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The Role of ICT Infrastructure in Its Application to Classrooms: A Large Scale Survey for Middle and Primary Schools in China

Chun Lu[1], Chin-Chung Tsai[2] and Di Wu[1*]

[1]National Engineering Research Center for E-Learning, Central China Normal University, Wuhan, China // [2]Graduate Institute of Digital Learning and Education, National Taiwan University of Science and Technology, Taipei, Taiwan // luchun@mail.ccnu.edu.cn // cctsai@mail.ntust.edu.tw // dr.wudi@gmail.com

[*]Corresponding author

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ABSTRACT

With the ever-deepening economic reform and international trend of ICT application in education, the Chinese government is strengthening its basic education curriculum reform and actively facilitating the application of ICT in education. Given the achievement gap of ICT infrastructure and its application in middle and primary schools between urban and rural areas, a divide exists between the needs of constructing ICT infrastructure and the patterns of promoting ICT application in education. This paper reports a survey conducted on the infrastructure and application of ICT in middle and primary schools in urban areas (city and county) and rural areas in China based on their demands for promoting ICT in education. The survey focused on 2,168 middle and primary schools, including 717 schools in cities (33.1%), 487 schools in counties (22.5%) and 964 schools located in rural areas (44.5%). Based on stepwise regression analysis, it was revealed that ICT infrastructure had different influences on its application for schools in urban and rural areas. Schools' proportion of ICT aided courses in counties, and utilization of multi-media classrooms in rural areas may be more associated with the infrastructure. These conclusions would be particularly useful for policy-makers in Asia. Moreover, the analysis model could highlight some areas where improvement plans could be implemented to reduce the digital divide. However, ICT infrastructure was found to play an insignificant role in "utilization of multi-media classrooms" or "proportion of ICT aided courses" in city schools, and thus its role in city schools should be reinterpreted.

Keywords

ICT application in education, ICT infrastructure, Large scale survey, Middle and primary schools, Factor analysis, Stepwise regression analysis

Introduction

The development of ICT in education

The rapid development of ICT has brought both challenges and opportunities to middle and primary schools, particularly as one of the important factors that innovates education by providing equal learning opportunities. Developed countries have always attached great importance to the application of ICT in education. For example, in the United Kingdom, the government spent £2.5 billion on educational ICT in 2008 to 2009 (Yilmaz, 2011). Several surveys have been carried out to investigate the factors related to the use of ICT in teaching and learning by teachers (Baek, Jung, & Kim, 2008; Türel, 2011). Integrating computer technologies into education requires successful development of ICT infrastructure(Sadegül, 2006). Depending on the context such as national ICT policy, the implementation process proves to be complex as it is influenced by various agents at different levels and scales. In addition, the schools' infrastructure and application of ICT have become more visible when examining the development of ICT in education.

ICT development in China

China is currently experiencing rapid economic growth, while the government is trying to eliminate the education divide between rural and urban areas during the process of urbanization and industrialization. It has been found that disparities in access to education between rural and urban areas are the major cause of educational inequality in China (Qian & Smyth, 2008). The Chinese government has consistently given priority to education development, adapting to the international trend of educational reform and ICT application in education (Zhang, Fang, & Ma, 2010). The central government should increase educational transfer payments to undeveloped provinces, and establish a financial system governed by a provincial institution (Yang, Huang, & Liu, 2014).

In China, middle and primary schools are divided into city schools, county schools, and schools in rural areas according to the administrative division. For local or national education administrative departments, in order to equitably and reasonably distribute the funding for ICT infrastructure, they need to compare different demands for ICT infrastructure in different regions (cities, counties and rural areas). Most city schools could offer ICT courses for all students. At least half of the classrooms are equipped with multimedia projectors to support and promote the utilization of digital technologies for learning and teaching, while some of them provide various digital instruction facilities. Besides, various courses can utilize information technology tools to assist teaching in city schools. However, county schools offer ICT courses for the third or higher grade students. The equipment for teachers to use consists mainly of multimedia classrooms, but some teachers of subsidiary courses, such as physics, chemistry, geography and history, cannot use information technology for teaching yet because of the lack of multi-media classrooms and digital instruction facilities. Only some schools in rural areas could offer ICT courses, and only a fraction of schools have multi-media classrooms, and these tend to have a poor operating environment and low utilization rates. Due to the lack of a network environment and hardware facilities, the equipment is not frequently applied in everyday teaching.

Previous research on ICT infrastructure

In the past, the relationship between infrastructure and application has been examined in some studies. ICT infrastructure measures the perceived availability and suitability of the ICT tools such as hardware, software and peripheral equipment provided in the school (Vanderlinde & Van Braak, 2010). It also refers to the availability of equipment, software, Internet access and other similar resources in the school (Pelgrum, 2001). A model has been built and tailored to the characteristics of public schools in a developing country (Solar, Sabattin, & Parada, 2013).

