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The Digital Divide? Analyzing Regional Differences of Tablet PC Use in Korean Middle Schools for Sustainable Development

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Abstract: The purpose of this study was to investigate the effects of digital learning environments using tablet Personal Computers (PCs) in Korean metropolitan and rural middle schools. After 12 weeks of professional development for six teachers to enhance ICT and instructional design competency, 48 metropolitan and 63 rural students participated in learning with tablet PCs in English, science, and social studies subjects for 12 weeks. As a result, teachers' various experiences of changes and challenges in digital learning environments were qualitatively analyzed and described. Also, quantitative measurements of students' self-regulated learning abilities, collaborative learning disposition, and learning satisfaction were conducted and findings indicated that rural students showed significant differences compared to urban students in all three variables. Based on the results, educational implications and suggestions are discussed.

Keywords: ICT; tablet PC; digital divide; regional differences; middle school

1. Introduction

Using the latest science and technology, various digitized instructional methods are continuously being developed to enhance learning effectiveness. The flipped classroom, massive open online courses, and immersive learning environments are some of the examples of innovative education. Moreover, mobile devices, such as laptops, smartphones, and tablet PCs, are expected to make classroom instruction more active and participatory. Specifically, the tablet PC has become a major instructional tool, which serves as a platform for digital textbooks and learning applications [1,2].

While educational progress with modern technology has drawn much attention from researchers, there are efforts to broaden the results of such outcomes more equitably. The digital divide is a core issue concerning this topic. In Korea, there are few problems related to accessibility, which is generally regarded as a fundamental issue in implementing digitized education. However, different socio-economic levels in Korea may lead to variations in the use of digital technology among pupils, which can cause an unequal impact of technologies on students' learning [3]. As such, a regional digital divide, that is, the difference between the privileged and underprivileged areas of the country, provides a representative example of technological inequality in Korea.

Studies related to the issue of new learning devices and the digital divide have been intermittently conducted in Korea. There have been reports on differences in computer literacy and related problems among students in Korea [4–6]. Kim (2003) recommended the implementation of school policies, and Kim, Kim, and Lee (2010) developed a curriculum to help alleviate the digital divide in Korean educational environments [7,8]. However, most of these studies were without a deep understanding of how the digital divide affected students and teachers. Moreover, practical measures to solve the issue were seldom proposed.

In light of the problems facing previous research, the present study does not attempt to uncover the effects of a specific tool or methodology, nor will a standardized improvement policy be suggested. Rather, the researchers sought an improved understanding of the effects of digitized learning environments on students and teachers in two diverse regions. To implement this objective, the researchers examined Korea's unique regional digital divide and how the differences between regions concerning digital technology affect their educational contexts.

2. Literature Review

2.1. The Digital Divide in the Korean Context

The digital divide generally refers to "the gap between individuals, households, businesses, and geographic areas at different socio-economic levels with regard both to their opportunities to access information and communication technologies (ICTs) and to their use of the Internet for a wide variety of activities" [9]. Bridging regional digital divides can even reduce disparities in economic activity and employment, as well as offer equal and fair opportunities for living [10]. However, it is hard to resolve regional disparity issues, as they encompass a number of variables, such as gender, age, and economic status.

In the case of India, rural areas have still not seen improvements in their access to technology since the government began addressing the regional digital divide issue more than 30 years ago [11]. In Scotland, there is a serious imbalance between urban and rural areas in terms of Internet and mobile connectivity, a situation referred to as "two-speed" Scotland; this urban–rural digital divide is not expected to lessen in the short term [12]. In contrast, in New Zealand, it was found that firms in remote provinces used email more often than those in metropolitan areas [13]. This implies that the degree of ICT usage varies depending on the circumstances or needs of the area once basic technological access is established.

Korea is considered an advanced country in the information technology field, and is ranked among the top five of the Organization for Economic Co-operation and Development (OECD) member states in terms of access to fixed and wireless broadband [14]. The benefits of technology have been enjoyed relatively evenly across the country. Accordingly, there are few issues concerning technology infrastructure inequalities between urban and rural areas in Korea. However, Armenta, Serrano, Cabrera, and Conte (2012) pointed out that the new regional digital divide includes aspects other than access, such as broadband penetration, sustainable development, technology adoption, and community participation [15]. According to this index, the next area of focus for Korea's regional digital divide issue should be broadband penetration.

Since 2011, the Korean government has been implementing a nationwide digital school initiative, which includes making changes in instructional methods and improving digital learning environments. Among the various ways in which the Korean government has attempted to address the regional digital divide is the creation of professional development schools. Professional development schools study issues related to educational policies, curriculum courses, and instructional methods, and the government aims to contribute to the development of education by disseminating and utilizing the results of their research [16]. Thanks to this policy, remote schools in Korea have received opportunities to benefit from the use of educational technology—specifically, to use devices, such as tablet PCs, for learning—by the designation of professional development schools.

2.2. New Media in Education

As mobile devices for learning have received attention with the advent of feature phones, personal digital assistants (PDAs), and smartphones, many studies on the application of these devices in education have been carried out. The tablet PC in particular has received much attention because of its unique physical characteristics of wider screen sizes and Internet connectivity, which could improve students' learning [1,2].

