectively, the independent variables exerted statistically significant effects on academic performance.

Table 4. Baseline Regression Analysis

	(1)	**(2)**	**(3)**	**(4)**
	score	**score**	**score**	**score**
media	0.0999**	-	-	-
	(2.02)	-	-	-
prepi	-	0.153***	-	-
	-	(2.63)	-	-
conti	-	-	0.124**	-
	-	-	(2.23)	-
selfi	-	-	-	-0.0506

	-	-	-	(-0.85)
size	0.159**	0.142**	0.157**	0.152**
	(2.45)	(2.20)	(2.42)	(2.33)
tage	0.127**	0.130**	0.122**	0.127**
	(2.46)	(2.52)	(2.35)	(2.44)
texp	0.0218	0.0154	-0.00241	0.00922
	(0.40)	(0.29)	(-0.04)	(0.17)
less	0.139**	0.148**	0.163**	0.160**
	(2.09)	(2.24)	(2.46)	(2.40)
hwfin	0.0485	0.0651	0.0576	0.0570
	(0.69)	(0.93)	(0.82)	(0.81)
male	0.129*	0.150**	0.155**	0.138**
	(1.96)	(2.31)	(2.37)	(2.09)
tutor	0.0274	0.0496	0.0515	0.0323
	(0.50)	(0.90)	(0.92)	(0.58)
_cons	0.824**	0.596	0.678	1.168***
	(2.03)	(1.40)	(1.60)	(2.82)
N	331	331	331	331
R2	0.082	0.089	0.084	0.072
adj.R2	0.059	0.067	0.061	0.049
F	3.575	3.955	3.697	3.123

t statistics in parentheses

*p<0.1,**p<0.05,***p<0.01

4.2.4 Heterogeneity analysis

To investigate differences in the impact of information-based teaching on academic performance among teachers with varying years of experience, we divided the sample into a "high-experience group" and a "low-experience group" based on teaching tenure and conducted grouped regression analysis. The results are shown in Table 5:

Proportion of multimedia teaching (media): In the low-seniority group, the coefficient was 0.110, significant at the 5% level ($p<0.05$); whereas in the high-seniority group, the coefficient was not significant. This indicates that teachers with shorter teaching experience rely more heavily on multimedia teaching, and their use of multimedia teaching yields greater improvements in student performance.

Preparation informatization (prepi): Both groups showed positive coefficients. The coefficient for the high-seniority group was 0.219 (larger) and significant at the 10% level; the coefficient for the low-seniority group was 0.154 and significant at the 5% level. This indicates that informatized preparation enhances performance for both senior and junior teachers, but senior teachers demonstrate greater potential for improvement through such preparation.

Digitalization of teaching content (conti): Only the coefficient for the low-seniority group was significant ($p<0.1$), while it was insignificant for the high-seniority group. This indicates that teachers with shorter tenure are more adept at converting digital teaching content into academic advantages.

Regarding control variables:

Class size (size): Significantly positive in the low-tenure group ($p<0.01$), insignificant in the high-tenure group. This indicates that teachers with less experience achieve greater teaching effectiveness in moderately sized classes.

Homeroom teacher experience (tage): Significantly positive in the high-experience group ($p<0.01$) with a larger coefficient, indicating that homeroom teachers with longer experience have a more pronounced effect on academic improvement due to their rich teaching and management expertise.

Weekly teaching hours (wless): Significantly positive in the low-experience group ($p<0.01$) and insignificant in the high-experience group, suggesting that reasonable lesson scheduling is more critical for the teaching effectiveness of less experienced teachers.

Homework completion rate (hwfin): This variable showed a significant negative effect in the senior group and a significant positive effect in the junior group. This discrepancy may stem from differing homework management approaches among teachers with varying experience levels, leading to opposite impacts on academic performance.

Gender ratio (male): This factor exhibited a significant positive effect only in the junior group. This may relate to teaching styles and competitive classroom environments favored by junior teachers, which tend to stimulate greater learning motivation among male students.

Furthermore, the R^2 values indicate that the models for the senior group (0.194–0.227) fit better than those for the junior group (0.097–0.103). However, the impact of information technology variables on academic performance is more pronounced in the junior group.