ICT equipment and access provided by the school is a key factor in ICT integration. The limitation of the access to technology is not only for computers but also for projectors, resources and other equipment. It has been found that laptop and tablet computers and mobile phones are increasingly considered as useful in education (Prensky, 2001). A literature review of UK research on the topic states that in order for a specific device to be used optimally, certain technical and organizational conditions must be fulfilled (Savill-Smith, 2005). It is necessary to clarify the demands for ICT infrastructure in education based on the current development status to remedy the disparities of regional development and reduce excess investment.

Most previous studies have mainly focused on the benefits brought by a single type of facility or equipment for learning and teaching. However, relatively fewer studies have been conducted to explore the relationship between the infrastructure and application of ICT in developing areas or even depressed areas on a nationwide scale. Therefore, this paper intends to study ICT application in primary and middle schools in cities, counties and rural areas, and to explore the correlation between the application and infrastructure of ICT so as to identify the types of ICT infrastructure to be increased and constructed in different regions in national or provincial plans in education.

Research purpose and research questions

Firstly, the main purposes of this study were to develop a model that can be used to identify Chinese middle and primary schools' ICT application based on the proposed theoretical framework. Secondly, the study aimed to explore the relationship between schools' ICT application and the development of ICT infrastructure in different regions. Besides, the effects of ICT infrastructure as the predictor of ICT application were investigated. Specifically, the study addressed the following questions:

- Do middle and primary schools in cities, counties and rural areas display grade differences in ICT application, such as "utilization of multi-media classrooms" and "proportion of ICT aided courses"?
- What are the relationships between Chinese middle and primary schools' ICT infrastructure and their application of ICT?
- Through stepwise regression analysis, can the ICT infrastructure indexes of middle and primary schools be used to make significant predictions about their ICT application?

Method

In this large-scale survey, around 4,500 middle and primary schools in 300 districts of 31 provinces in China were surveyed to gather data about their construction of ICT infrastructure and application in education. The research group randomly selected no less than 10 sample districts in each province. The Departments of Education in each province were asked to nominate a provincial coordinator. All middle and primary schools in the sample districts were asked to complete the questionnaire. The leader and head teachers of each school completed the questionnaire according to the current situation of ICT at the whole-school level and sent it back to the provincial coordinator. Finally, the coordinators in each province sent back all the questionnaires to the research group.

In the questionnaire, questions about ICT infrastructure mainly related to the proportion of students attending ICT courses, the number of multi-media classroom seats per student, types of multi-function classroom, educational satellite receivers, and types of digital instruction facilities. The level of ICT application was evaluated according to the utilization of multi-media classrooms and the proportion of ICT aided courses.

A series of ANOVA analyses was employed to examine the infrastructure and application of ICT in the different regions. Subsequently, a stepwise regression model was built according to the analysis of the data collected. Based on the prediction results and the analysis of the model, some suggestions on improving the ICT infrastructure of schools in different regions are provided to improve the ICT application at the national level.

Sample

Samples gathered for this research are 2,168 questionnaires of middle and primary schools over 31 provinces in China, and the return rate is 48.2%. These samples were selected randomly, and the scale of the samples meets the standard for correlation and stepwise regression analysis. Among all the valid samples, 717 were schools in cities, accounting for 33.1% of the total, 487 schools were located in counties, constituting 22.5% of the total, and 964 schools were in rural areas, making up 44.5% of the total. The average student number of all the 2,168 schools was 856.09. Of the 2,168 schools, 42.7% (1,064) had over 1,000 students, 29.7% (740) had 500 to 1,000 students, and the remaining 27.6% had 100 to 500 students.

Instrument

We developed an integrated model that allowed us to investigate whether ICT infrastructure efforts influence the application of ICT for Chinese middle and primary schools in cities, counties and rural areas (see **Error! Reference source not found.**).

By gathering national or provincial domestic preliminary research specified in the *China Education Yearbook* about ICT infrastructure in middle and primary schools, a questionnaire was designed based on the comparison of trends and the implementation of this year. The questionnaire for middle and primary schools in *Monographic Research Reports on Construction and Application of Educational Informatization in China* (Group, 2010) was also considered.

Before the questionnaire was implemented, it was sent to the relevant experts including education experts, educational IT academics, school leaders and education officials by e-mail for three rounds of discussion. During the first round of discussion, the 15 experts who participated gave advice on the structure of the questionnaire and the coverage area of the problems. After supplementing the content of the questionnaire according to the experts' suggestions, the second round of consultation was held. School principals and administrators were consulted about the readability of the questionnaire and the effectiveness of the questions. According to the feedback, the questionnaire was modified again and experts in the field of educational information technology and provincial education administrative departments were consulted before it was then finalized.

Two sections from the large survey were analyzed in this study: (1) ICT infrastructure, and (2) ICT application. We developed an integrated model to investigate whether ICT infrastructure efforts influence the application of ICT for Chinese middle and primary schools in cities, counties and rural areas.