Research has attempted to gauge the effectiveness of tablet PC-enhanced instruction. Jones, Alston, English, and Gayle (2013) found that college students majoring in agricultural sciences preferred using tablet PCs, which allowed them to use geographical information system applications in a way that stationary units would not have facilitated [17]. Preservice teachers in Turkey appreciated the ability of tablet PCs to engage learners with visual effects and animation [18]. Chen and Sager (2011) insisted that tablet PCs helped demonstrate the problem-solving process, provided visual support, and kept records of instructional content with high interactivity in the classroom. In an English learning environment in Korea, tablet PC-based instruction positively affected elementary and middle school students' reading skills and learning autonomy [19]. However, the authors of the same study warned that even though administrators and practitioners might think using tablet PCs in the classroom is revolutionary and reflective of current instructional technology, accumulated empirical evidence and careful consideration of the constraints of each instructional context must also be taken into consideration. In the case of the United Kingdom, Coughlan (2014) found no clear evidence of academic improvement for pupils using tablet devices, even though almost 70% of primary and secondary schools in the United Kingdom use them [2].

Moving beyond the initial stage of using tablet PCs in education, research has become more interested in examining how to organize pupils' learning experiences than in studying the effectiveness of the device itself. This trend is probably related to the fact that the number of useful applications for mobile devices has increased. The numbers of applications available in "Google Play" and the "App Store" was 2.1 million and 1.8 million, respectively, as of the first quarter of 2019 [20]. Among them, applications for educational use in the case of iOS constituted the third largest percentage, followed by applications for games and business [21].

Educational applications provide students with rich learning experiences through activities with academic content or learning assistant tools. In terms of academic content, digital textbooks are a representative example. In the U.S., the Federal Communications Commission (2015) introduced the "Digital Textbook Playbook", a comprehensive guide to help K-12 educators and administrators build rich digital learning experiences for students [22]. Similarly, countries in Europe, Asia, Oceania, and Africa have pursued their own digital textbook policies [23]. The Korean government also implemented a national digital textbook distribution initiative in 2007 [24]. Through the results of a meta-analysis, digital textbooks were found to be effective in learners' various constructs [25–27].

However, there is relative dearth of research on how educational applications work in the classroom. Moreover, comprehensive analyses of learning environments in which students use digital devices are still necessary.

2.3. Learning Effectiveness with Tablet PCs

In this study, the research participants were asked to actively take part in the classes, asking questions and working together using tablet PCs. Lecture-based directive instructions are deeply rooted in the Korean education culture [28,29]. This study focused on observing changes in the students' self-regulated learning abilities, collaboration skills, and learning satisfaction.

Self-regulated learning refers to the self-directive process by which learners transform their mental abilities into academic skills [30]. Zimmerman (1990) stated that self-regulated learning includes the use of self-regulated learning strategies, the responsiveness to self-oriented feedback about learning effectiveness, and the interdependent motivational process [31]. The use of tablet PCs has been shown to be effective in both motivation and participation in learning activities [32]. Accordingly, the use of tablet PCs was expected to lead to the facilitation of self-regulation. Alegría, Boscardin, Poncelet, Mayfield, and Wamsley (2014) found that medical students enhanced their abilities to develop and employ self-regulated skills after using tablet PCs for learning activities [33]. Papadopoulou and Palaigeorgiou (2016) also insisted that interactive video learning with tablet PCs enabled self-regulated learning in the classroom [34].

In addition, studies have begun to explore the advantages of tablet PC use in the classroom to facilitate learner interaction and collaboration due to the device's ability to lay flat on a desk or be propped up at a convenient angle for multi-user viewing and access—factors that are particularly relevant in supporting classroom collaboration [35]. Falloon (2015) also found that tablet PCs with cloud-based applications extended students' collaboration in elementary classroom environments [36]. More recently, with the advent of various helpful applications, learners have been able to participate in collaborative activities by working together, learning from peers, and exchanging feedback [37]. Thus, tablet PC-based learning environments can facilitate vigorous communication activities both online and offline, as long as learners are provided with relevant applications and proper instructional support.

Online collaborative learning has generally been found to positively affect students' motivation and learning satisfaction [38,39]. However, study results on the relationship between self-regulated learning activities and learning satisfaction have been inconsistent [40,41]. Still, learning with a tablet PCs was a new experience for most of the participants; therefore, high satisfaction, especially in the initial stage due to the novelty effect, was expected.

Regarding teacher variables, some studies have examined teachers' perceptions of digital learning [42], preservice teachers' perceptions and policy suggestions for digital learning [43], and predicting variables for teachers' use of digital learning materials [44]. For teacher development and education, research on curriculum design [45,46] or on specific strategies, such as self-directed learning [47] and digital storytelling [48,49], has been conducted. However, it is hard to find empirical studies of how teachers use digital resources in educational contexts.

This study examined the effects of digital learning environments on both students and teachers. Specifically, these experiences were compared in urban and rural school environments. For this objective, the following research questions were investigated:

(1) Are students' self-regulated learning, collaborative learning skills, and learning satisfaction as a result of tablet PC use different between a metropolitan and rural school?
(2) Are teachers' responses to the changes and challenges of tablet PC use different between a metropolitan and rural school?

A quantitative analysis was conducted for the first research question, and qualitative observations and interviews were conducted for the second question.

3. Method

3.1. Participants

Two middle schools in Korea were selected for the research on the basis of convenience. One school was located in a metropolitan area and the other was a rural school. Public officials in each school district were initially asked to recommend schools that had typical characteristics of the area in terms of location, capacity, and parents' socio-economic status. More than 500 students went to the metropolitan school, and the parents were known to be of middle-income status or above. These parents generally did not expect much from the school, as most of the students attended private institutes to supplement their education. In contrast, the rural school located in a remote area comprised approximately 200 pupils and the parents were said to be of middle to lower income, and most worked in nearby factories. These parents were less likely to send their children to private academies and had higher expectations of the school. The teachers and students who participated in the present study are as follows:

Students: Two classes consisting of 48 students from the metropolitan school and three classes consisting of 63 students from the rural school participated.

