



The effect of individual differences in the inner and outer states of ICT on engagement in online reading activities and PISA 2009 reading literacy: Exploring the relationship between the old and new reading literacy

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ABSTRACT

With the prevalence of ICT, the concept of reading literacy has evolved to encompass both online reading and printed texts. This study clarifies the relationship between reading printed texts and online electronic texts from the perspective of individual differences in the inner and outer phases of ICT in a partial mediation model. We used the PISA 2009 data with 297,295 fifteen-year-old students (49.6% males) across 42 regions. The inner state of ICT represents students' attitude toward computers and confidence in high-level ICT tasks, whereas the outer state of ICT represents students' access to ICT facilities at home or school. The indirect results showed students' reading literacy improved with better attitude toward computers, confidence, and ICT availability at home, as long as the effect was mediated through engagement in online reading activities, even though availability of ICT at home had a direct and negative impact on PISA 2009 reading literacy.

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1. Introduction

In the age of information and communication technology (ICT), the concept of reading literacy includes not only reading printed texts (i.e., old reading literacy) but also an evolution to reading electronic or online texts (i.e., new reading literacy) (Coiro, 2003; Dresang & McClelland, 1999; Leu & Kinzer, 2000). When reading electronic texts, people need basic ICT skills, such as moving a mouse, scrolling down pages, and clicking on links, as well as advanced cognitive skills such as scanning and skimming among hyperlinks to search for meaningful and relevant material or judging the credibility of a text (Leu et al., 2008). Therefore, the cognitive processes and strategies involved in reading these two types of texts are similar, but the processes are much more complex for electronic texts (Coiro & Dobler, 2007; Reinking, 1997; Snyder, 1997). As a result of this digital trend, the OECD Programme for International Student Assessment (PISA) expanded its reading framework to include electronic texts as an additional international option to “[acknowledge] the fact that any definition of reading in the 21st century needs to encompass both printed and digital texts” (OECD, 2009a, p. 20).

1.1. The similarities and differences in online versus traditional reading

Both online and traditional text readers construct their own mental models to make meaning of text (Leu et al., 2009). The fundamental difference between traditional printed text and new reading literacy is that new literacy is centered around a problem and requires the readers to choose among different online links to actively construct their own intertext (Coiro & Dobler, 2007) and to evaluate the quality as well as coherence of the text they read (Burbules & Callister, 2000). Compared to the traditional printed text, the intertextual connection in online reading is often made more explicit so that it provides increasing access to complex texts for readers to explore in their mind and on the screen (Coiro & Dobler, 2007). Leu, Kinzer, Coiro, and Cammack (2004) summarized five online reading processing practices, including (a) identifying important questions; (b) locating information; (c) critically evaluating information; (d) synthesizing information, and (e) communicating information. Most of these practices are shared with traditional reading, but tend to weigh more in the online reading context. For example, critical thinking to evaluate the information is more important for online readers due to the sophistication of infinite informational cyberspace. In terms of synthesis, more work is needed for online synthesis due to the more complex online construction of mental models and intertext. Moreover, new skills and strategies are required to communicate effectively online using tools such as email, blogs, wikis, discussion board, chats, and messaging. Among these reading practices, locating information is unique to online reading. When searching for information online, one needs to use a search engine, to read the results provided by search engine, to locate information on webpages, and to

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make an inference and determine which link will lead to the desired information from one site to another (Henry, 2006). The online information search skills are so important that they decide whether the readers succeed or fail to comprehend the online text as evidenced by the nonisomorphic example of a struggle offline reader who performed well in the online reading environment because he acquired the skills, strategies, and disposition fundamental to online reading comprehension (Leu et al., 2007).

1.2. The relationship among online reading activities, reading literacy, and the inner and outer states of ICT

In addition to comparing the similarities and differences in online versus traditional reading, the inner and outer states of ICT also play an important role in traditional and online reading. The inner state of ICT represents students' feelings toward ICT, such as attitudes toward computers and confidence in high-level ICT tasks. The outer state of ICT represents students' access to ICT facilities at home or school. Effective use of computer-based programs and internet-based information requires a combination of skills and psychological characteristics, including computer literacy, a positive attitude toward ICT, and reading proficiency to understand and evaluate information (Collins, Onwuegbuzie, & Jiao, 2008). Using PISA 2006 data, Tomte and Hatlevik (2011) showed that higher self-efficacy in high-level ICT tasks was positively related to the use of ICT for both leisure use and educational use. Collins et al. (2008) showed that students with lower reading levels had difficulty accessing resources in computer-based activities, which subsequently impaired their attitude and their educational use of the Internet and negatively influenced their academic achievement that required computer-based skills. Moreover, Luu and Freeman's (2011) study found that students who had prior ICT experiences, frequent internet browsing activity, and confidence in basic ICT task obtained higher scientific literacy scores than those who did not, holding demographic characteristics constant.