Table 5. Analysis of Heterogeneity in Teaching Experience

-	**High seniority**	**Low teaching tenure**	**High seniority**	**Low teaching tenure**	**High seniority**	**Low teaching tenure**
-	score	score	score	score	score	score
media	0.105	0.110**	-	-	-	-

-	(1.01)	(1.98)	-	-	-	-
prepi	-	-	0.219*	0.154**	-	-
-	-	-	(1.89)	(2.31)	-	-
conti	-	-	-	-	0.0810	0.125*
-	-	-	-	-	(0.75)	(1.94)
size	0.117	0.206***	0.0870	0.189***	0.0990	0.204***
-	(0.76)	(2.87)	(0.57)	(2.64)	(0.64)	(2.84)
tage	0.348***	0.0706	0.359***	0.0739	0.349***	0.0632
-	(3.47)	(1.15)	(3.64)	(1.21)	(3.47)	(1.03)
less	0.160	0.148**	0.169	0.157**	0.187	0.171**
-	(1.15)	(1.97)	(1.26)	(2.10)	(1.36)	(2.29)
hwfin	-0.376**	0.131*	-0.370**	0.149*	-0.338**	0.131*
-	(-2.35)	(1.69)	(-2.37)	(1.91)	(-2.10)	(1.68)
male	-0.0414	0.167**	-0.0293	0.194***	-0.0177	0.195***
-	(-0.31)	(2.24)	(-0.22)	(2.62)	(-0.13)	(2.62)
tutor	0.0352	0.0333	0.0869	0.0519	0.0681	0.0540
-	(0.29)	(0.54)	(0.72)	(0.84)	(0.54)	(0.86)
_cons	1.732**	0.525	1.300*	0.308	1.517*	0.401
-	(2.38)	(1.17)	(1.70)	(0.65)	(1.79)	(0.85)
N	78	253	78	253	78	253
R2	0.199	0.097	0.227	0.103	0.194	0.097
adj.R2	0.119	0.072	0.150	0.077	0.113	0.071
F	2.489	3.779	2.934	4.000	2.407	3.750

5. Conclusions and Recommendations

5.1 Research Conclusions

Based on questionnaire and academic performance data from 331 urban and rural secondary school classes, this study examines the impact of information-based teaching on student academic achievement. Using multiple regression and group regression methods across four dimensions-proportion of multimedia instruction, level of information-based lesson preparation, level of information-based teaching content, and proportion of information-based independent learning-the primary findings are as follows:

Across the entire sample, the proportion of multimedia instruction, the degree of information technology integration in lesson preparation, and the degree of information technology integration in teaching content all exerted significant positive effects on student academic performance. Among these, the degree of information technology integration in lesson preparation had the strongest impact coefficient, indicating that investing information technology resources during the instructional design phase more effectively translates into academic advantages for students. While the proportion of information-based self-directed learning showed a positive effect on grades, it was not statistically significant. This suggests that the effectiveness of self-directed learning is constrained by student self-discipline and learning objectives-if students cannot use information tools appropriately for learning, it is difficult to improve their grades.

Controlling for variables, moderate class size, longer teaching experience of homeroom teachers, and reasonable class scheduling all significantly improved student grades. while the average teaching experience of subject teachers, homework completion rates, and the proportion of extracurricular tutoring had no significant impact on academic performance.

Heterogeneity analysis indicates that among teachers with shorter teaching experience, multimedia instruction and the informatization of teaching content have a more pronounced positive effect on academic performance. Conversely, among teachers with longer teaching experience, the homeroom teacher's instructional expertise and management capabilities play a greater role in academic improvement.

Overall, information-based teaching positively impacts academic performance in both urban and rural secondary schools, though its effectiveness varies across contexts (e.g., urban-rural disparities, hardware conditions) and groups (e.g., teachers with different teaching experience, students with varying levels of self-

discipline). This implies that differentiated measures tailored to specific circumstances are necessary when formulating educational informatization policies and implementation strategies to maximize the benefits of information-based teaching.

