

A Comparative Analysis of the Relationship Between ICT Resources and Students' Reading Performance: Evidence from China, Japan and Singapore

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Abstract. ICT resources served as important prerequisites for students' ICT-related academic performance. By using the PISA 2018 data across Hong Kong, Macao, Chinese Taipei, Singapore, and Japan, this study examined the association between the availability of ICT resources and students' digital reading performance. The results showed that ICT available at home was negatively associated with digital reading performance, with this relationship relatively stronger in Macao. There was no significant correlation between ICT available at school and digital reading performance. However, general ICT resources were associated with increased digital reading performance, whereas ICT as a topic in social interaction was associated with decreased digital reading performance. These two associations were stronger in Singapore. The findings of this study might inspire educational administration to attach more importance to ICT resources construction.

Keywords: PISA 2018; ICT resources; digital reading performance; regression.

1. Introduction

The digital era is swiftly changing our lives in every aspect. According to OECD, less than 5% of students in OECD countries reported that they did not have any access to the Internet at home by 2018. With regard to ICT use, students spent 6.5 hours every week on average online in 2019 [1]. Digital resources are more accessible than ever, particularly during pandemics when we suddenly switch from in-person instruction to distance education under constraints [2]. It also changes how people read and exchange information. Compared with print reading, digital reading generates a new type of text that is significantly more complex. The ability to access, comprehend, and critically evaluate digital texts is a key requirement for students to participate in the 21st century societies [3]. Nevertheless, the possibility to access digital resources for students in different areas remains different. Students in developed countries averagely enjoy more digital resources than those in developing countries, while cultural differences across regions might also exert influence on the digital resources that students possess. Therefore, research needs to be conducted to explore the relationship between digital resources and digital reading performance in different regions.

2. Literature review

2.1 Digital reading performance

Digital reading performance refers to reading performance in the digital environment. More specifically, digital reading means reading text from screens such as tablets, smartphones and computers, compared to reading text from paper [4]. Given that print reading and digital reading all concerned the information input and process procedures, digital reading performance can be predicted by print reading ability to a certain extent. Generally, a competent print reader might have good digital reading performance [5]. However, existing differences between print reading and digital reading determine that discoveries on print reading could not be directly applied to digital reading context, for which digital competence should be developed to adapt to new changes. Digital text is usually a hypertext arranged in a nonlinear format, hence reading digital texts requires a specific process called navigation where text comprehension intersects with operating digital environments [6]. Students'

navigating proficiency, digital reading strategies and readers' attitudes can predict digital reading performance [3, 7].

Digital reading performance was most often assessed using online English reading tests, and students respond to the reading materials using both their computer literacy and reading literacy. PISA, in its latest cycle in 2018, adopted large-scale online reading test. PISA 2018 assesses students' reading performance according to their proficiency in locating information, understanding text, evaluating and reflecting on text [8]. The digital reading performance has strong pedagogical implications for worldwide reading teachers.

Except for the direct assessment of digital reading performance, factors that are beneficial or harmful to students' digital reading performance have been explored by a diversified range of literature, and researchers focused on print reading skills and digital experience of students particularly [6]. Searching information online is assumed to positively predict navigation, which could improve the digital reading performance. While social activities online are assumed to negatively predict navigation, so it is probably not detrimental and not beneficial to digital reading performance [9]. Moderate use of single-player online games is related to increased performance. However, playing collaborative online games frequently is negatively related to performance in general [10]. Student background is a highly relevant predictor of digital reading performance. The gender gap is one of the most prevalent variables. In most nations in the ePIRLS 2016, girls outperformed boys in terms of average achievement. Girls also outperformed boys in knowledge retrieval and simple inference [11].

Providing that international programs have attached importance to digital reading skills and performance, pedagogical implications on advantaged factors of digital reading performance might be drawn to improve students' digital reading competence [12].

2.2 Categories of ICT resources

Information and Communication Technology (ICT) is a means to receive information, communicate with each other, or influence the environment through electronic or digital equipment [13]. ICT resources have associations with digital reading performance. ICT resources have been widely available nowadays. More than 40 percent of the world's population currently has access to the Internet. ICT gives new opportunities for better education for those who are disadvantaged in educational resources, providing them with more categories of courses and learning assistance. In addition, it is necessary for governments, school, parents and learners to find strategies to adapt to these changes based on research and data [14]. ICT resources are closely related to students' ICT-related learning quality, engagement and familiarity in use digital devices [15]. Most information provided through ICT resources is in text or in a written form in a digital environment [16].