In the PISA 2009 student questionnaire, engagement in online reading activities include using online dictionaries, reading email, participating in discussion forums, and searching for a particular topic or practical information. Using an online dictionary or encyclopedia, such as Wikipedia®, can be regarded as a scaffolding strategy for reading comprehension by increasing the capacity of working memory for the cognitive load needed to understand the text and reducing the extraneous cognitive load of irrelevant disturbances from unfamiliar vocabulary (Sweller, 2010; Sweller, Van Merriënboer, & Paas, 1998). However, research has shown that reading comprehension did not differ for students who used online or printed versions of a dictionary, although students who used the electronic version approached the dictionary more often (Grimshaw, Dungworth, McKnight, & Morris, 2007). Similarly, Liu and Lin (2011) found no difference in reading comprehension in their study, but vocabulary improvement was highest for those who used the pop-up dictionary compared to the type-in or book dictionaries.

Email, on the other hand, has been widely used as an instructional medium because it is easily accessible, cost effective, and promotes student–student and student–instructor interaction in a natural context. Studies suggest that reading and writing email improves student outcomes. For example, in a teacher preparation course on “Computers in Education,” 68 prospective teachers were randomly assigned to an email-diffusion class and a non-email diffusion class, differing in the medium of distributing course materials (Yu & Yu, 2002). Besides disseminating course materials via email two days before the class, students in the email-diffusion class were encouraged to send course inquiries to their classmates or instructors through email in particular. In the non-email diffusion condition, students got their course materials in hard copies during the class. The instructor did not specifically encourage the use of email for inquiry. The

result indicated that students in the email-diffusion group showed significantly better academic performance and attitude toward computers. Through qualitative analysis of the email content, the authors also found students in the email-diffusion class produced reflective messages in addition to direct questions and actively constructed meaning out of the course materials instead of being a passive recipient of knowledge. In another study, email was also shown to improve teacher–student relationship and critical literacy skill in the technology environment among a group of Australian indigenous middle school students (Doherty & Mayer, 2011). Students participated in the Positive Links between Universities and Schools (PLUS) Project and were supplied with their own machine, an email account, network drives, and Internet access in a university laboratory. Email was exchanged among students and the teaching team during the 2-hour lab session for 8 weeks, either as broadcast or individualized messages. The authors found a fostered teacher–student relationship as a byproduct in the end of the project besides the original intended critical literacy. Use of email for educational purposes also included paired cross-national keypal relationship for reading and writing instruction in ESL classrooms (Mahfouz, 2010; Vinagre, 2005).

Likewise, online discussion forums have been used extensively as additional platforms for interaction among students, peers, and instructors. Researchers suggest that discussion forums are a perfect venue for expressing academic opinions. By reading responses and adding input, participants increase their engagement in the discussion, foster critical thinking and reflection, and construct a shared reservoir of knowledge (Dehler & Porras-Hernandez, 1998; Warschauer, 1997). Nevertheless, learning outcomes are dependent upon individuals' differences in motivation to participate in the forums (Yang, Li, Tan, & Teo, 2007). The degree of participation differs by gender, computer skills, reading ability, and migration status (Prinsen, Volman, & Terwel, 2007). To promote critical thinking in discussion forum, Garrison, Anderson, and Archer (2001) proposed the practical inquiry model as an assessment framework for online asynchronous discussion. They maintained participants acquire higher-order learning outcomes through constant resolving disagreement and problems in the full cycle of critical thinking process which include triggering event, exploration, integration, and resolution with skilled facilitation and an understanding of the medium of communication (Garrison et al., 2001). The importance of the competence in computer-mediated communication for both students and the instructor as well the facilitation skills of the instructor was again reiterated in Khine, Yeap, and Lok (2003). Dooley and Wickersham (2007), on the other hand, warned the emergence of distraction of topics, dominant discussion by a few people, and lack of interaction in a whole-class discussion setting, despite the presence of critical thinking regardless of the size of discussion group.