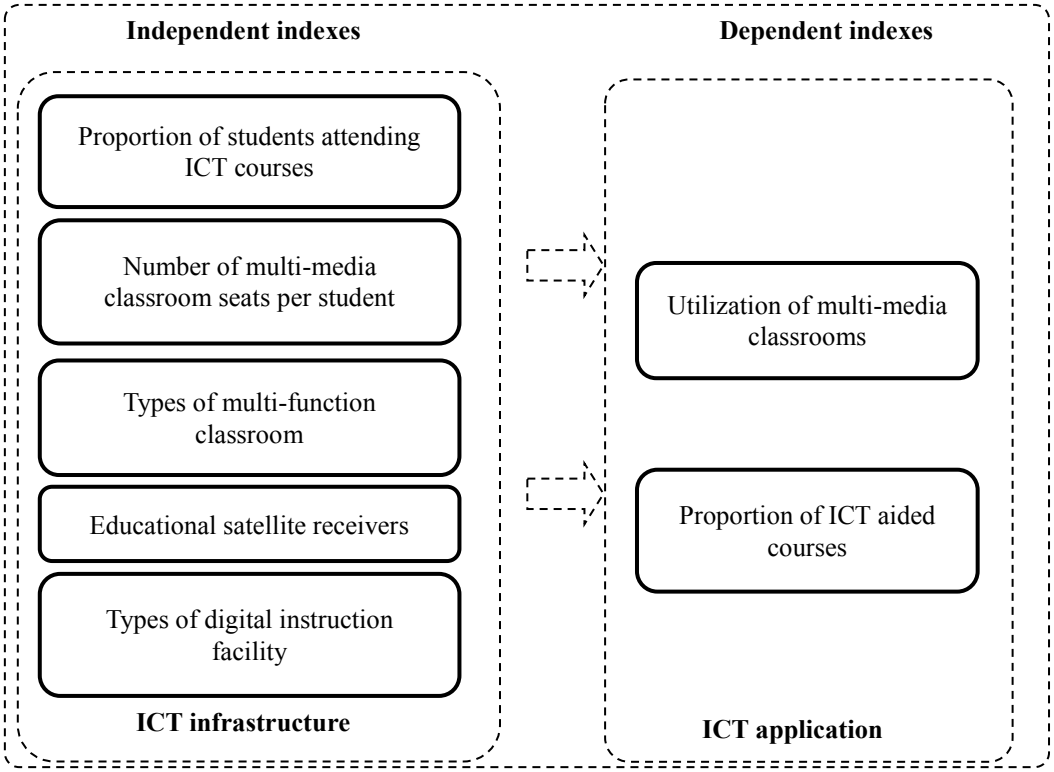

Figure 1. Indexes of ICT infrastructure and application in the model

Although a range of infrastructure indicators could be used to represent a school ICT infrastructure, specific items were chosen according to the recent research and common practice in China. For example, multimedia classroom represents one of the basic ways of conventional e-learning implementation (Zhao & Jiang, 2010). Therefore, "utilization of multi-media classrooms" and "number of multi-media classroom seats per student" were considered in our items. The main places where teachers integrate IT into classroom teaching were the computer classroom, multimedia classroom and multi-function e-classroom (Yeh, Chang, & Chang, 2011). With well-equipped multi-function classrooms, students and teachers can undertake a range of personal and professional learning activities. "Type of multi-function classroom" is therefore considered. Microcomputers, printers, VCRs, camcorders, satellite receivers, and computer modems have become available for use in Chinese education. Schools should make efforts to improve both the multimedia hardware and software devices to establish well-equipped multimedia classrooms and libraries with comprehensive content of resources and courseware (Dai & Fan, 2012). It is also necessary to consider the use of "digital instruction facilities" in basic education. Computer network technology and satellite digital technology have been widely used in teaching in schools and in the management of educational technology of national and local governments (Liu, Cheng, & Liu, 2010). "Educational satellite receivers" are also considered. In middle schools, the level of ICT literacy differed between students who took an ICT subject and those who did not (Hyeoncheol, Soonyong, Jamee, Hongrae, & Junghee, 2011). Middle schools need to offer ICT as a subject to teach ICT to all students (Aoki, Kim, & Lee, 2013). The primary schools in Taiwan offer ICT courses for third and higher grade students (Lin & Liu, 2010), but only some of the middle and primary schools in China could offer ICT courses for most students. Moreover, according to the *Compendium of Chinese ICT course in Middle and Primary Schools*, the ICT courses in those schools comprise no fewer than 68 class hours per academic year, and the courses performed on computer are no less than 70% of the total lessons (MOE, 2010). Thus, "proportion of students attending ICT courses" in China could reflect the construction condition of multimedia classrooms and computer classrooms at the school level. The measurement of the ICT level of schools indicates how well prepared schools are for using ICT and how much they are using it (Aoki et al., 2013). The use of ICT should not be limited to certain subjects, such as ICT and computer courses, but should also be used in some main and subsidiary courses, such as

physics, chemistry, geography and history. In our item, "proportion of ICT aided courses" is considered to show the use of ICT in the teaching of all subjects.