ICT resources have different categories according to different criteria. From one aspect, it includes entertaining or educational software, social media, complementary digital learning tools such as whiteboards.

Moreover, students can get ICT resources from school and home. This study will discuss from these two aspects. ICT resources at school refer to school access to technology and teachers' use of digital educational resources. And school support and teachers' capacity to utilize the digital devices has influence on its effect [15]. In addition, online information on digital devices is more available for students at home. Gender, economic, social and cultural status are factors affecting students' availability to ICT resources at school and home [16]. ICT resources at home have a great effect on students' reading proficiency when few ICT resources are used extensively at school [3]. On one hand studies have revealed that ICT resources in school have no relation to or a negative effect on student achievement [17, 18]. On the other hand, the association between ICT resources at home and digital reading performance is uncertain [16].

And the different intentions of using ICT resources have different process and outcomes. A research finds that students' PISA test scores in reading increase with the intensity of computer use for fun while they decrease with the intensity of computer use for learning [19]. Another research

illustrates that the use of social media is negatively relevant to student literacy across the countries [20].

2.3 ICT resources in reading comprehension

The Internet affects both the nature of reading and the sources of information that we use for learning [13]. ICT resources have close relation to students' reading comprehension. The OECD Programme for International Student Assessment (PISA) conducted digital reading assessment and this study will give further analyses based on PISA. PISA 2018 had 79 participating countries and regions, with approximately 710,000 15-year-old students completing the test tasks and the survey. The influence of ICT resources on students near the end of their compulsory education needs further exploration. In PISA 2018, reading was the main domain of assessment. It provides various questionnaires for students, parents, teachers and schools, particularly in regard to ICT resources, which is conducive to secondary analysis [8].

A study has shown that ICT availability and use had an inversely u-shaped relationship with digital reading performance [3]. Over time, this relationship changed. It became more positive at low levels and less negative at high levels. And more students belong to the 'high levels of use' category from 2009 [21]. Other evidence revealed that reading on digital devices frequently and searching information online were positively related to digital reading achievement, whereas using digital devices frequently was negatively related to digital reading achievement [22]. While the relationship between online social experience and reading comprehension is ambiguous [9]. These studies were conducted among different educational levels and different learner groups, leading to varied results on the effects of ICT resources on digital reading performance. Therefore, given the inconsistency of current research findings, further studies that target wider learner groups are called for explaining the influence mechanisms.

Based on the literature review, two research gaps were identified, which would help guide the current study: a) Most previous research only focus on a single region or country, and studies concerning cross-regional comparison are still few; b) Most studies paid attention to how students utilize ICT applications, but neglect the provision of ICT resources as a basis. Therefore, this study aims to bridge these gaps by exploring the association between various categories of ICT resources and digital reading performance.

3. Methodology

3.1 Data

The data source for this study was PISA 2018 database, an open-access database which incorporates students' disciplinary performance and organized by OECD, PISA measures 15-year-olds' ability to use their reading, mathematics and science knowledge and skills to meet real-life challenges. A total of 79 countries and regions participated in PISA 2018, and reading was the main domain of this assessment. It provides various questionnaires for students, parents, teachers and schools, particularly in regard to ICT resources. 29,840 students from Hong Kong, Macao, Chinese Taipei, Japan, Singapore were selected as the sample in this study. Given that these regions and counties belong to the Confucian cultural circle in Asia and all of them have good economic conditions, it is conducive to secondary comparative analysis.

3.2 Variables

This study employed six variables. There were four independent variables including ICT available at home (ICTHOME), ICT available at school (ICTSCH), general ICT resources (ICTRES), and ICT as a topic in social interaction (SOIAICT). Plausible value 1 in reading comprehension (PV1READ) was taken as the dependent variables. In addition, control variable was introduced in this study, as index of economic, social and cultural status (ESCS) was used to hold its effects on the dependent variable. These four independent variables are representative elements of ICT resources in home and

school. And students' economic, social and cultural status is an important factor of their reading performance.