Being the unique element to online reading, searching online for a particular topic or for practical information requires a sequence of decision making, including inputting keywords and jumping from one hyperlink to another. These processes require readers to interact with the text and to understand, use, and reflect upon it. With the availability of ICT, searching behavior has gained popularity because it is much faster and easier than going to the library and turning pages in an encyclopedia or related books. The concept of information-seeking behavior refers to “the purposive seeking for information as a consequence of a need to satisfy some goal” (Willson, 2000, p. 49). The availability of online search engines has produced a proliferation of individual information-seeking behavior (Bilal, 2000).

1.3. Purpose of the study

The above-mentioned studies investigated the relationship between specific online reading activity and reading, between attitudes toward ICT and ICT use, and between ICT-related attitude/activities

and reading literacy. However, no study to date has examined the interrelationship among these multiple aspects. The current study aimed to examine the relationship between the old reading literacy and new reading literacy using PISA 2009 data. Specifically, we investigate how students' text-based reading literacy and their individual differences in the inner and outer states of ICT were bridged by engagement in online reading activities. Therefore, the objective of this study is to explore the following research questions:

- ◆ How do individual differences in the inner states of ICT (i.e., attitudes toward computers and confidence in high-level ICT tasks) and outer states of ICT (i.e., availability of ICT at home and at school) affect their engagement in online reading activities and PISA reading literacy?
- ◆ How does students' engagement in online reading activities relate to their PISA reading literacy?
- ◆ Is there a mediation effect from individual differences in the inner and outer states of ICT to PISA reading literacy through engagement in online reading activities?

The hypothesized mediation model is presented in Fig. 1.

2. Method

2.1. Sample

We used PISA 2009 data for this study. PISA 2009 data was obtained using a two-stage stratified sampling scheme. In the first stage, schools were selected with probability proportional to their size, a measure of the number of 15-year-old students within the school, from a sampling frame of a comprehensive national list of schools. At least 15 schools were chosen for each country. In the second stage, a random sample of 35 students was selected from each of the participating schools.

Sixty-five countries and regions participated in PISA 2009. Of these, 42 (64.6%) regions completed the optional ICT familiarity component questionnaire. For the purposes of this study, we used data from regions with available ICT familiarity components. The resulting

sample consisted of 297,295 students, with nearly equal proportions of males (49.6%) and females (51.4%). Twenty-six countries were OECD countries, and sixteen were non-OECD countries.

2.2. Materials and instruments

The PISA 2009 reading framework consists of three broad aspects of reading, including accessing and retrieving, integrating and interpreting, and reflecting and evaluating. The text format can be divided into continuous and non-continuous texts. Continuous texts are organized hierarchically in terms of sentences, paragraphs, sections, chapters...etc. Non-continuous texts appear in the form of a single list or a combination of lists. Examples of non-continuous texts are lists, tables, graphs, diagrams, advertisements, or schedules. Therefore, the reading scores can be reported for five different aspects of PISA reading literacy. The current study used the combined scale reading score to evaluate the overall reading performance, including all five aspects. The PISA combined scale reading has an average score of 500 and a standard deviation of 100.

In addition to the assessment of reading literacy, two questionnaires were required for all countries and economies. Students completed a 30-minute questionnaire to provide information about themselves and their homes. School principals or administrators answered a 20-minute questionnaire about their school. As described below, we used several PISA index variables (please see OECD (2010) for how the index variables are derived through specific statistical procedures).

2.2.1. Students' inner state of ICT

Students' inner state of ICT includes their attitude toward computers and their confidence in high-level ICT tasks. Attitude toward computers is an index that consists of four items: (1) it is very important to me to work with a computer, (2) I think playing or working with a computer is fun, (3) I use a computer because I am very interested, and (4) I lose track of time when I am working with the computer. Students answered 1 for *strongly disagree* and 4 for *strongly*