Teachers: From both schools, teachers of English, science, and social studies in charge of first-grade students participated in the present study. The teacher demographics are displayed in Table 1.

Table 1. Demographics of the teachers.

Area	Subject	Gender	Career (year)
Metropolitan	English	Female	7
	Science	Male	28
	Social Studies	Male	10
Rural	English	Female	25
	Science	Male	12
	Social Studies	Female	2

3.2. Research Environment and Instruments

3.2.1. Research Environment

Before the class, every teacher and student who participated in the present study was provided with a 10-inch tablet PC model containing digital textbooks and educational applications. The teachers attended three workshops a week for three months on the relevant features of the tablet PC, including instructional methods for teaching with digital textbooks and on educational software that would be used with the help of the researchers.

After the teacher training workshops were completed, the teachers and their 13-year-old first-grade students started digital learning. For a total of 12 weeks, students took 45-min digitized learning classes three times a week in the three subjects. One class consisted of 45 min. The students had additional opportunities to learn with tablet PCs at home by watching video clips as part of the flipped classroom method or doing homework, since the students were allowed to take their tablet PC home.

The teachers made instructional plans for the whole semester with the help of the researchers. The plans included learning methods ranging from the flipped classroom and problem-based learning to specific strategies, such as using digital textbooks and learning applications. As mentioned above, since the Korean education system is still typically based on teacher-centered instructional methods, learner-centered digital learning was new and challenging for the teachers and students. Therefore, the teachers consulted the researchers whenever needed during the study.

3.2.2. Instructional Instruments

The principal research instruments included the digital textbook and learning applications. For the study, the science and social studies teachers used digital textbook content from the Korean national curriculum. However, for the English teachers, the researchers provided digital learning materials from a private learning company, since there was no digital textbook content offered by the Korean government at the time of research. The students could watch video clips, read learning content, and write answers to questions in the digital textbooks. Example pages from the social studies textbook are shown in Figure 1.

The three main applications the teachers and students used in the present study were “Pingpong”, “Padlet”, and “Thinkwise”. Pingpong is a tool to check learner responses in real time to various types of questions, such as single answer or multiple choice. Using this application, the teacher can receive the students’ answers in the form of multiple choice, written, and image responses. The application was used for quick quizzes and formative assessments. In the Figure 2, example pages of Pingpong are shown.

Using Padlet, the students posted their ideas on a virtual board. The teachers and students could write their thoughts in the blank box. By using this application, the teachers could facilitate the students’ ideas and stimulate collective intelligence. For example, the rural English teacher asked the students to think about their dreams and post their ideas in Padlet. The goal of this activity was to help students shape their careers as well as to improve their English skills. The students posted their dreams and were able to compare them with the answers of their classmates. The teacher asked

the students to further discuss their dreams with the class and gave feedback. Figure 3 displays a screenshot of this Padlet activity.

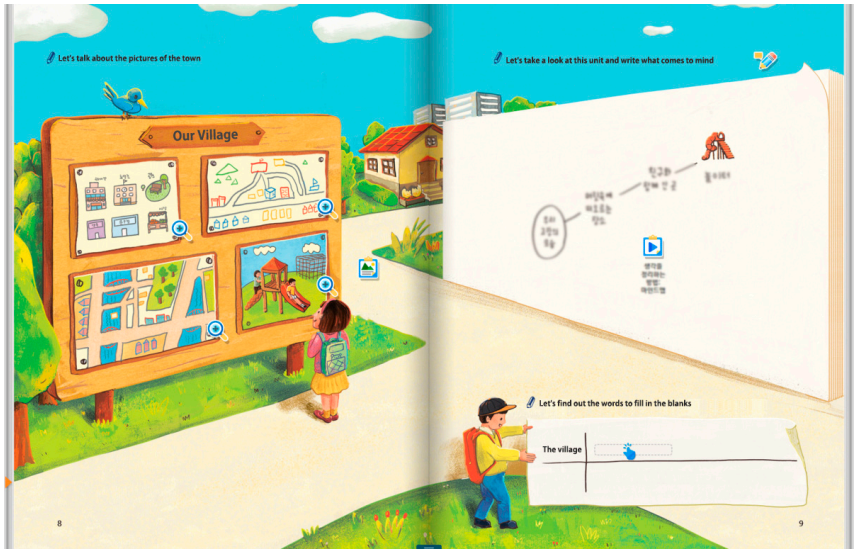

Figure 1. Example pages from the social studies digital textbook.

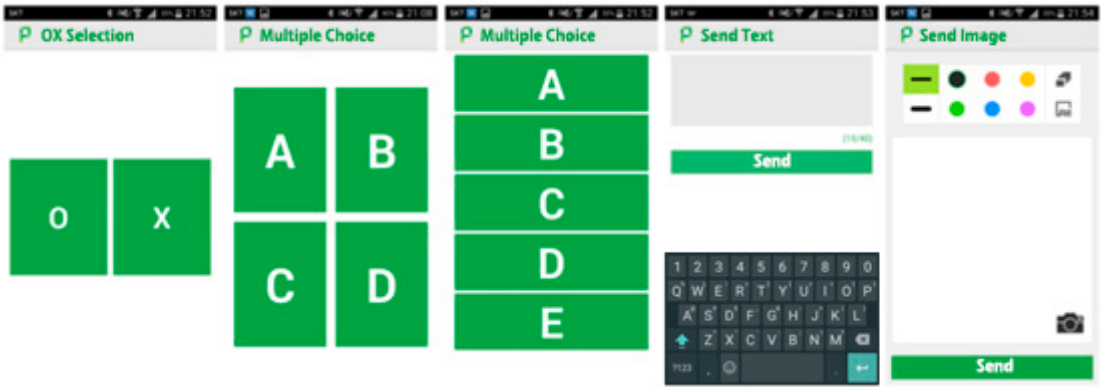

Figure 2. Answer types on Pingpong.