At the same time, through a brainstorming session with researchers who had several years of experience in this field and the guide of officials in ICT development in basic education of the Ministry of Education, we identified five independent indexes of ICT infrastructure and analyzed two aspects of a school's ICT application.

Indexes of ICT infrastructure and application

These independent variables were chosen because of their potential impact on ICT application based on previous studies. Although many of them share similarities, they are grouped into different categories, such as ICT courses, multi-media classroom, multi-function classroom and other digital instruction facilities. Without established and verified scales, they work as single item independent variables.

- Proportion of students attending ICT courses: ICT courses in middle and primary schools can train students' abilities to explore problems with the help of ICT, foster their spirit of innovation, and cultivate their practical abilities. Ensuring the quantity and quality of ICT courses has become a part of the development strategy of ICT in education in China.
- Number of multi-media classroom seats per student: Together with other digital instruction facilities, multi-media classrooms have become the most commonly adopted modern teaching platform in middle and primary schools. In order to make full use of multi-media classrooms in teaching, a sufficient number of seats must be provided for students.
- Types of multi-function classroom: With the widespread use of multi-media technologies in teaching, multi-function classrooms catering to different teaching needs are gradually being used in daily teaching activities in middle and primary schools. The extensive use of multi-function classrooms is definitively to bring innovation and reform to teaching activities and enhance both the depth and width of ICT application in education.
- Educational satellite receivers: For schools in counties and particularly in rural areas, educational satellite receivers have become the major way of obtaining the necessary teaching resources due to their lack of access to cable broadband.
- Types of digital instruction facilities: Providing diversified digital instruction facilities for teachers and students in the course of teaching will not only satisfy different needs for multi-media applications, but will also enhance students' interest in making use of such digital instruction facilities in their learning.

This study used a multilevel model to explore the impact of different infrastructure factors on ICT application at the school level. The dependent variables are "utilization of multi-media classrooms" and "proportion of ICT aided courses." The extensive use of ICT infrastructure in middle and primary schools was mainly reflected in the frequency and scope of the application of ICT infrastructure in daily teaching activities. Hence, in this work, the following two indexes of ICT application were mainly examined:

- Utilization of multi-media classrooms: Frequent use of multi-media classrooms indicates that ICT has been regularly used in teaching. The higher the utilization rate of multi-media classrooms, the greater the number of teachers and students who will use the ICT infrastructure to facilitate teaching and learning.
- Proportion of ICT aided courses: A high proportion of subjects with ICT aided teaching indicates extensive use of ICT in teaching. Effective use of ICT for education emphasizes the integration of ICT with teaching activities in all or the majority of subjects, and encourages extensive ICT application in teachers' daily work.

The items for ICT infrastructure and application are shown in *Table 1*.

Table 1. Items for ICT infrastructure and application

ICT infrastructure	
Proportion of students attending ICT courses	The proportion/ratio of students who attended ICT courses in the recent academic year is _____%.
Number of multi-media classroom seats per student	The total number of students is__. The total number of seats in multimedia classrooms is__.
Types of multi-function classroom	The multi-functional classrooms include ( )(multiple answers possible) A. None B. Recording room C. Remote video classroom D. Digital language lab E. Machine room for preparing lessons F. Micro-classroom G. Other

Educational satellite receivers	Have an educational satellite receiver ( ) A. Yes B. No
Types of digital instruction facility	The digital instruction facilities include (multiple answers possible)( ) A. None B. Computer C. Set Top Box D. Interactive Whiteboard E. Projector F.TV G. Television with touch screen H. All-in-one machine I. Stenograph J. Multimedia center console K. Visual Presenter L. Screen for writing M. Other
ICT application	
Utilization of multi-media classrooms	The average utilization of multi-media classrooms for teaching is about %.
Proportion of ICT aided courses	The subjects which use ICT for assisted teaching frequently are ( )(multiple answers possible) A. None B. Chinese C. Mathematics D. English E. Physics F. Chemistry G. Politics H. Geography I. Biology J. History K. Other

Data analysis

In order to draw a diagram of the relationship between the infrastructure and application of ICT in middle and primary schools, the correlations within and between the ICT infrastructure and application factors were analyzed. To examine the differences in these factors across the three regions, an ANOVA analysis was conducted. The ICT infrastructure factors were considered as predictor variables, whereas the ICT application factors were processed as outcome variables. Finally, the important infrastructure factors that influence ICT application in education in schools of different regions were analyzed according to the regression analysis results.

