Analysing the Effects of Traditional and Digital Learning on Reading Literacy: Using Data from the 2018 Programme for International Student Assessment in Taiwan

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Abstract

Digital learning is commonly perceived as an educational progression, whereas traditional learning is deemed obsolete. This research empirically compared the influences of digital and traditional learning on reading literacy by analyzing the 2018 Programme for International Student Assessment of Taiwan. The results highlight that traditional learning has more beneficial effects on reading literacy than digital learning does. A large number of paper books on diverse subjects was found to be most beneficial. E-books, however, were observed to have an unfavourable influence on reading literacy. Possible explanations and practical implications of the results are discussed in depth. In conclusion, this research highlights the irreplaceable value of traditional learning and cautions against investment in digitalisation without investigation.

Keywords: reading literacy, digital learning, traditional learning

1. Introduction

Reading literacy is the cornerstone of individual and national competitive advantages. In the current era of the knowledge economy, knowledge, rather than labour or capital, holds premium value. The knowledge that students acquire in schools through reading forms the basis of the social skills that they utilise to apply themselves in society and acquire competitive advantages in the job market (Cooper et al., 2014). Individuals collectively form a nation. Therefore, individual reading literacy offers the whole nation a competitive advantage (OECD, 2009).

Reading appears to be undergoing a shift from a traditional to digital paradigm. In light of the exponential innovations in the field of technology, technology is now essential to human life and learning. Digital texts, ranging from concise (text messages; annotated search engine results) to lengthy (tabbed, multipage websites; newly accessible archival material scanned from microfiches),

are rapidly evolving and widely available (OECD, 2019a). Digitalisation is quickly entering mainstream reading practices and has changed our reading environment and behaviours, both at home and in school.

The advent of digitalisation in the field of education has evoked mixed responses. Digital texts, such as e-books, offer exciting interactive and entertaining features to attract readers' attention and increasing their interest. Young users are reported to enjoy reading e-books and become quickly attached to them (Ciampa, 2016). However, previous research has warned that digitalisation may not lead to expected learning outcomes (Das, 2012; Reich et al., 2016). Albeit exciting, the interactive and entertaining features of digital texts come at the price of readers experiencing attention diversion, cognition overload, and long-term memory compromise (Rutkowski & Saunders, 2018; Simola et al., 2011). More often than not, digital content provides fragmented and shallow information, as opposed to systematic and deep knowledge (Carr, 2020). Young users particularly find it challenging to resist attention diversion and shallow reading, which may have detrimental consequences (Chua & Chang, 2016).

Because of digitalisation's linkage to innovation, schools frequently employ digitalisation to present a progressive image of themselves to boost student enrolment. By promoting an untested image of progressiveness in absence of empirical evidence, schools risk wasting precious resources and effort (Piper et al., 2016). Among all aspects of a school curriculum, reading literacy has been proposed to benefit the most from digitalisation (Petersen□Brown et al., 2019). To ensure the wise allocation of educational resources and effort, empirical analysis of the relationship between digital learning and reading literacy is warranted.

While digital learning is presented in a progressive light, traditional learning has been deemed obsolete and irrelevant. However, previous literature has indicated that reading literacy is closely associated with traditional learning environments and behaviours.

Reading is an interactive activity that involves readers, texts, and the environment. During the process of reading, readers engage not only with the text but also with physical activities and physical environment (Lemer, 2000). Physical activities such as answering questions in books (working memory) and comparing the content of different books or writing related texts (comprehension/knowledge) have been shown to promote active engagement and deep thinking during reading (Allen & Hancock, 2008). Under proper guidance from teachers, these physical activities can enable students to engage in metacognitive reflection of the reading process and construct a visual coding system to represent their inner thinking (Connor et al., 2004). Likewise,

variables concerning the physical environment at home, such as exposure to copious amounts of diverse books, access to a quiet area, and ownership of a study desk (Mol & Bus, 2011; Niklas & Schneider, 2013; Teachman, 1987; Wang et al., 2020) have been argued to foster independent leisure time reading and voracious reading.