Figure 3. A screenshot of the Padlet dream-sharing activity.

Thinkwise is a concept map application. The teachers used this application for summarizing or categorizing what the students thought and learned. Figure 4 displays a screenshot of a Thinkwise

activity in which the rural English teacher asked the students to write down keywords about summer and think about their meaning.

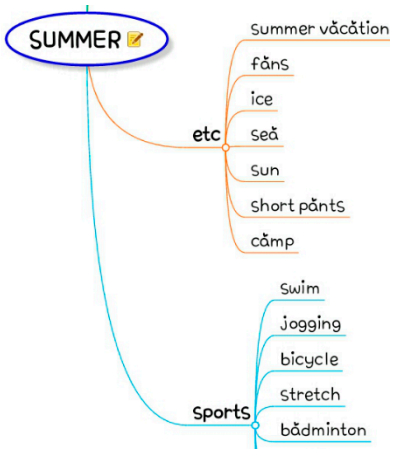

Figure 4. An example of Thinkwise usage.

Regarding the instructional methods used, all the teachers allowed the students to ask questions whenever they needed to ensure that the classes were learner centered. Moreover, the flipped classroom and problem-based learning methods were used. Through consultation with the researchers, each teacher determined and implemented their own 12-week lesson plan tailored to the subject and personal preferences. Table 2 displays a sample social studies lesson plan.

Table 2. An example of a social studies lesson plan (translated to English by the authors).

Chapter		10. Social changes and development 2. Changes in Korean society and the division of Korea into north and south
Learning objectives		1. Students can explain the divided Koreas. 2. Students can recognize the need for reunification and propose ways to overcome the division.
Instructional methods		Flipped classroom, problem-based learning
Learning applications		Padlet
Process	steps	Activities
Pre-class	Online learning	Using video clips made by the teacher, students understand the situation of the divided Korea. Additional video clips by the government titled "for reunified Korea" are recommended: https://www.uniedu.go.kr/uniedu/atchfile/stream/F000004139.mp4
In-class	reading	Read the 198–199 pages of the digital textbook, understand the need for reunification, and learn what efforts are underway.
	…	…
	sharing	Students search for blocks that hinder reunification through online searching and share it using the Padlet.
	…	…

3.2.3. Research Instruments

In the present study, two different research approaches were used. For the students, quantitative analyses were conducted to measure self-regulated learning, collaborative learning, and learning satisfaction. To measure self-regulated learning, 48 questionnaire items were adapted from Choi (2006),

Guglielmino (1978), and Zimmerman and Martinez-Pons (1986, 1988) [50–53]. The items consisted of indicators, such as "I am willing to take on challenges" and "I am able to study well". To measure collaborative learning, the inventories from Kim (2009) were used, which were originally developed to measure learning styles by Grasha and Reichmann (1974) [54,55]. The researchers reviewed and modified the items to make them more appropriate for the age of the participants in the present study. Fifteen questionnaire items, such as "I share my ideas with my classmates" and "When I have problems, I ask my classmates for help", were used. To measure learning satisfaction, seven indicators, such as "I have fun in class", "I would recommend my school to other friends", and "I am generally satisfied with my school classes", were used. The questionnaire was developed on the basis of Song (2014) [56]. A 5-point Likert scale ranging from "strongly disagree" to "strongly agree" was used for all three variables. For the analyses, the questionnaires were distributed to the participants twice, to compare pre- and post-study results.

For the teachers, a qualitative approach based on classroom observations and interviews was used. The researchers observed classes every other week, and teachers were interviewed in a semi-structured manner. Major question inventories assessed the teachers' emotional reactions to the digital learning program, such as their impressions, anxiety, and satisfaction. In addition, the researchers encouraged the teachers to freely express their feelings.

4. Results

4.1. Quantitative Findings

The purpose of using a quantitative approach was to compare the differences between the two schools regarding the three dependent variables (i.e., self-regulated learning, collaborative learning, and learning satisfaction) as well as to determine whether applying digital education was effective by comparing the pre- and post-survey results from each school. An analysis of variance (ANOVA) with repeated measures was used to find the results of the comparison.

The main portion of the data analysis was conducted with repeated measures for comparing sequential data (pre- and post-survey tests) for the students in each school. Analysis of the data revealed different means for the three variables for each school. The means of the pre- and post-survey for each school are summarized in Table 3. The results showed that the three variables for the rural school increased from pre-survey to post-survey, whereas the same variables for the metropolitan school slightly decreased.

Table 3. Estimated marginal means for school and time.

Variable	Mean (SD)	
	Pre-Test	**Post-Test**
Self-regulated learning ability		
Metropolitan	3.61 (0.58)	3.59 (0.66)
Rural	3.74 (0.45)	3.87 (0.55)
Collaboration		
Metropolitan	3.73 (0.62)	3.69 (0.78)
Rural	3.80 (0.47)	4.00 (0.60)
Learning satisfaction		
Metropolitan	3.77 (0.79)	3.65 (0.89)
Rural	4.23 (0.63)	4.24 (0.64)

The results of the repeated measure ANOVA are reported in Table 4. The results indicated that there were significant differences between metropolitan and rural schools for all three dependent variables after the treatment. Thus, it can be interpreted that employing innovative digital education

has made differences on the students' self-regulated learning, collaborative learning, and learning satisfaction at both schools.

Table 4. Repeated measures ANOVA for school and time.