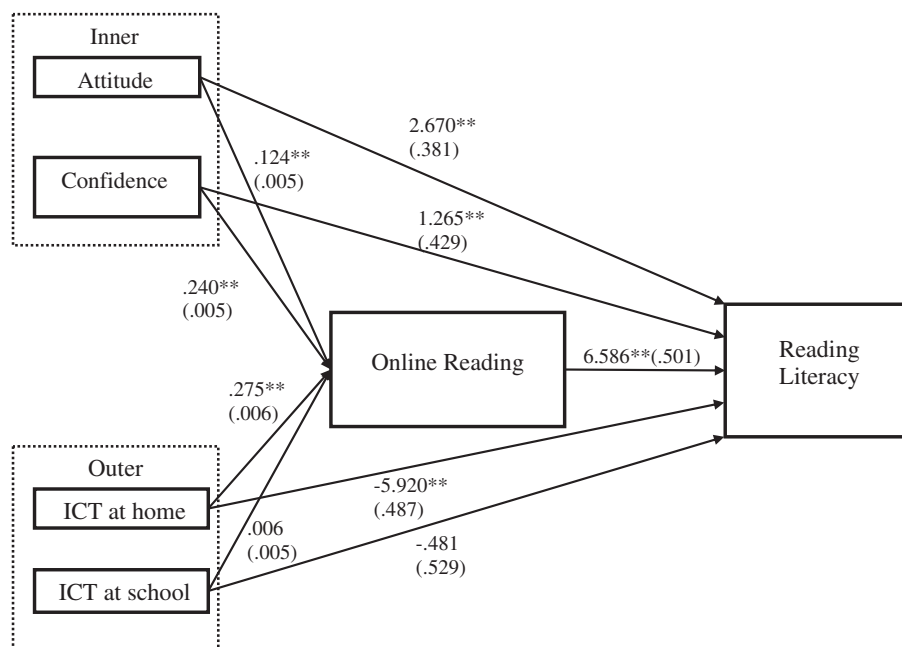


Fig. 1. Illustration of the hypothesized mediation model with unstandardized path coefficients. ** $p < .001$. Inner = Subjective phases of ICT. Outer = Objective phases of ICT. Attitude = Computer attitude; Confidence = Confidence in high-level ICT tasks; ICT at home = Availability of ICT at home. ICT at school = Availability of ICT at school. Online reading = Engagement in online reading activities. Reading literacy = PISA 2009 reading literacy. Engagement in online reading activities and PISA 2009 reading literacy were controlled for student gender, ESCS, and OECD country status. Numbers in the parentheses were standard errors of the path coefficients.

agree. The scale student index ranged from -2.89 to $.83$, with a mean of $.023$ and SD of $.987$ for the current sample.

The PISA index of confidence in high-level ICT tasks comprised 5 items: (1) editing digital photographs or other graphic images, (2) creating a database, (3) using a spreadsheet to plot a graph, (4) creating a presentation (e.g., using Microsoft PowerPoint®), and (5) creating a multi-media presentation. The answers had four levels, from “I can do this very well by myself” to “I don’t know what this means.” The scale student variable ranged from -3.59 to 1.62 with a mean of $.020$ and SD of 1.008 for the current sample.

2.2.2. Students’ outer state of ICT

Students’ outer state of ICT was conceptualized in terms of access to various ICT items at home and at school. Students answered the questions on three different levels, including “No” (access to the item), “Yes, but I don’t use it,” and “Yes, and I use it.” The index of ICT availability at home ranged from -4.19 to 1.41 , with a mean of $-.109$ and SD of 1.050 . ICT availability at school ranged from -2.79 to 1.80 , with a mean of $-.075$ and SD of 1.026 .

2.2.3. Engagement in online reading activities

The index of engagement in online reading activities included seven online activities: (1) reading emails, (2) chatting online (e.g., MSN®), (3) reading online news, (4) using an online dictionary or encyclopedia, (5) searching for online information to learn about a particular topic, (6) participating in online group discussions or forums, and (7) searching for practical information online. Students had five possible levels of response, from “I don’t know what this is” to “several times a day.” We used a joint index of engagement in online reading activities to represent the mutual association among the activities as shown in the five phases of online reading processes in Leu et al. (2004). We believed that each of these activities would be better treated as an integrative rather than a stand-alone process in this study. The score of the index ranged from -5.35 to 3.51 , with a mean of $-.032$ and SD of 1.082 for the current sample. Higher values denote more frequent online reading activities.