To summarise, in light of the rapidly growing trend of digitalisation, empirical studies that can assist wise educational investments and efforts are in demand. Scholars have contended that studies with robust samples are particularly emergent (Fortunati & Vincent, 2014). To respond to this demand, the current study empirically compared the effects of digital and traditional learning on reading literacy using the 2018 Programme for International Student Assessment (PISA) data from Taiwan.

2. The 2018 PISA of Taiwan

PISA is a prominent education indicator worldwide. Since 2000, the Organisation for Economic Co-operation and Development (OECD) has administrated waves of PISAs to evaluate student skills, with rotating emphasis on reading, mathematics, and science every 3 years. PISA values students' analytical and problem-solving skills, as well as their ability to employ knowledge when facing challenges in new arenas (OECD, 2019a). This global student evaluation serves its participants as salient indicators of education outcomes, policy governance, and national competitiveness (Hanushek et al., 2012).

The 2018 PISA specifically aimed at assessing reading literacy. Since 2006, Taiwan has participated in the PISA five times. In terms of reading literacy, Taiwan has performed consistently better than the average of all participants each time. An analysis of Taiwan's 2018 PISA data can reveal the significant factors contributing to the country's above-average educational outcome and serve as a valuable reference for other educational systems.

Despite presenting a general picture of success, Taiwan's reading education is not without faults. The 2018 PISA Country Note (OECD, 2019b) highlighted that the gap between Taiwanese students with high and low levels of reading literacy is widening. Between 2009 and 2018, the percentage of Taiwanese students with a high level of reading literacy has increased by 6%, and the percentage of students with a low level of reading literacy has remained constant. The identification of problems associated with Taiwan's reading education could also have reference value.

3. Research Design

The following explanation of the present study's research design details the sampling methods, conceptual framework, variables, and data analysis methods adopted.

3.1 Research sampling

The sample population analysed in this research comprised 15-year-old Taiwanese students who participated in the 2018 PISA. By the age of 15, students generally approach the completion of compulsory education in most OECD countries. An evaluation of the students at this age concerns the skill outcomes achieved over the years of compulsory school education and indicates how well the students are equipped to engage in society and address future life challenges (OECD, 2013).

The 2018 PISA employed a two-stage stratified sample design. In the first stage, schools enrolling 15-year-old students were sampled. In the second stage, 38 qualified students were sampled from each school. Finally, 193 schools and 7,243 students were sampled from Taiwan (OECD, 2019c).

To further strengthen the data collected from the PISA, this research employed listwise deletion to rigorously process missing values. Students with missing values in any of the variables adopted in our research were completely removed from the sample. Listwise deletion often leads to the removal of a considerable number of samples but enables researchers to stabilise statistical power throughout the research process by computing various research questions with one identical set of samples (Schafer & Graham, 2002). After deleting 916 (12.65%) students from Taiwan's 2018 PISA data, the final sample size of this research was 6,327.

3.2 Research conceptual framework and variables

This research organised its independent variables under the following four dimensions: physical environment, digital environment, physical activity, and digital activity. Physical environment and activity represented traditional learning. Instead of congregating variables into one construct in every dimension, the research deliberately maintained the individuality of each variable. Such a research design yields a dual benefit of presenting macroviews of the general dimensions while allowing microscale observations of individual variables. Equipped with both macroviews and microscale observations, we were able to put the study results into perspective, conduct an in-depth and extensive discussion and provide specific recommendations.

Reading literacy was the dependent variable in this research. The 2018 PISA defines reading literacy as 'understanding, using, evaluating, reflecting on, and engaging with texts in order to achieve one's goals, to develop one's knowledge and potential, and to participate in society' (OECD, 2019a). The 2018 PISA archived the reading literacy of each student through 10 plausible values (PVs). Specific theory and operations of the PVs are explained in detail on the PISA official website (OECD, 2018). For regression analysis, the intsvy R package was used in this research to reproduce PVs as a single variable (Caro & Biecek, 2017).

Table 1 presents the coding schemes of the independent and dependent variables used in this research. For brevity, the table presents only the original item number of the variables, which can easily be used to retrieve the survey questions on the PISA official website.