Variables, except students' digital reading performance, were measured by the ICT familiarity questionnaires that PISA offered to students in its background survey.

3.2.1 Plausible value 1 in reading comprehension (PV1READ)

Plausible value 1 in reading comprehension (PV1READ) was used to quantify students' digital reading performance. All assessed students were offered computer-mediated mode of reading test in the official language of their country. Since PISA samples school from each participating region, and samples students from each school, plausible values were adopted to represent students scores. Plausible value 1, namely PV1READ, representative of all plausible values, was used in this investigation.

3.2.2 ICTHOME

ICTHOME was measured by question, "Are any of these devices available for you to use at home?" Each item (i.e., desktop computer, portable laptop or notebook, <Tablet computer>, Internet connection, <Video games console>, <Cell phone> (without Internet access), <Cell phone> (with Internet access), portable music player, printer, USB (memory) stick, <ebook reader>) was responded by yes/no options, and PISA processes students' answer and generated a final score by counting the number of yes/no choices.

3.2.3 ICTSCH

ICTSCH was measured by question, "Are any of these devices available for you to use at school?" Each item (i.e., desktop computer, portable laptop or notebook, <Tablet computer>, Internet connected school computers, Internet connection via wireless network, storage space for school-related data, USB (memory) stick, <ebook reader>, data projector, Interactive whiteboard) was responded by yes/no options, and PISA processes students' answer and generated a final score by counting the number of yes/no choices.

3.2.4 SOIAICT

SOIAICT was measured by questionnaire: Thinking about your experience with digital media and digital devices: To what extent do you disagree or agree with the following statements? "To learn something new about digital devices, I like to talk about them with my friends." "I like to exchange solutions to problems with digital devices with others on the Internet." "I like to meet friends and play computer and video games with them." "I like to share information about digital devices with my friends." "I learn a lot about digital media by discussing with my friends and relatives." This latent variable, composed of these items, was processed as a continuous variable by PISA officially.

3.2.5 ICTRES

ICTRES is a composite variable which was measured by asking students whether or not and how many instruments are available at home. Two items (i.e., educational software and a link to the Internet) were responded by yes/no options. Four items (i.e., <Cell phones> with Internet access, computers, <Tablet computers> and e-book readers) were responded by numbers. And PISA processes students' answer and generated a final score by counting the number of choices.

3.2.6 ESCS

ESCS is also a composite variable which was measured by asking their parents' highest level of schooling, qualification and job, and whether or not and how many instruments are available and how many books they have at home.

3.3 Procedure

Data cleaning and pre-processing were conducted before formal analysis. First, all outliers have been checked and removed to avoid biases in analysis. Second, the data was checked for its missing

rate, and the list-wise deletion method was used to process the missing values. Third, all variables were standardized with Z-score to ensure they were comparable on the same scale.

The hypothesized model is presented in the figure 1.

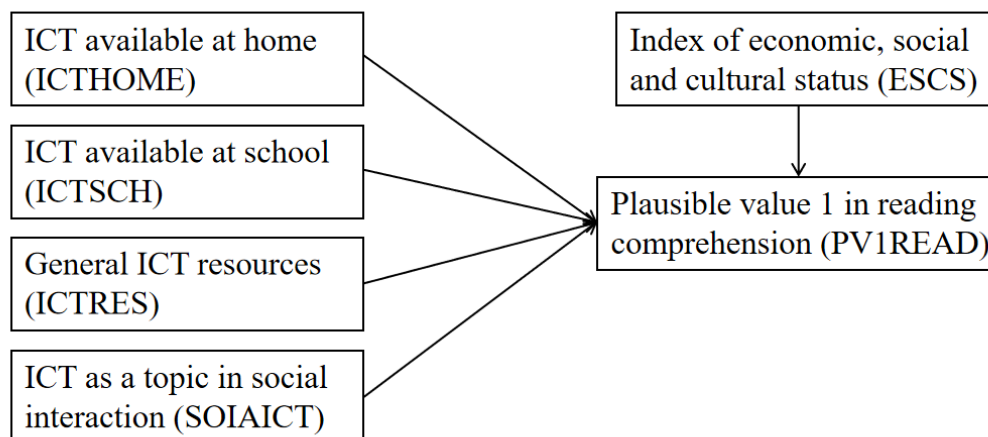


Fig. 1 The hypothesized model

A multiple regression model was established to probe into the research questions. Multiple regression model was adopted because it can analyse the linear relationship between several independent variables and a dependent variable, and predict the value of dependent variable according to values of independent variable. The formal analysis was conducted using SPSS 25.0.