2.2.4. Controlled variables

This study included three covariates for statistical control. The controlled variables were gender (coded 0 for girls and 1 for boys), status of OECD country (coded 0 for non-OECD and 1 for OECD), and the index of economic, social and cultural status (ESCS) (mean = $-.056$, SD = 1.009 , range = 2.51). Three indices comprise ESCS, including highest occupational status of parents, highest educational level of parents in years of education, and home possessions, where home possessions contain indices of family wealth, cultural possessions, home educational resources, and number of books at home (OECD, 2010).

2.2.5. Data analysis

The two-stage sampling scheme of PISA data should be carefully dealt with to have consistent and correct statistical inference of parameter estimates (Wu and Kwok, 2012). We performed the mediation analysis (MacKinnon, 2008) with replicate weights and plausible values to prevent biased population parameter estimates, to preserve the nature of the PISA two-stage stratified sampling scheme, and to approximate each individual’s true score/ability (OECD, 2009b) using Mplus 6.11 (Muthén & Muthén, 2010). The Sobel (1982) was conducted to investigate the indirect effect of students’ inner and outer states of ICT on PISA reading literacy through engagement in online reading activities in addition to the delta method standard error to test statistical significance (Krull & MacKinnon, 1999, 2001). Evaluation of model fit was based on the RMSEA (Root Mean Square Error of Approximation, Steiger, 1998) and SRMR (Standardized Root Mean Square Residual). The model fit chi-square test and related model fit indices were not provided because they were

not available with analysis employing replicate weights. R² or variance explained was reported as an effect size measure for the mediation model. To check the possible bidirectional relationship of the proposed model, the reversed mediation model was also examined.

3. Result

All study variables were positively and significantly correlated (r ranged from $.063$ to $.556$, $p < .01$) except PISA reading literacy and ICT availability at school, which were not statistically significant ($r = -.005$, $p = .383$), as shown in Table 1. The mediation model had an adequate fit to the data (RMSEA = $.005$, SRMR = $.001$) according to the commonly used thresholds (Hu & Bentler, 1998). We report the unstandardized path coefficients so the coefficients can be interpreted on meaningful metrics.

3.1. Controlled demographic variables

ESCS ($b = .088$, $SE = .007$, $p < .001$) and OECD status ($b = .199$, $SE = .020$, $p < .001$) positively predicted engagement in online reading activities, while gender was not statistically significant ($b = -0.011$, $SE = 0.010$, $p = 0.272$). Students who had higher ESCS and lived in OECD countries had higher levels of engagement in online reading activities. For PISA reading literacy, significant demographic predictors included ESCS ($b = 34.229$, $SE = .506$, $p < .001$), gender ($b = -39.018$, $SE = 1.059$, $p < .001$), and OECD status ($b = 40.688$, $SE = 1.771$, $p < .001$). For every 1-point increase in ESCS, students’ reading literacy increased 34.229 points, holding all else constant. On average, girls had higher reading literacy scores than boys by 39.018 points, controlling for all other covariates. OECD countries also had higher reading literacy scores than non-OECD countries by 40.688 points, holding all other variables constant.

3.2. Main study variables

Confidence in high-level ICT tasks and attitude toward computers positively predicted students’ engagement in online reading activities ($b = .240$, $SE = .005$, $p < .001$, and $b = .124$, $SE = .005$, $p < .001$), and PISA reading literacy ($b = 2.670$, $SE = .381$, $p < .001$, and $b = 1.265$, $SE = .429$, $p = .003$). For every 1-unit increase in confidence in high-level ICT tasks, students’ engagement in online reading activities increased $.240$ units and PISA reading literacy increased 1.265 points, holding all else constant. For every 1-unit increase in computer attitude, students’ engagement in online reading activities increased $.124$ units, and PISA reading literacy increased 2.670 points, controlling for all other variables.

ICT availability at home positively predicted engagement in online reading activities ($b = .275$, $SE = .006$, $p < .001$) but had a negative influence on students’ reading literacy ($b = -5.920$, $SE = .487$, $p < .001$). For every 1-unit increase in ICT availability at home, students’ engagement in online reading activities increased $.275$ units, but PISA reading literacy decreased 5.920 points, controlling for all the other

Table 1
Correlation matrix among interval study variables.