Table 1 Variables and coding schemes of this research

Item number	Variable	Coding scheme
Independent Variables		
Physical Environment (at home)		
ST011Q01TA	Study desk	PISA coding: 1 = yes, 2 = no. We recoded to: 1 = yes, 0 = no.
ST011Q03TA	Quiet area for study	
ST011Q07TA	Classical literature	
ST011Q10TA	School-related books	
ST011Q12TA	Dictionary	
ST013Q01TA	Number of books	1 = 0–10, 2 = 11–25, 3 = 26–100, 4 =101–200, 5 = 201–500, 6 = >500
Digital Environment		
ST011Q04TA	Computer at home	PISA coding: 1 = yes, 2 = no Our recoding: 1 = yes, 0 = no
IC001Q04TA	Internet at home	PISA coding: 1 = Yes, and I use it. 2 = yes, but I don't use it. 3 = no. We recoded to: 1 = no. 2 = yes, but I don't use it. 3 = Yes, and I use it.
IC001Q11TA	E-books at home	
IC009Q01TA	Computer at school	
IC009Q05NA	Internet at school	
IC009Q09TA	E-books at school	
Physical Activity		
ST153Q02HA	Writing descriptions of characters	PISA coding: 1 = yes, 2 = no We recoded to: 1 = yes, 0 = no
ST153Q04HA	Sharing personal thoughts	
ST153Q05HA	Answering book	

	questions	
ST153Q06HA	Comparing the content of books	
ST153Q09HA	Explaining reasons for liking or disliking passages	
ST153Q10HA	Writing related text	
ST154Q01HA	Most number of pages read	1 = <1 page, 2 = 2–10 pages, 3 = 11–50 pages, 4 = 51–100 pages, 5 = 101–500 pages, 6 = >500 pages
Digital Activity		
ST176Q01IA	Checking emails	
ST176Q02IA	Chatting online	
ST176Q03IA	Reading news on the Internet	1 = I don't know what this is. 2 = Never or almost never. 3 = Several times a month. 4 = Several times a week. 5 = Several times a day.
ST176Q05IA	Searching educational information	
ST176Q07IA	Searching information related to everyday life	
Dependent Variable: Reading literacy		
PV1 READ - PV10 READ		

3.3 Data analysis

We computed five logistic regression models to examine how traditional and digital learning may affect reading literacy. Models 1–4 sequentially showed the specific effects of the following four dimensions on reading literacy: the physical environment (M1), the digital environment (M2), physical activity (M3), and digital activity (M4). Model 5 (M5) revealed the comprehensive effects of the four dimensions on reading literacy.

4. Results and Discussion

Overall, the regression analysis revealed no risk of multicollinearity violations, with multicollinearity diagnostic coefficients of zero-order correlations (ranging from −.04 to .55), variance inflation factors (ranging from 1.08 to 1.74; all were <10), and tolerance statistics (ranging from .57 to .93; all were >.1). Table 2 presents the detailed results of the five regression models. The comprehensive model (M5) yielded an adjusted R^2 value of 33%, indicating that the comprehensive model could sufficiently explain the variance of reading literacy.

Table 2 Regressions of how traditional and digital reading influence reading literacy

	M1	M2	M3	M4	M5
R^2	.16	.15	.10	.05	.33
(*Intercept*)	374.52***	407.86***	463.85***	423.42***	316.73***
			Estimate (β)		
Physical Environment (at home)					
Study desk	11.69**				5.55
Quiet area for study	−1.74				−1.39
Classical literature	11.97***				11.47***
School-related books	15.90***				12.09***
Dictionary	43.86***				21.05***
Number of books	20.33***				17.35***
Digital Environment					
Computer at home		36.78***			20.82***
Internet at home		17.87***			10.07**
E-books at home		−15.66***			−18.26***
Computer at school		6.70**			5.24**
Internet at school		26.32***			17.18***

E-books at school	−32.90***			−24.53***
Physical Activity				
Writing descriptions of characters		−17.15***		−10.78***
Sharing personal thoughts		29.28***		17.96***
Answering book questions		39.66***		21.84***
Comparing the content of books		−17.34***		−15.76***
Explaining reasons for liking or disliking passages		−20.81***		−13.12***
Writing related text		−32.70***		−20.64***
Most number of pages read		10.20***		3.03**
Digital Activity				
Checking emails			−8.03***	−4.76***
Chatting online			−0.02	−0.86
Reading news on the Internet			9.49***	4.84***
Searching educational information			9.88***	5.86***
Searching information related to everyday life			9.83***	7.07***