	Effects	SS	*df*	MS	*F*
Self-regulated learning ability	Within-subjects				
	Time (Pre- and Post-)	0.18	1	0.18	0.83
	Time × School	0.33	1	0.33	1.54
	Between-subjects				
	School (Metropolitan and Rural)	2.34	1	2.34	5.82 *
Collaboration	Within-subjects				
	Time (Pre- and Post-)	0.36	1	0.36	1.18
	Time × School	0.87	1	0.87	2.89
	Between-subjects				
	School (Metropolitan and Rural)	1.97	1	1.97	4.30 *
Learning satisfaction	Within-subjects				
	Time (Pre- and Post-)	0.15	1	0.15	0.49
	Time × School	0.19	1	0.19	0.62
	Between-subjects				
	School (Metropolitan and Rural)	15.35	1	15.35	20.17 *

* $p < 0.05$.

Comparisons of self-regulated learning, collaborative learning, and learning satisfaction between the schools revealed that there were significant differences between the metropolitan and rural schools for all three dependent variables. The rural school students' self-regulated learning abilities and collaborative learning dispositions in the post-survey increased from the pre-survey, whereas all three variables descriptively decreased from pre- to post-survey for the students at the metropolitan school. In addition, students' learning satisfaction in the rural school remained relatively unchanged from pre- to post-survey, but both sets of scores were higher than those of the metropolitan students.

4.2. Qualitative Findings

The interviews were naturally conducted before, during, and after the experimental treatment. All teachers actively participated in the interviews, with the exception of one English teacher from the urban school who was unable to participate in the interviews for personal reasons. The teachers in the urban school had had many previous opportunities to participate in innovative instructional projects, so they felt they had done well in the research. On the other hand, the rural teachers had had relatively fewer opportunities to participate in innovative instructional research and were worried about participating in the study. Therefore, the research team focused on informing the teachers of new skills, while they first had to explain the need to change one's attitude toward new methods to the rural teachers in the professional development workshop before the experiment. Accordingly, metropolitan teachers ran classes as a way of adding new things to their existing methods, and rural teachers followed the instructions of the research team.

The metropolitan science teacher was a professional. When the research team met him first, he looked very confident. He was famous at his school for applying innovative instructional methods. He explained, "Some teachers seldom try new things. Every teacher can do a new class. I've already been using an innovative way of teaching for a long time." He showed his own teaching methods note to the research team. "Teachers can develop and implement new methods of teaching as well." Before the research team's training workshop began, he said, "Just let me know what I can and should do with this tablet PC. I'll do my best to use the tablet PC." During the experiment period, he opened his class to teacher observation, and many educators attended as it was highly reputed. He was very

joyful and enthusiastic in the classroom. "Since I make fun classes, the students are always engaged. There's a lot of stuff you can do with your tablet PC." He expertly used almost all the applications the research team recommended. The research team found that his classes were successful because of his competence. Despite the students' engagement, it was not a student-centered class. This differed from the expectations of the research team, who wanted the teachers to switch to learner-centered and participatory classes.

The metropolitan social studies teacher acted as a teacher consultant helping other teachers to improve their instruction methods. During the experiment, he hardly used the learning applications since he felt that he already ran participatory classes and thus did not need the applications. However, he enjoyed using the digital textbooks. He answered, "What matters is how to apply a relevant instructional strategy rather than what you use. Of course, it would be better if digital tools made the classroom more effective." Thus, he felt that instructional strategies were more important than instructional tools.

The atmosphere among the teachers at the rural school was quite different. The rural science teacher made the research team uncomfortable. At the first meeting, the team felt he was reluctant. "I have too much work to do. So, I'm not sure if I can do this as you expect." He seemed unsure whether he could participate in the study properly. He was reserved as well. He said that he would not know until just before each class whether he would use the tablet PC for learning, since he had already planned his lessons. Eventually, he ran into what we wanted. When we visited the class for observation, he conducted classes in his own way, based on how he had been trained at the workshop. Students used their tablet PCs to take photos or record the scientific experiments the teacher had assigned. After that, the students uploaded the files to a blog the teacher managed and shared with each other. This seemed to be an effective strategy; the students loved the activities and learned by comparing their work with that of other groups. However, his teaching methods were generally teacher-centered, and he spoke quietly in his classes without taking questions from the students. At the end of the study, he told the researchers that, "It was really hard trying to do something new. I ran out of time to prepare for this, and I had too many other tasks to do, so it was hard to do it properly."

The rural social studies teacher did not use the technology well, but she was very passionate, "I don't know much about electronic devices. I am almost technologically illiterate . . . and that's why I am so afraid that you (the research team) are asking me to use the tablet PCs and apps." The researchers felt that she did not want to participate in the study and let her know that she could quit whenever she wanted. As time passed, her technological literacy appreciably improved, even though her complaints and questions continued. She kept asking the research team when she encountered issues or problems to deal with the tablet PC and the applications. After the study had ended, she stated, "Yes, it was working for me, but it's so tough, as well." The researchers found that she spent most of her time learning the new instructional methods. Even though it is difficult to say that her class was exemplary, she kept trying to embrace new things.

Finally, the rural English teacher was afraid at first, too. She stated, "I'm definitely scared, but I'm thrilled to learn a new way of instruction. I'll try my best." During the teacher training, she asked many questions and had plenty of time to discuss how to improve the quality of teaching and learning with new technologies. She actively participated and learned easily. She responded, "Well, I'll do my best. Please help me as much as you (the research team) can." Through class observations, the researchers found that she was faithfully implementing the instructional methods targeted in the study. She taught almost everything in the instructional plans, and her students' participation and reactions were naturally the most ideal. The digital resources were not treated as isolated tools but were used as facilitating materials harmonized with the class. After the experiment ended, she made the most of the digital environment. She did not simply change her instructional tools but combined them with learner-centered methods to maximize their effects. She stated, "Frankly, it was hard to use the new devices and methods because I needed to study the apps and tablet PCs thoroughly in order to use them as much as I desired. It took considerable time."