	1	2	3	4	5	6
1. Attitude toward computers						
2. Confidence in ICT high level tasks	.153*					
3. Online reading	.205*	.332*				
4. PISA reading literacy	.064*	.087*	.199*			
5. ICT availability at home	.176*	.296*	.427*	.233*		
6. ICT availability at school	.063*	.108*	.075*	-.005	.160*	
7. ESCS	.091*	.192*	.298*	.399*	.556*	.075*

* $p < .01$.

variables. ICT availability at school had no effect on either engagement in online reading activities ($b = .006$, $SE = .005$, $p = .233$) or PISA reading literacy ($b = -0.481$, $SE = .529$, $p = .363$).

The mediator, engagement in online reading activities, also positively predicted PISA reading literacy ($b = 6.586$, $SE = .501$, $p < .001$). The R^2 change on PISA reading literacy was 4% by adding engagement in online reading activities as a mediator. For every 1-unit increase in online reading activities, PISA reading literacy increased 6.586 points.

To our most interest, the indirect effect of attitude toward computers on PISA reading literacy with engagement in online reading activities as a mediator was statistically significant ($b = .815$, $SE = .072$, $p < .001$). Likewise, the indirect effect from confidence in high-level ICT tasks to PISA reading literacy through engagement in online reading activities was also significant ($b = 1.579$, $SE = .115$, $p < .001$). However, the indirect effect of ICT availability at school on PISA reading literacy was not significant ($b = .041$, $SE = .034$, $p = .230$). Most importantly, the indirect effect of ICT availability at home on PISA reading literacy was significant in the positive direction ($b = 1.806$, $SE = .133$, $p < .001$) despite its negative direct effect on PISA reading literacy. Through engagement in online reading activities, every 1-unit increase in attitude toward computers, confidence in high-level ICT tasks, or ICT availability at home indirectly resulted in a change of .815, 1.579 or 1.806 points in PISA reading literacy scores, holding all other variables constant. The overall R^2 for the mediation model on PISA reading literacy was 24%.

The possible bidirectional relationship of the proposed model was also examined, but no statistically significant reversed indirect path was found, further confirming the result of the proposed casual mediation model with the current cross-sectional data.

4. Discussion

4.1. Controlled demographic variables

Among the three controlled variables, ESCS and OECD status were found to affect both engagement in online reading and PISA reading literacy. The finding was similar to [Luu and Freeman's \(2011\)](#) study in which ESCS was associated with students' learning outcomes. Students' reading literacy and engagement in online reading activities improved with better economic, social, and cultural background. In addition, students from OECD countries, where people are better off, on average, than those from non-OECD countries, had higher reading literacy and engagement in online reading activities. In contrast, gender was associated with PISA reading literacy but not engagement in online reading activities. Consistent with previous research, girls had higher PISA reading literacy than boys ([Chiu & McBride-Chang, 2006](#); [Guiso, Monte, Sapienza, & Zingales, 2008](#)). Results of the current study, however, showed that boys and girls did not differ in the degree of engagement in online reading activities.

4.2. Main study variables

We explored four indirect effects on PISA reading literacy through the mediator of online reading engagement. Individual differences in attitude toward computers, confidence in high-level ICT tasks, and ICT availability at home had positive and significant indirect effects on PISA reading literacy through online reading engagement, even though ICT availability at home was directly and negatively associated with PISA reading literacy. What surprised us most is that we found the effect of ICT availability at home could benefit PISA reading literacy only through the proxy of engagement in online reading. When students have the freedom to use ICT facilities, there is a risk that they may wander along the web, browse inappropriate content (e.g., violence or pornography) ([Wolak, Finkelhor, Mitchell, & Ybarra, 2008](#); [Wolak, Mitchell, & Finkelhor, 2007](#)), or become

addicted to online game playing or gambling ([Grüsser, Thalemann, & Griffiths, 2006](#); [Wan & Chiou, 2006](#)). Nevertheless, if students are directed to or spontaneously read online materials in a meaningful way (e.g., read online news, specific topics, or practical information), take advantage of online resources (e.g., wikis or online encyclopedias), or actively participate in online discussion forums, a positive result in reading literacy may be attained. The finding of the indirect effect of ICT availability at home on reading literacy emphasized that gains in reading literacy is not readily obtained unless students were provided with direction and structure to do online reading activities. Parents or guardians should carefully monitor each student's use of ICT facilities at home and teach them to use online resources or introduce them to various online reading activities, thereby encouraging them to use ICT for educational purposes and improve their online reading skills and text-based reading literacy.