Results

The comparisons of ICT infrastructure and application among middle and primary schools in the three regions

To draw a clear definition among different education development patterns, an ANOVA analysis was employed to compare the ICT application and infrastructure in different regions, as shown in *Table 2*. Once a significant F-value was obtained in an ANOVA analysis, post hoc tests were widely used to examine the significances of all possible pair-wise comparisons among regions. *Table 2* shows the numbers of schools in each region, the mean values of the ICT application and infrastructure indicators in each region, and the comparisons of the post hoc tests. The results of the ANOVA analyses revealed that there are significant differences among regions for the ICT development indicators of "utilization of multi-media classrooms" ($F = 51.15$, $p < 0.001$), "proportion of ICT aided courses" ($F = 4.36$, $p < 0.05$), and for the ICT infrastructure indicators of "number of multi-media classroom seats per student" ($F = 54.92$, $p < 0.001$), "types of multi-function classroom" ($F = 14.89$, $p < 0.001$), "educational satellite receivers" ($F = 89.92$, $p < 0.001$), and "types of digital instruction facility" ($F = 47.06$, $p < 0.001$).

Table 2. ANOVA for ICT application and infrastructure for the three regions

		N	*Mean*	*SD*	*F*	Post hoc
Proportion of students attending ICT courses	1	717	0.80	24.06		
	2	487	0.82	22.08		
	3	964	0.79	23.66		
	total				1.75	(.174)
Number of multi-media classroom seats per student	1	717	1.36	0.76		
	2	487	1.10	0.71		1 > 2
	3	964	0.98	0.72		2 > 3
	total				54.92**	
Types of multi-function classroom	1	717	1.24	1.03		
	2	487	1.31	1.08		1 > 3
	3	964	1.03	0.99		2 > 3
	total				14.89**	
Educational satellite receivers	1	717	0.18	0.38		

	2	487	0.53	0.84		3 > 1
	3	964	0.52	0.50		2 > 1
	total				89.92**	
Types of digital instruction facility	1	717	3.41	2.02		
	2	487	3.00	2.04		1 > 2
	3	964	2.45	1.99		2 > 3
	total				47.06**	
Utilization of multi-media classrooms	1	717	0.69	0.22		
	2	487	0.65	0.23		1 > 2
	3	964	0.57	0.24		2 > 3
	total				51.15**	
Proportion of ICT aided courses	1	717	0.48	0.26		
	2	487	0.51	0.27		2 > 1
	3	964	0.47	0.25		2 > 3
	total				4.36*	

Note. 1: City schools; 2: County schools; 3: Rural area schools. $^{**}p < .001$. $^{*}p < 0.05$.

Furthermore, a series of post hoc tests (Bonferroni) were performed to compare the differences among regions. The results revealed that the utilization of multi-media classrooms of city schools (*mean* = 68.84%) is higher than that of county schools (*mean* = 64.64%) and rural area schools (*mean* = 57.48%). In addition, the proportion of ICT aided courses in counties (*mean* = 50.74%) is higher than that in cities (*mean* = 48.37%) and in rural areas (*mean* = 46.52%). In terms of ICT infrastructure, city schools are better off than the county and rural area schools.

Correlation between ICT infrastructure and ICT application

Based on the statistical analysis of all samples, the correlation between the schools' infrastructure and application of ICT in cities, counties and rural areas is presented in *Table 3*.

Table 3. Correlation between ICT infrastructure and application in the three regions

Scale	Proportion of students attending ICT courses	Number of multi-media classroom seats per student	Types of multi-function classroom	Educational satellite receivers	Types of digital instruction facility
City					
Utilization of multi-media classrooms	.09*	.31**	.04	.00	.26**
Proportion of ICT aided courses	.08*	.05	.13**	.02	.11**
County					
Utilization of multi-media classrooms	.10*	.30**	.08	.02	.28**
Proportion of ICT aided courses	.11*	.11*	.06	.48**	.18**
Rural area					
Utilization of multi-media classrooms	.23**	.40**	.05	-.08*	.34**
Proportion of ICT aided courses	.33**	.12**	.13**	.03	.17**

$^{**}p < 0.01$. $^{*}p < 0.05$.

For middle and primary schools in cities, it was found that "utilization of multi-media classrooms" was significantly related to selected ICT infrastructure, such as number of multi-media classroom seats per student and types of digital instruction facility ($r = 0.31$, $p < 0.01$, $r = 0.26$, $p < 0.01$, respectively). As for county schools, the infrastructure

index with the highest degree of correlation to the proportion of ICT aided courses is "educational satellite receivers" ($r = 0.48$, $p < 0.01$). For schools in rural areas, infrastructure related to "utilization of multi-media classrooms" covers "number of multi-media classroom seats per student," "types of digital instruction facility" and "proportion of students attending ICT courses" ($r = 0.30$, $p < 0.01$, $r = 0.28$, $p < 0.01$, $r = 0.10$, $p < 0.05$, respectively).

In short, there is a certain degree of correlation between infrastructure and application of ICT in schools of all regions. The results of the correlation analysis indicate that the level of schools' ICT infrastructure is relatively low in counties and rural areas, where the degree of the correlation between infrastructure and application of ICT is higher.