5. Conclusions and Suggestions

In this study, the ICT environments based on tablet PCs led to interesting results in the metropolitan and rural regions. These findings have implications for how methods of growing digital learning environments should cope with regional gaps and for the sustainable development of education.

These differing results can likely be explained as follows. First, many parents from the metropolitan school only reluctantly agreed to allow their children to participate in the research, and expressed that they hoped the teachers would not change their instructional methods. This resistance can likely be explained by the fact that the parents had fixed expectations from public and private education. Therefore, the likely reason that the digital learning program had relatively little effect on the metropolitan school children is that the parents did not have high expectations or enthusiasm for the school. This attitude might have affected their children; therefore, the children did not show much interest in the new digital learning tools or instructional methods. The metropolitan students' scores for learning satisfaction were consistently low, which could be interpreted as evidence for the above explanation. In contrast, the rural school parents who were quite supportive of school policies might have encouraged their children to actively participate in the study. The positive attitudes of the parents might have affected their children, resulting in their relatively higher reported learning satisfaction.

Another issue might have stemmed from the degree of familiarity with the new learning environment. The rural teachers told the research team that most of their students were very curious and interested because they had not used tablet PCs before. This likely made the students very interested in the digital learning lessons. For this reason, the students might have experienced the novelty effect throughout the study period. Accordingly, the rural school might have been a more conducive environment for the implementation of the digital learning program. It is meaningful that self-regulated learning abilities and collaborative learning dispositions were significantly higher among the rural students. Therefore, this may imply that the effects of digital learning could be higher in rural areas.

The findings from the classroom observations and teacher interviews also have important implications. The metropolitan teachers had years of experience working in a school designated as a professional development school, where challenging tasks were often required of them. Moreover, the metropolitan teachers were eager to use, and were accustomed to using, new methods. After deciding what to do, the teachers quickly began to develop and apply the necessary knowledge and skills. On the other hand, two of the metropolitan teachers had high self-efficacy, and the research team had some difficulty convincing them that they needed to improve some shortcomings because they believed that their teaching methods were already proven effective. Interestingly, this tendency also appeared in the rural science and social studies teachers, who had had relatively fewer chances to experiment with new instructional methods. Thus, the more teaching experience one has, the harder it may be to change and adapt to new teaching methods and tools.

All three rural teachers had high levels of anxiety before the study. During the teacher training, it took more time for the rural teachers to become familiar with the new learning tools and methods. Fortunately, the social studies and English teachers were very eager to learn. The two teachers tried to make the most of the digital tools that the research team asked them to use during the experiment. In the end, the rural English teacher not only used the digital textbook and learning applications but also changed her instructional method to a learner-centered style, in contrast to the other teacher participants. We found that, although this research for teachers was based on case studies with a small sample size, it is difficult to change teachers with diverse backgrounds in a uniform way. Therefore, it is important to fully understand teachers' personalities and experiences, and provide them with appropriate and adaptive support when implementing digital learning. This is because the quality of the teacher determines the quality of the education.

The following suggestions can be made for further sustainable development of future learning environments. First, it is effective to take care of relatively less privileged areas in terms of technology access. Despite regional differences, there was little issue in the educational infrastructures of the two

schools. However, in areas where classroom technology is not reliably supported, the effectiveness and efficiency of digitized learning should be considered with importance. Therefore, considerations for underprivileged learners should continue to resolve the inequity and move toward a better society. Moreover, since the aspects of inequity vary according to gender, age, and region, it is necessary to analyze and respond to learning environments accordingly.

Second, teachers matter. As Prensky (2001) pointed out, the teacher should be prepared not to direct "digital native" students but to facilitate their learning [57]. In this study, teachers with diverse backgrounds and personalities showed different attitudes toward digital learning. Therefore, it is crucial to understand the characteristics and experiences of teachers to help them improve the quality of education for students. For this aim, systematic professional development programs should be offered.

Third, more research on practical approaches to improving instruction is needed. It is insufficient to understand the reality of digital learning environments when only the effects of specific digital learning tools or applications are examined. For example, qualified instructional methods and content should be continuously generated for sustainable development of education and digital learning [58]. The use of technology in classrooms and schools should not be superficial if the goal is to ensure sustainability in other contexts [59]. More comprehensive guidelines that reflect real classroom environments should be developed to help more students learn and more teachers facilitate learning in effective and efficient ways.