The indirect effect of ICT availability at school was not significant. The result was reminiscent of different levels of the digital divide ([Hohlfeld, Ritzhaupt, Barron, & Kemker, 2008](#)). Under the condition of no ICT availability at home, increasing the availability of ICT at school might be a temporary relief for the issue of the digital divide at the first level, where hardware, software, and internet access are available at school ([Adelman et al., 2002](#); [Parsad, Jones, & Greene, 2005](#)). Given the non-significant indirect effect of ICT availability at school, we concluded that the first level of the digital divide had no differential effect on student reading literacy. The second level of the digital divide is whether teachers and students frequently use technology in classrooms ([Attewell, 2001](#); [Wayne, Zucker, & Powell, 2002](#)). Most importantly, the third level of the digital divide is whether each student is empowered or knows how to use technology to better attain their life goals ([Kim & Kim, 2001](#)). We posit that the digital divide at the second or third level might exist in schools and might influence students' reading literacy. Hence, the teaching and learning practices in reading involving ICT at school need improvement and warrant more research in the field.

As for the direct effects, students with better attitude toward computers and more confidence in completing high-level ICT tasks had a higher level of engagement in online reading activities. When students perceived playing or working with computers to be important, fun, or interesting, they were more likely to spend more time in online reading activities. Students proficient in advanced ICT tasks also engaged more frequently in online reading activities. Reading or interacting with online materials or electronic texts is an essential step for students to understand and comprehend the materials and thus to construct meaning from the electronic texts. Reading may not be students' initial intent when working with computers, but they unconsciously become engaged in online reading activities, due to a better attitude toward computers and confidence in high-level ICT tasks.

Interestingly, ICT availability at school had no effect on students' engagement in online reading activities. In the classroom setting, student activities were dominated by teachers' choice. If teachers choose not to do online reading as an activity, students may not have the opportunity for online reading. Although ICT has the potential to transform the curriculum from teacher-directed teaching to student-centered learning ([Robertson, 2005](#)), students may still not have the flexibility to complete online reading activities at school due to time constraints or teaching plans. In other words, the availability of ICT at school is not significant for its use in online reading despite teachers' ability to direct and to provide structure in performing meaningful online reading activities. In contrast, the higher the availability of ICT at home, the higher the engagement of online reading activities for students. Students have greater flexibility at home and can decide what to do with greater degrees of freedom in their leisure time. As a result, ICT availability at home is a positive predictor of students' engagement in online reading activities.

5. Conclusions

In the 21st century, the notion of reading literacy encompasses printed and online electronic texts. This study clarified the relationship between reading printed texts and online electronic texts based on individual differences in the inner and outer phases of ICT. We investigated subjective (attitude/confidence) and objective (availability at home/at school) aspects of ICT on reading literacy and examined the mediator effect of engagement in online reading. Our results showed that both inner and outer phases of ICT, except ICT availability at school, influenced students' online reading engagement and reading literacy. In particular, both phases of ICT improved student reading literacy if students could become engaged in online reading activities. When students had better attitude, confidence, and access to ICT (at home), they read more online/electronic texts, even though their original intention may not have been to read. The accumulation of online reading experiences, which involves complex cognitive processing of online information and the use of reading strategies, ultimately transferred to and enhanced students' reading of printed texts.

This study is unique in that it is an overall trend analysis examining the mediation effect of online reading engagement based on ICT-related phases for PISA 2009 reading literacy using large-scale, high quality data. The use of a large-scale dataset facilitates the modeling and clarification of a general pattern of the relationship between new literacy and old literacy across nations and economies. The current mediation model is a partial mediation model because the direct effects of the inner and outer aspects of ICT on PISA 2009 reading literacy were still statistically significant, suggesting that future research could be devoted to exploring additional possible mediators, such as self-efficacy, motivation, and learning strategies.