4. Results

In accordance with the research design described earlier, multiple linear regression analysis was employed to analyze the data to examine the statistical significance of the effects of the ICT resources on digital reading performance. In this regression model, the effects of ESCS were controlled. The findings are presented below.

All results were displayed in Table 1. It was found that the R^2 value were .059, .057, .044, .119, .012 for Hong Kong, Macao, Chinese Taipei, Singapore and Japan, respectively, signifying that 5.9%, 5.7%, 4.4%, 11.9%, 1.2% of variability in students' digital reading performance was explained by four independent variables combined.

Table 1 Regression results

Country (Region)	R^2	ICTHOME		ICTSCH		SOIAICT		ICTRES	
		B	p	B	p	B	p	B	p
Hong Kong	.059	-.160	<.001	-.044	<.001	-.118	<.001	.210	<.001
Macao	.057	-.251	<.001	.043	.008	-.034	.035	.226	<.001
Chinese Taipei	.044	-.085	<.001	-.047	<.001	-.076	<.001	.225	<.001
Singapore	.119	-.104	<.001	-.097	<.001	-.160	<.001	.308	<.001
Japan	.012	-.029	.063	.019	.161	-.073	<.001	.098	<.001

In order to explore the relationship between students' digital reading performance and their ICT resources, we based our analysis on the Z-scores of four independent variables among five regions and countries. Coefficients B show the criteria increase per each predictor's increasing unit, keeping the rest of predictors constant. Results found that ICTHOME was associated with decreased digital reading performance Hong Kong ($B = -.160$, $p < .001$); Macao ($B = -.251$, $p < .001$); Chinese Taipei

($B = -.085$; $p < .001$) and Singapore ($B = -.104$, $p < .001$)). It was noteworthy that this association was not significant in Japan ($p = .063$).

In a similar vein, it was found that SOIAICT was negatively associated with digital reading performance (Hong Kong ($B = -.118$, $p < .001$); Macao ($B = -.034$, $p = .035$); Chinese Taipei ($B = -.076$, $p < .001$); Singapore ($B = -.160$, $p < .001$) and Japan ($B = -.073$, $p < .001$)).

However, results indicated that ICTRES was associated with increased digital reading performance (Hong Kong ($B = .210$, $p < .001$); Macao ($B = .226$, $p < .001$); Chinese Taipei ($B = .225$, $p < .001$); Singapore ($B = .308$, $p < .001$) and Japan ($B = .098$, $p < .001$)). The association between ICTSCH and digital reading performance was uncertain, because ICTSCH in Macao was positively associated with digital reading performance ($B = .043$, $p = .008$), while ICTSCH of Hong Kong, Chinese Taipei and Singapore was negatively associated with digital reading performance (Hong Kong ($B = -.044$, $p < .001$); Chinese Taipei ($B = -.047$, $p < .001$) and Singapore ($B = -.097$, $p < .001$)), and it was not significant in Japan ($p = .161$).

5. Discussion

The present study showed that ICT resources had an association with digital reading performance in these five regions, representative of the Confucianism culture circle. With similar cultural background, the results of those five regions were different, which need to further discuss. This study concerned cross-regional comparison, and this association was more obvious in Singapore than other four regions. Most previous studies paid attention to how students utilize ICT applications and differentiate reading by purposes (i.e., reading for academic purposes and reading for entertainment purposes) [9, 10, 12, 20], while the current research focused on the provision of ICT resources as a basis and mainly discussed ICT resources which students get from school and home.