Dependent variable: reading literacy

***$p < .001$, **$p < .01$

An overall comparison of Models 1–4 indicated that in terms of effect on reading literacy, traditional learning was more influential than digital learning. Physical activity (M3, R^2 = .10) demonstrated a considerably higher influence than that of digital activity (M4, R^2 = .05). Furthermore, the physical environment (M1, R^2 = .16) had a stronger influence than the digital environment did (M2, R^2 = .15); however, the difference was small.

The results provide ample support for the efficacy of traditional learning. In the age of digitalisation, when traditional learning is quickly turning obsolete, our empirical results highlight that it holds unique value which cannot be replaced by digital learning. For example, paper books, which appear less appealing than e-books, offer readers tactile stimulations and soothing effects. Research has shown that turning the pages of a book with the fingers and feeling the thickness of the pages improves reading comprehension (Mangen et al., 2013). Compared with on-screen reading, paper-based reading feels less tiring and more relaxing (Fortunati & Vincent, 2014).

Our findings contribute to the literature because the sample comprised 15-year-old students. Previous literature has supported the conventional belief that older generations prefer traditional learning over digital learning in the context of reading (Ackerman & Goldsmith, 2011; Levine-Clark, 2006). Teenagers, however, are characterised by strong adaptive abilities and weak resistance to digital tools. Therefore, this conventional belief promotes the assumption that digital learning exerts a higher influence on younger generations than traditional learning. The current study disputes this belief and contributes to the literature by demonstrating that traditional learning has a substantial influence on reading across generations.

The regression results of Models 1 and 5 together highlight that, among the variables concerning the physical environment, having a large number of books has a greater influence than having a study desk or study area. The amount and variety of books at learners' disposal (classical literature, school-related books, and dictionaries) offered significant and consistent benefits both in the dimension model (M1) and the comprehensive model (M5). However, the availability of a study desk and study area was seen to exert a relatively small and inconsistent influence in these models.

The amount and variety of books are strong possible indicators of the availability of reading opportunities. Access to a large number and variety of books in the physical environment enables readers to read whenever and wherever they want. In the context of home environments, a large number of books on diverse subjects could be highly beneficial for students. Students are more likely to freely immerse themselves in pleasure reading if they can easily access books of their interests after school at home or during holidays when they

experience less academic pressure and are under no time constraints.Studies have attested that students with high reading literacy have access to numerous books at home (Mol & Bus, 2011; Niklas & Schneider, 2013; Wang et al., 2020).

Another noteworthy finding concerns the statistical nonsignificance of the availability of a study desk and study area at home. This result offers practical implications regarding how families, particularly those with limited funds and space, can best allocate their resources. On the basis of our results, we suggest that families facing budget or spatial restraints should invest their limited resources in increasing the amount and variety of books instead of in developing dedicated study spaces.

M2 offered the surprising finding that e-books pose a significant disadvantage to reading literacy, both at home ($\beta = -15.66$, $p < .001$) and in school ($\beta = -32.90$, $p < .001$). Taking all dimensions into consideration, the disadvantageous effects of e-books were also observed in M5 (at home $\beta = -18.26$, $p < .001$; at school $\beta = -24.53$, $p < .001$). The disadvantageous effect of e-books could be attributed to their interference with reading memory and reading comprehension.

Relevant literature has argued that e-books interfere with readers' spatial memory of text layouts (Cataldo & Oakhill, 2000; Jabr, 2013; Mangen et al., 2013). In e-books, the text layout is not fixed but is in a constant state of flux. With e-books, the page is turned through scrolling, which inevitably alters the layout of the text on the screen. Constant changes in the text layout disturbs the formation of mind maps and long-term memory. By contrast, paper books have a fixed text layout. When we read paper books, we not only memorise the content of the text but also the spatial representation of the text's layout. Paper books allow for the collaborative effects of the content and layout of a text in reinforcing reading memory.