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References

1. Choi, O. The Effects of Self-Regulation Learning Strategy Training on the School Achievement of Elementary School Students. Ph.D. Thesis, Chungnam National University, Daejon, Korea, 2006.
2. Coughlan, S. Tablet Computers in '70% of Schools'. BBC. Available online: http://www.bbc.com/news/education-30216408 (accessed on 3 December 2018).
3. Lim, K.; Park, Y.; Kim, J. Analyses on attitudes to Smart Education-Related variables based on parents' age, levels of education and income. *J. Korea Soc. Comput. Inf.* **2013**, *18*, 255–264.
4. Ahn, S. Analysis of cause on difference of ICT literacy level according to region scale in elementary school. *J. Korean Assoc. Inf. Educ.* **2017**, *21*, 595–605. [CrossRef]
5. Kang, B. A Correlation between the Education Gap and Information Literacy. *J. Korean Libr. Inf. Sci. Soc.* **2018**, *49*, 179–199.
6. Kang, B. A case study on school library educational services to reduce the information literacy gap due to the education gap. *J. Korean Libr. Inf. Sci. Soc.* **2018**, *49*, 307–329.
7. Kim, H.; Kim, J.; Lee, W. Development of curriculum for solving the recognition of digital divide in elementary and secondary schools. *Second. Educ. Res.* **2010**, *58*, 177–201.
8. Kim, M. The analysis of school effect on student digital divide. *J. Educ. Adm.* **2003**, *21*, 91–116.
9. OECD. *Understanding the Digital Divide*; OECD: Paris, France, 2001.
10. Labrianidis, L.; Kalogeressis, T. The digital divide in Europe's rural enterprises. *Eur. Plan. Stud.* **2006**, *14*, 23–39. [CrossRef]
11. Malhotra, C. Bridging digital divide: Special emphasis on rural India. *Productivity* **2014**, *55*, 276–285.
12. Philip, L.J.; Cottrill, C.; Farrington, J. 'Two-speed' Scotland: Patterns and implications of the digital divide in contemporary Scotland. *Scott. Geogr. J.* **2015**, *131*, 148–170. [CrossRef]
13. Howell, B. The rural–Urban 'digital divide' in New Zealand: Fact or fable? *Prometheus* **2001**, *19*, 231–251. [CrossRef]
14. OECD. *Historical Penetration Rates, Fixed and Wireless Broadband, Top 5*; OECD: Paris, France, 2017; Available online: http://www.oecd.org/sti/broadband/oecdbroadbandportal.htm (accessed on 7 June 2019).

15. Armenta, A.; Serrano, A.; Cabrera, M.; Conte, R. The new digital divide: The confluence of broadband penetration, sustainable development, technology adoption and community participation. *Inf. Technol. Dev.* **2012**, *18*, 345–353. [CrossRef]
16. National Law Information Center. *Regulations of the Professional Development School*; Korea Legislation: Seoul, Korea, 2013. Available online: http://www.law.go.kr/lsSc.do?menuId=0&p1=&subMenu=1&nwYn=1&section=&tabNo=&query=%EC%97%B0%EA%B5%AC%ED%95%99%EA%B5%90%EC%97%90%20%EA%B4%80%ED%95%9C%20%EA%B7%9C%EC%B9%99#undefined (accessed on 8 July 2019).
17. Jones, J.L.; Alston, A.J.; English, C.W.; Gayle, G. An analysis of a tablet PC enhanced learning environment in the agricultural sciences. *NACTA J.* **2013**, *57*, 20–26.
18. Uzoglu, M.; Bozdogan, A.E. An examination of preservice science teachers' views related to use of tablet PCs in science and technology course in terms of different variables. *Mevlana Int. J. Educ.* **2012**, *2*, 1–14.
19. Oh, J.; Lee, H.; Park, M.; Cho, Y. Exploring the effects of tablet pc-based English learning. *Engl. Teach.* **2014**, *69*, 151–176.
20. Statista. Number of Apps Available in Leading App Stores as of 1st Quarter 2019. Available online: https://www.statista.com/statistics/276623/number-of-apps-available-in-leading-app-stores/ (accessed on 10 July 2019).
21. Statista. Most Popular Apple App Store Categories in May 2019, by Share of Available Apps. Available online: https://www.statista.com/statistics/270291/popular-categories-in-the-app-store/ (accessed on 10 July 2019).
22. Federal Communications Commission. Digital Textbook Playbook. Available online: https://www.fcc.gov/general/digital-textbook-playbook (accessed on 20 November 2015).
23. Noh, Y. *Global Digital Textbook Trends*; Korea Education and Research Information Service: Daegu, Korea, 2016.
24. Kim, Y. *Research on the Effectiveness of the Digital Textbook*; Korea Education and Research Information Service: Daegu, Korea, 2008.
25. Ahn, S. The effect of computer literacy on learner's cognitive aspects learning ability. *J. Korean Assoc. Inf. Educ.* **2019**, *23*, 169–177.
26. Chang, J.; Park, J.; Song, J. The Features of Inquiry Activities Using Technology in Elementary Science Digital Textbook. *J. Korean Elem. Sci. Educ.* **2019**, *38*, 275–286.
27. Jang, D.; Yi, P.; Shin, I. Examining the effectiveness of digital textbook use on students' learning outcomes in South Korea: A meta-Analysis. *Asia Pac. Educ. Res.* **2016**, *25*, 57–68. [CrossRef]
28. Lim, K. A case study on the effect of real-Time microblogging activities in offline lecture environments. *J. Digit. Contents Soc.* **2011**, *12*, 195–203. [CrossRef]
29. Park, S.; Wang, K.; Lim, C.; Park, I.; Lee, J.; Kim, M.; Lim, J.; Jung, H. *New Paradigm for Educational Technology Research*; Kyoyookbook: Seoul, Korea, 2006.
30. Zimmerman, B.J. Becoming a self-Regulated learner: An overview. *Theory Pract.* **2002**, *41*, 64–70. [CrossRef]
31. Zimmerman, B.J. Self-Regulated learning and academic achievement: An overview. *Educ. Psychol.* **1990**, *25*, 3–17. [CrossRef]
32. Hung, C.; Sun, J.C.; Yu, P. The benefits of a challenge: Student motivation and flow experience in tablet-PC-Game-Based learning. *Interact. Learn. Environ.* **2015**, *23*, 172–190. [CrossRef]
33. Alegría, D.A.H.; Boscardin, C.; Poncelet, A.; Mayfield, C.; Wamsley, M. Using tablets to support self-regulated learning in a longitudinal integrated clerkship. *Med. Educ. Online* **2014**, *19*, 23648.
34. Papadopoulou, A.; Palaigeorgiou, G. Interactive video, tablets and self-Paced learning in the classroom: Preservice teachers perceptions. In Proceedings of the IADIS International Conference on Cognition & Exploratory Learning in Digital Age, Mannheim, Germany, 28–30 October 2016.
35. Falloon, G.; Khoo, E. Exploring young students' talk in iPad-Supported collaborative learning environments. *Comput. Educ.* **2014**, *77*, 13–28. [CrossRef]
36. Falloon, G. What's the difference? Learning collaboratively using iPads in conventional classrooms. *Comput. Educ.* **2015**, *84*, 62–77. [CrossRef]
37. Albadry, H. An investigation into the role of tablet devices in facilitating collaborative learning in EFL language course. *Int. J. Emerg. Technol. Learn.* **2017**, *12*, 39–52. [CrossRef]
38. Cobb, S.C. Social presence and online learning: A Current view from a research perspective. *J. Interact. Online Learn.* **2009**, *8*, 241–254.
39. Hrastinski, S. A Theory of online learning as online participation. *Comput. Educ.* **2009**, *52*, 78–82. [CrossRef]