This study found that ICT available at home, in contrast to the hypothesis, was negatively related to digital reading performance. This also ran contrary to the idea that poor digital reading performance was due to a lack of access to ICT. Given the popularization of the Internet connection and many kinds of digital devices, the effects of the use of ICT at home on digital reading performance should be considered further. Two explanations may lend themselves to this finding. First, it is important to distinguish between different forms of ICT use, as Steffens pointed out [23]. ICT resources can be used for learning or for leisure. Out of different intentions, students' navigating proficiency, digital reading strategies and readers' attitudes are different. And these factors can predict digital reading performance, as the literature review mentioned. Then this finding coincided with a previous study in which it was shown that using ICT outside school for leisure frequently was related to decreased digital reading performance [16]. Second, ICT available at home and the frequency of using ICT resources were not equivalent. More and more students belong to the 'high levels of use' category. And a previous study has shown that ICT availability and use had inversely u-shaped relation with digital reading performance [3]. By comparing the results from four regions, this relationship was obvious in Macao.

Meanwhile, the present study discovered that ICT as a topic in social interaction was negatively associated with digital reading performance, and this negative association was comparatively more significant in Singapore. Nevertheless, the reasons accounting for such negative correlation were less clear with reference to existing studies. One explanation might be that the relation between online social experience and reading comprehension is ambiguous and playing with collaborative online games frequently is related to decreased digital reading performance in general [9, 10]. Online social experience and computer games are partly included in ICT as a topic in social interaction.

This study indicated that the associations between ICT available at school and digital reading performance were different among four regions, suggesting cross-region and cross-culture divergence of ICT influence. This association was negative in Hong Kong, Chinese Taipei and Singapore, which aligned with the previous study that ICT resources in school displayed no relation to or a negative effect on student achievement [17]. Nevertheless, the positive association between ICT available at

school and digital reading performance was only shown in Macao. In addition to the availability of ICT resources in school, it was notable that school support and teachers' capacity to utilize the ICT resources had influence on its effect. The management of ICT resources in schools and the use of ICT resources in curriculum may alter its effect.

The current study revealed another finding that general ICT resources were positively associated with digital reading performance. Previous studies did not reach a consistent conclusion on this association [16, 17, 18]. ICT resources were closely related to students' ICT-related learning quality, engagement and familiarity in use digital devices [15]. From this standpoint, general ICT resources may improve students' digital reading performance. The improvement was significant in Singapore and less significant in Japan, revealing more regional differences that specifying ICT resource effects.

The reasons for the regional differences might be complicated. Different regulations of each region on the use of electronic products for teenagers and differences of ICT facilities may alter those relationships. Additionally, different cultures may also have influence, for example, parents can restrict the use of ICT resources [24].

In conclusion, ICT resources, by their categories, have diversified effects on students' reading performance. It is vital to improve digital reading performance and further research it in order to adjust to the shift from print to digital reading. This paper might have pedagogical implication for ICT resources using and provide some views to promote the digitalization of education. It may also help to improve information and reading literacy of students. Schools, teachers, parents and students themselves should take advantage of ICT resources to enhance students' reading competence greatly. ICT resources at school should be managed and used fully, through possible approaches of replacing teaching in a traditional mode to blended teaching. ICT resources at home, which are not fully utilized for learning, might be abused in various other non-academic areas. Parents or caretakers should pay adequate attention to students at home to avoid inappropriate ICT using habits, such as continuous use of social media and excessively browsing information.

A limitation of this study is that though the index of economic, social and cultural status was used to hold its effects on the dependent variable, finding out the differences between different regions and countries might provide a more insightful interpretation to the associations in this research. Further research can explore the relationship between ICT resources and reading performance from economic, social and cultural aspects.

6. Conclusion

This study provided an secondary comparison analysis of PISA 2018 database and demonstrated that ICT resources has a significant impact on students' performance on the basis of the classification of this study. Overall, general ICT resources were positively related to students' digital reading performance, whereas ICT at home or as a topic in social interaction were negatively related to digital reading performance. Although these five regions' students have similar economic circumstances and cultural backgrounds, their students' digital reading performance varies. Parents and teachers could supervise their children on ICT resources use and take good advantage of ICT resources. If students could use ICT resources properly and master the ability to access, comprehend, and critically evaluate digital texts, they could improve their digital reading competence, which is a competitive advantage in this digital world. This study expects to provide researchers and other stakeholders with more knowledge of digital reading. Economic, social and cultural factors could also be taken into consideration when explored in future research.

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