Stepwise regression estimates for predicting ICT adoption in city schools

As shown in *Table 4*, for schools in cities, the indexes that are highly predictive for utilization of multi-media classrooms include the following: "number of multi-media classroom seats per student" ($t = 7.51$, $p < 0.001$), "types of digital instruction facility" ($t = 5.15$, $p < 0.001$) and "proportion of students attending ICT courses" ($t = 2.95$, $p < 0.001$), of which the overall prediction proportion reaches 15%. The results of the statistical analysis revealed that in order to increase the efficiency of multi-media classrooms, schools could increase the number of such classrooms, actively encourage students to study in these classrooms, offer teachers and students diversified digital instruction facilities, arouse students' enthusiasm for learning with ICT equipment, and increase the proportion of students attending ICT courses. Compared with the proportion of ICT aided courses among all subjects, the utilization of multi-media classrooms depends more on ICT infrastructure, which means that constructing ICT infrastructure is an effective measure to increase the utilization rates of ICT infrastructure such as multi-media classrooms.

Table 4. Stepwise regression between ICT infrastructure and application for city middle and primary schools ($n = 717$)

Dependent variables	Predicting variables	*B*	*S.E.*	*B*	*T*	R^2
Utilization of multi-media classrooms	Number of multi-media classroom seats per student	8.84	1.18	.27	7.51	.15
	Types of digital instruction facility	2.27	.44	.19	5.15	
	Proportion of students attending ICT courses	.11	.04	.10	2.95	
	Constant	46.71	3.77		12.38	
Proportion of ICT aided courses	Types of multi-function classroom	.32	.09	.13	3.45	.03
	Types of digital instruction facility	.14	.05	.11	2.86	
	Constant	3.98	.22		18.50	

Indexes highly predictive of the proportion of ICT aided courses include "types of multi-media classroom" ($t = 3.45$, $p < 0.001$) and "types of digital instruction facility" ($t = 2.86$, $p < 0.001$), of which the prediction proportion only reaches 3%. The results show that the ICT infrastructure indexes have slight predictive power for ICT application. Currently, the multi-function classrooms in city schools mainly consist of remote video classrooms and e-lesson preparation rooms. Other types of multi-function classrooms such as microteaching classrooms and IWBs for the training of teaching methods and behavior have also become popular.

Stepwise regression estimates for predicting ICT adoption in county schools

As shown in *Table 5*, for the utilization of multi-media classrooms, average student seat number per classroom ($t = 5.20$, $p < 0.001$) and types of digital instruction facility ($t = 4.64$, $p < 0.001$) are highly predictive, with an accumulative prediction percentage of 13%. Regression analysis revealed that the number of multi-media classroom seats per student and the types of digital instruction facility could influence the utilization of such classrooms, which also suggests that the number of multi-media classrooms could not meet teachers and students' needs for regular teaching use.

Table 5. Stepwise regression between ICT infrastructure and application for county middle and primary schools (n = 487)

Dependent variables	Predicting variables	*B*	*S.E.*	*B*	*T*	R^2
Utilization of multi-media classrooms	Number of multi-media classroom seats per student	7.43	1.43	.23	5.20	.13
	Types of digital instruction facility	2.31	.50	.21	4.64	
	Constant	49.54	2.03		24.44	
Proportion of ICT aided courses	Educational satellite receivers	3.17	.25	.52	12.95	.29
	Types of digital instruction facility	.42	.10	.17	4.04	
	Number of multi-media classroom seats per student	.71	.30	.10	2.39	
	Proportion of students attending ICT courses	.02	.01	.10	2.48	
	Types of multi-function classroom	-.43	.19	-.09	-2.24	
	Constant	.29	.85		0.34	

Indexes which are predictive of the proportion of ICT aided courses of county schools include "educational satellite receivers" (t = 12.95, p < 0.001), "types of digital instruction facility" (t = 4.04, p < 0.001), "number of multi-media classroom seats per student" (t = 2.39, p < 0.001) and "proportion of students attending ICT courses" (t = 2.48, p < 0.001), of which the prediction degree reaches 29%. The results of the regression analysis show that county schools could promote ICT application in all subjects by being equipped with educational satellite receivers and diversified digital instruction facilities, to offer students more seats in multi-media classrooms and more ICT courses. In terms of ICT infrastructure, the predictive effect the index for infrastructure has on the proportion of ICT aided courses is high, indicating that the accessibility of digital resources is important for the development of ICT in county schools.

Compared with other factors, the index for infrastructure is the most predictive for the proportion of ICT aided courses in county schools, suggesting that the construction of education ICT infrastructure could promote ICT application in education effectively in those schools.

Stepwise regression estimates for predicting ICT adoption in rural schools

As shown in *Table 6*, for schools in rural areas, the predictive indexes that closely correlate with ICT application in different subjects are "number of multi-media classroom seats per student" (t = 9.30, p < 0.001), "proportion of students attending ICT courses" (t = 6.24, p < 0.001) and "types of digital instruction facility" (t = 5.65, p < 0.001). The total predictive degree of all these factors reaches 22%. The factor of infrastructure is more predictive for the utilization of multi-media classrooms in rural schools. Among all the indexes for infrastructure, the number of multi-media classroom seats per student is the most predictive for the utilization of such classrooms, indicating that strengthening the construction of multi-media classrooms can improve the utilization rates in rural schools. However, it also shows that multi-media classrooms in rural schools fail to meet the basic demands of all students. Actually, these schools have reduced chances of using such classrooms for teaching to achieve educational equity.