In addition, e-books interfere with reading comprehension by requiring extra cognitive resources (Rutkowski & Saunders, 2018; Simola et al., 2011). Reading e-books involves complex multimedia operations, including scrolling and switching screens, using note-taking tools, and turning sound effects on and off. Navigating through these complex multimedia functions consumes of readers' attention and cognitive resources that could otherwise be allocated to achieving high levels of reading comprehension.

The regression results of M3 highlight the various effects of physical activities on reading literacy. Sharing personal thoughts (β =29.28, $p < .001$), answering book questions ($\beta = 39.66$, $p < .001$), and most number of pages read ($\beta = 10.20$, $p < .001$) were found to be significantly beneficial to reading literacy. However, writing descriptions of characters ($\beta = -17.15$, $p < .001$),

comparing book content ($\beta = -17.34$, $p < .001$), explaining reasons for liking or disliking passages ($\beta = -20.81$, $p < .001$), and writing related text ($\beta = -32.70$, $p < .001$) were significantly detrimental. Despite our extensive search of previous literature, no comparable results were found. Future studies are recommended to document and analyse the effect of physical activities on reading and reading literacy.

M4 showed that among all of the digital activities, frequently checking emails had significant negative effects on reading literacy ($\beta = -8.03$, $p < .001$), whereas frequently reading news on the Internet ($\beta = 9.49$, $p < .001$), searching for educational information ($\beta = 9.83$, $p < .001$), and searching for information related to everyday life ($\beta = 9.88$, $p < .001$) significantly benefitted reading literacy. This trend was also observed in the results of M5, in which all dimensions were considered. Among all the listed digital activities, why was only checking emails found to hamper reading literacy? In which ways does checking email differ from other activities in terms of its effect on reading literacy? One possible explanation is that frequently checking emails hinders reading depth and concentration (Carr, 2020; Wilson, 2010). This effect may be particularly pronounced among teenagers (Chua & Chang, 2016), who comprised the sample of our research.

It can be assumed that the majority of teenagers' emails predominantly contain shallow content consisting of correspondences with peers or advertisements, rather than deep content such as well-researched articles or serious documents. The more frequently teenagers check their emails, the more shallow reading content they are exposed to. Large amounts of shallow reading prevent teenagers from being able to seize valuable opportunities to develop high-level reading skills, including critical-thinking and reasoning skills as well as the ability to empathise (Greenfield, 2014). Therefore, frequently checking emails is not only futile, but also detrimental to teenagers' reading literacy.

Emails also disrupt user concentration. The recipient of social media correspondences such as emails often receives automatic notifications, be they through sound alerts, pop-ups, or vibrations. Social media platforms have programmed users to never miss a notification. After receiving notifications, most users would as addictively and compulsively pause the task at hand to check their emails (Carr, 2020). Emails thus constantly disturb and disrupt user concentration, which could compromise user performance to a great degree. Studies have reported that distraction due to incoming emails could lower users' IQ by as much 10 points (Wilson, 2010). Trying to concentrate on more than one thing at a time could also lower productivity by as much as 40%. This is the cognitive equivalent of pulling an all-nighter (Czerwinski et al., 2004). Concentration disruption can be felt even more acutely among teenagers—the age group with particularly high engagement in peer interactions on social media (Chua & Chang, 2016).

5. Conclusion

This research enriches the current understanding of the prevailing digitalisation in education, through both theoretical reflections and empirical analysis. From an analysis of Taiwan's 2018 PISA data, this research examines the influences of the physical environment, digital environment, physical activity, and digital activity on reading literacy. The results highlight that among these four dimensions, the physical environment yields the strongest influence. Furthermore, access to a large number of books substantially benefits reading literacy. By contrast, using e-books, either at home or in school, has a negative influence on reading literacy. The findings were compared with those reported in the literature, with an in-depth discussion of possible explanations.

The overall results suggest that although digitalisation has become a dominant trend in schools and at home, traditional learning still has essential and irreplaceable value. Furthermore, this research issues a warning against the blind investment in and application of digitalisation based on unsupported assumptions instead of research evidence. Blind digitalisation not only wastes limited resources but may also undermine education outcomes. Future research is warranted to assist schools and families to wisely collaborate in traditional and digital educational endeavours to enhance learning.

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