5.2 Related Recommendations

5.2.1 Strengthen the development of information infrastructure

Research indicates that information-based teaching can enhance student academic performance. However, disparities persist in technological infrastructure and resource accessibility between urban and rural areas, particularly as rural schools remain relatively underdeveloped in hardware equipment, network environments, and digital resources. In response, the following recommendations are proposed:

Education authorities should increase financial support for underdeveloped regions like rural areas during the advancement of educational informatization. Priority should be given to improving infrastructure such as multimedia classrooms, smart blackboards, and stable campus networks to ensure rural schools possess the fundamental conditions for implementing information-based teaching.

Establish cross-regional educational resource sharing platforms to facilitate the flow of high-quality urban digital educational resources to rural schools, addressing the issues of "having equipment but lacking resources" and "having resources but not knowing how to use them." For example, platforms can share premium courseware, videos of renowned teachers' lectures, and digital experimental resources, enabling rural students to access high-quality teaching content.

Develop phased digitalization plans tailored to regional conditions, establishing a cyclical system of "hardware upgrades → software implementation → maintenance and supply" to ensure long-term functionality of digital equipment and resources. Simultaneously, encourage collaboration among governments, enterprises, and non-profit organizations to attract social capital investment in rural educational digitalization. This approach advances "hardware upgrades, software provision, and teacher training" concurrently, progressively narrowing the urban-rural digital divide.

5.2.2 Enhancing teachers' digital literacy

Empirical analysis indicates that the degree of information technology integration in teachers' lesson preparation has the most significant impact on student academic performance. This demonstrates that the level of IT application in instructional design directly determines the effectiveness of digital teaching. Therefore, enhancing teachers' digital literacy is crucial. Specific recommendations are as follows:

Educational administrative departments and schools at all levels should establish comprehensive teacher training mechanisms for information technology. Training content should not only cover the use of digital tools (such as PowerPoint creation, online lesson preparation platforms, and intelligent question banks) but also encompass practical skills like digital resource integration, smart classroom instructional design, and student learning data analysis. This ensures teachers not only "know how to use technology" but also "use technology effectively," deeply integrating information technology with curriculum instruction.

Transition from traditional "lecture-style" training to more practical approaches like workshops, demonstration classes, and peer-to-peer support. For instance, organize outstanding teachers to showcase digital teaching cases for on-site observation and exchange among peers. Establish a "mentor-mentee pairing" system where digitally proficient teachers assist less experienced colleagues to enhance training effectiveness.

Design differentiated training programs based on teachers' years of experience and expertise: For newer teachers, prioritize technical support and classroom management guidance to help them quickly master digital teaching methods. For more experienced teachers, focus on strengthening training in digital teaching concepts, guiding them to integrate their rich teaching experience with digital technology to innovate teaching models.

5.2.3 Guide students to engage in self-directed learning through information technology in a scientific manner

The correlation between the proportion of information-based self-directed learning and academic performance is not significant, indicating that the effectiveness of self-directed learning depends on students' self-discipline, learning objectives, and usage methods. To fully leverage the potential of information-based self-directed learning, schools, teachers, and families

must jointly guide students in the scientific use of information technology. Specific recommendations are as follows:

Schools and teachers should integrate self-directed learning tasks into classroom instruction. For example, under teacher guidance, students can complete inquiry-based tasks using digital tools such as online courses, intelligent question banks, and simulated experiments to cultivate self-directed learning habits. Concurrently, teachers should provide timely feedback on students' self-directed learning progress and correct inappropriate learning methods.

Schools should establish dedicated learning management platforms to track students' digital self-directed learning duration, progress, and task completion in real time. This aids students in organizing their study schedules effectively, integrating online and offline learning. For instance, platforms can recommend personalized learning resources based on individual progress and remind students to complete assignments on time.

Strengthen students' information literacy education to cultivate their ability to evaluate online resources (e.g., distinguishing high-quality learning materials from entertainment content) and manage time effectively. This prevents the misuse of digital tools for entertainment, which can lead to wasted study time and distracted attention. Families should collaborate with schools in supervision, fostering a positive home learning environment to help students develop sound attitudes toward digital learning.

For students with weaker self-discipline, adopt a "phased goal-setting and evaluation" intervention approach. For instance, break down independent learning tasks into short-term, achievable goals. Provide immediate encouragement and feedback upon completion of each goal to gradually enhance their self-discipline and independent learning capabilities.

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