40. Joo, Y.J.; Joung, S.; Kim, J. Structural relationships among self-regulated learning, learning flow, satisfaction, and learning persistence in cyber universities. *Interact. Learn. Environ.* **2014**, *22*, 752–770. [CrossRef]
41. Kuo, Y.; Walker, A.E.; Belland, B.R.; Schroder, K.E.E. A predictive study of student satisfaction in online education programs. *Int. Rev. Res. Open Distance Learn.* **2013**, *14*, 16–39. [CrossRef]
42. Çelik, S.; Aytın, K. Teachers' views on digital educational tools in English language learning: Benefits and challenges in the Turkish context. *Electron. J. Engl. Second Lang.* **2014**, *18*, 1–18.
43. Lim, K.; Lee, D. Research on pre-Service teachers' perceptions of smartphones for educational use and suggestions for school policy. *J. Digit. Converg.* **2012**, *10*, 47–57.
44. Kreijns, K.; Vermeulen, M.; van Acker, F.; van Buuren, H. Predicting teachers' use of digital learning materials: Combining self-Determination theory and the integrative model of behaviour prediction. *Eur. J. Teach. Educ.* **2014**, *37*, 465–478. [CrossRef]
45. Kong, S.C.; Song, Y. A principle-Based pedagogical design framework for developing constructivist learning in a seamless learning environment: A teacher development model for learning and teaching in digital classrooms. *Br. J. Educ. Technol.* **2013**, *44*, 209–212. [CrossRef]
46. Leary, H.; Severance, S.; Penuel, W.; Quigley, D.; Sumner, T.; Devaul, H. Designing a deeply digital science curriculum: Supporting teacher learning and implementation with organizing technologies. *J. Sci. Teach. Educ.* **2016**, *27*, 61–77. [CrossRef]
47. Bullock, S.M. Using digital technologies to support self-Directed learning for preservice teacher education. *Curric. J.* **2013**, *24*, 103–120. [CrossRef]
48. Hodge, L.L.; Wright, V.H. Using digital storytelling in teacher learning: Weaving together common threads. *J. Technol. Integr. Classr.* **2010**, *2*, 25–37.
49. Konokman, G.Y.; Yelken, T.Y. Preparing digital stories through the inquiry-Based learning approach: Its effect on prospective teachers' resistive behaviors toward research and technology-Based instruction. *Educ. Sci.* **2016**, *16*, 2141–2165. [CrossRef]
50. Choi, J.; Jung, S.; Lee, E.; Kim, J. *Issue Report on Digital Textbook Instructional Model Analysis*; Korea Education and Research Information Service: Daegu, Korea, 2014.
51. Guglielmino, L.M. Development of the self-Directed learning readiness scale. (Doctoral dissertation, University of Georgia, 1977). *Disse. Abstr. Int.* **1978**, *38*, 6467.
52. Zimmerman, B.J.; Martinez-Pons, M. Construct validation of strategy model of student self-Regulated learning. *J. Educ. Psychol.* **1988**, *80*, 283–290. [CrossRef]
53. Zimmerman, B.J.; Martinez-Pons, M. Development of a structured interview for assessing student use of self-regulated learning strategies. *Am. Educ. Res. J.* **1986**, *23*, 614–628. [CrossRef]
54. Grasha, A.F.; Riechmann, S.W. A rational to developing and assessing the construct validity of a student learning styles scale instrument. *J. Psychol.* **1974**, *87*, 213–223.
55. Kim, M. The Effects of Learners' Interaction on the Learning Styles and Reward Structures in Web-Based Cooperative Learning. Ph.D. Thesis, Korea University, Seoul, Korea, 2009.
56. Song, Y. The relationships among learners' perfectionism, self-Efficacy, flow, academic achievement and satisfaction in e-Learning. *J. Lifelong Learn. Soc.* **2014**, *10*, 105–123. [CrossRef]
57. Prensky, M. Digital natives, digital immigrants. *Horizon* **2001**, *9*, 1–6.
58. Ganapathi, J. User-Generated content's impact on the sustainability of open educational resources. *Open Prax.* **2019**, *11*, 211–225. [CrossRef]
59. Niederhauser, D.S.; Howard, S.K.; Voogt, J.; Agyei, D.D.; Laferriere, T.; Tondeur, J.; Cox, M.J. Sustainability and scalability in educational technology initiatives: Research-Informed practice. *Technol. Knowl. Learn.* **2018**, *23*, 507–523. [CrossRef]