Table 6. Stepwise regression between ICT infrastructure and application for rural area middle and primary schools (N = 964)

Dependent variables	Predicting variables	*B*	*S.E.*	*B*	*T*	R^2
Utilization of multi-media classrooms	Number of multi-media classroom seats per student	10.08	1.08	0.30	9.30	.22
	Proportion of students attending ICT courses	.19	.03	.18	6.24	
	Types of digital instruction facility	2.23	.40	.18	5.65	
	Constant	27.37	2.56		10.70	

Proportion of ICT aided courses	Proportion of students attending ICT courses	.03	.00	.30	9.81	.14
	Types of digital instruction facility	.16	.04	.12	4.08	
	Types of multi-function classroom	.22	.08	.09	2.87	
	Constant	1.64	.28		5.80	

Comparatively speaking, ICT infrastructure in rural areas is more contributive to the proportion of ICT aided courses, so it is important to provide students with enough ICT courses to reach the national standard, and to allocate enough time for students to have hands-on practice. As for the basic hardware facilities for ICT courses, the most important step to take is to increase the number of multi-media classroom seats per student.

With regard to the utilization rate of multi-media classrooms, indexes which are highly predictive include "proportion of students attending ICT courses" ($t = 9.81$, $p < 0.001$), "types of digital instruction facility" ($t = 4.08$, $p < 0.001$) and "types of multi-media classroom" ($t = 2.87$, $p < 0.001$). The accumulative prediction degree of these three indexes reaches 14%. The results of the analysis indicate that a higher proportion of students attending ICT courses together with more diversified digital instruction facilities and multi-function classrooms could advance the progress of ICT aided teaching. The prediction results also show that sufficient and efficient ICT courses could be significantly useful for enhancing students' IT literacy and popularizing ICT aided courses.

Figure 2 shows the relationships in the regression analysis results. The ICT infrastructure factors, "proportion of students attending ICT courses," "average student seat numbers in multi-media classrooms," and "types of digital instruction facility" could make significant predictions for the ICT application in the three regions. "Types of multi-function classroom" is the predictor for both city and rural area schools. "Educational satellite receivers" is the only predictor to explain the "proportion of ICT aided courses" of the rural area schools.

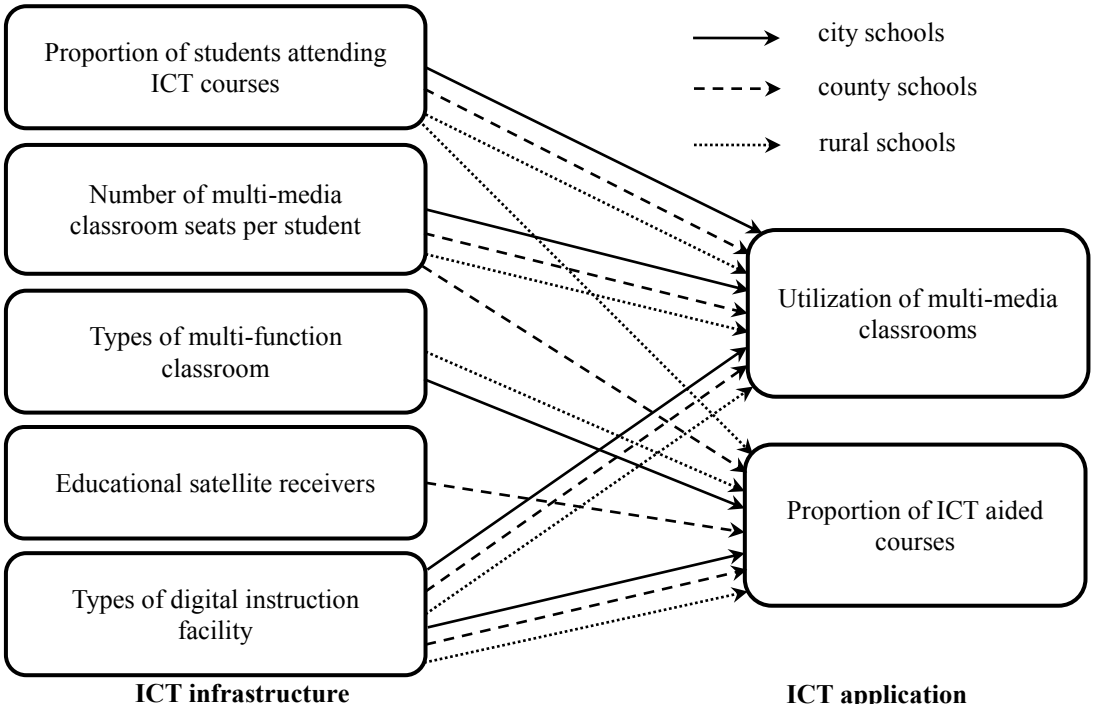

Figure 2. Stepwise regression models of ICT application

In conclusion, improvement of ICT infrastructure plays a limited role in promoting ICT application in ICT aided teaching for schools in cities. However, for the adoption of ICT in teaching in counties and rural areas, such improvement could be greatly advanced.

Discussion

During the past decades, the Chinese government has invested in its ICT education infrastructure increasingly to promote development. The regional disparities of ICT development have become an important indicator of the education balance in China. There is gap between the ICT application and the investment policy of ICT infrastructure. It is critical to investigate the correlation between infrastructure and application of ICT in middle and primary schools between urban and rural areas.

Our research was to explore the ICT development models and actual needs. "Types of digital instruction facility" is the most important indicator that could predict the "utilization of multi-media classrooms" and "proportion of ICT aided courses" for the three regions. Some Chinese schools have started to explore interactive teaching based upon intellectualization, virtual experiment, and mobile teaching and learning (Ding, Niu, & Han, 2010).

"Proportion of students attending ICT courses" could predict "utilization of multi-media classrooms" for the three regions and "proportion of ICT aided courses" for only rural area schools. It has become very important to empower students to be self-directed knowledge "navigators" on the information super-highway (Skagen, Torras, Blaabjerg, & Hansen, 2006).

"Number of multi-media classroom seats per student" could predict "utilization of multi-media classrooms" for the three regions and "proportion of ICT aided courses" for only county schools. Due to budget constraints, most traditional classrooms are not equipped with LCD projectors. Likewise, access to a projector contributes significantly to teachers' production of multimedia materials (Hsu & Kuan, 2013). It is important for rural and county schools to offer enough multi-media classrooms in everyday teaching.

"Types of multi-function classroom" could predict "proportion of ICT aided courses" for city and rural area schools. It is possible that if schools provide more types of multi-function classroom, concentrated efforts in fostering peer and technical support would be undertaken. In developed areas, many schools have started to use new instruction software, platform tools and new style IT products, exploring new models and new ways of applying ICT in instruction (Zhang et al., 2010).

"Educational satellite receivers" could only predict the "proportion of ICT aided courses" of county schools. To promote mutual sharing of optimized educational resources between urban and rural areas, rural junior middle schools are equipped with satellite instruction reception sites. Computer network technology and satellite digital technology have been widely used in teaching and management (Liu et al., 2010).

Conclusion

The rapid development of ICT in education in Chinese middle and primary schools has been diminishing the education gap between areas, although it is too early to claim that ICT will eliminate the education divide across the country. To overcome the lack and limitations of the ICT infrastructure, the necessary financial resources should be provided (Goktas, Gedik, & Baydas, 2013). Depending on the type of ownership of physical resources and infrastructure, an important issue is to choose the deployment model appropriate for the educational institution (Despotović-Zrakić, Simić, Labus, Milić, & Jovanić, 2013).

Using a large representative dataset of 2,168 schools in China, a stepwise regression prediction model was constructed to analyze the influence that ICT infrastructure construction may exert on the adoption of ICT. Based on the prediction results of the model and the comparison of schools' ICT infrastructure and ICT application in cities, counties and rural areas, suggestions for the construction of ICT infrastructure in the three regions are provided for the purpose of further popularizing ICT application in education. Our suggestions for distributing the funding for ICT infrastructure for the different regions are as follows:

For city schools, there are fewer correlation indexes regarding ICT application in all subjects than for schools in the other regions. In general, they should try to make breakthroughs in fields other than ICT infrastructure. In primary

schools, the need for effectively designed materials to use with the hardware and appropriate physical environments have now become prominent in developing countries (Goktas et al., 2013).
County schools have reached a certain level in terms of their infrastructure and application of ICT. To achieve balanced application in different subjects, these schools should attach greater importance to the construction of digital teaching resources in every discipline, and try to provide better access to resources for teachers and students.

Rural schools are currently lacking in multi-media teaching environments, especially multi-media classrooms. More educational investment and ICT infrastructure should be allocated to disadvantaged areas. Therefore, the construction of multi-media classrooms could significantly increase the utilization rates of ICT infrastructure for schools in rural areas. Moreover, ICT courses should pay great attention to improving students' abilities in using ICT technologies and adapting to the ICT learning environment.

There are limitations of the current research, and these issues suggest directions for further investigation. In this research, ICT infrastructure factors are emphasized. However, other researchers may find that additional variables have collective effects which should be examined, such as ICT education resources, ICT policy for education, and ICT integration for teachers. Moreover, ICT infrastructure was found to play an insignificant role in promoting ICT application in city schools. To determine which variables mentioned above are significant predictors for city schools is another challenge for analysis. Future studies can investigate the trend of the digital gap across regions to apply the knowledge from the analysis of ICT development related to the regional digital divide.

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