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References

- Adelman, N., Donnelly, M. B., Dove, T., Tiffany-Morales, J., Wayne, A., & Zucker, A. (2002). *The integrated studies of educational technology: Professional development and teachers' use of technology*. Arlington, VA: SRI International.
- Attewell, P. (2001). Comment: The first and second digital divides. *Sociology of Education*, 74(3), 252–259.
- Bilal, D. (2000). Children's use of the yahoooligans! Web search engine: Cognitive, physical, and affective behaviors on fact-based search tasks. *Journal of the American Society for Information Science*, 51, 646–665.
- Burbules, N. C., & Callister, T. A., Jr. (2000). *Watch IT: The risks and promises of information technologies for education*. Boulder, CO: Westview Press.
- Chiu, M. M., & McBride-Chang, C. (2006). Gender, context, and reading: A comparison of students in 43 countries. *Scientific Studies of Reading*, 10(4), 331–362, doi: 10.1207/s1532799xssr1004.1.
- Coiro, J. (2003). Reading comprehension on the Internet: Expanding our understanding of reading comprehension to encompass new literacies. *The Reading Teacher*, 56, 458–464.
- Coiro, J., & Dobler, E. (2007). Exploring the online reading comprehension strategies used by sixth-grade skilled readers to search for and locate information on the Internet. *Reading Research Quarterly*, 42(2), 214–257.
- Collins, K. M. T., Onwuegbuzie, A. J., & Jiao, Q. G. (2008). Reading ability and computer-related attitudes among African American graduate students. *Cyberpsychology & Behavior*, 11(3), 347–350, doi:10.1089/cpb.2007.0074.
- Dehler, C., & Porras-Hernandez, L. H. (1998). Using computer mediated communication (CMC) to promote experiential learning in graduate studies. *Educational Technology*, 38(3), 52–55.
- Doherty, C., & Mayer, D. (2011). E-mail as a "contact zone" for teacher–student relationships. *Journal of Adolescent and Adult Literacy*, 46(7), 592–600.
- Dooley, K. E., & Wickersham, L. E. (2007). Distraction, domination, and disconnection in whole-class, online discussions. *The Quarterly Review of Distance Education*, 8(1), 1–8.
- Dresang, E. T., & McClelland, K. (1999). Radical change: Digital age literature and learning. *Theory into Practice*, 38(3), 160–167.
- Garrison, D. R., Anderson, T., & Archer, W. (2001). Critical thinking and computer conferencing: A model and tool to assess cognitive presence. *American Journal of Distance Education*, 15(1), 7–23.
- Grimshaw, S., Dungworth, N., McKnight, C., & Morris, A. (2007). Electronic books: Children's reading and comprehension. *British Journal of Educational Technology*, 38(4), 583–599.
- Grüsser, S. M., Thalemann, R., & Griffiths, M. D. (2006). Excessive computer game playing: Evidence for addiction and aggression? *Cyberpsychology & Behavior*, 10(2), 290–292.
- Guiso, L., Monte, F., Sapienza, P., & Zingales, L. (2008). Culture, gender, and math. *Science*, 320, 1164–1165, doi:10.1126/science.1154094.
- Henry, L. A. (2006). SEARCHing for an answer: The critical role of new literacies while reading on the Internet. *The Reading Teacher*, 59(7), 614–627.
- Hohlfeld, T. N., Ritzhaupt, A. D., Barron, A. E., & Kemker, K. (2008). Examining the digital divide in k-12 public schools: Four-year trends for supporting ICT literacy in Florida. *Computers in Education*, 51(4), 1648–1663.
- Hu, L., & Bentler, P. M. (1998). Fit indices in covariance structure modeling: Sensitivity to underparameterized model misspecification. *Psychological Methods*, 3, 424–453.
- Khine, M. S., Yeap, L. L., & Lok, A. T. C. (2003). The quality of message ideas. Thinking and interaction in an asynchronous CMC environment. *Educational Media International*, 40, 115–126, doi:10.1080/0952398032000092161.
- Kim, M. C., & Kim, J. K. (2001). Digital divide: Conceptual discussions and prospect. *The Human Society and the Internet Internet-Related Socio-Economic Issues* (pp. 78–91).
- Krull, J. L., & MacKinnon, D. P. (1999). Multilevel mediation modeling in group-based intervention studies. *Evaluation Review*, 23(4), 418.
- Krull, J. L., & MacKinnon, D. P. (2001). Multilevel modeling of individual and group level mediated effects. *Multivariate Behavioral Research*, 36(2), 249, doi: 10.1207/s15327906MBR3602.06.
- Leu, D. J., Coiro, J., Castek, J., Hartman, D. K., Henry, L. A., & Reinking, D. (2008). Research on instruction and assessment in the new literacies of online reading comprehension. In C. C. Block, S. Parris, & P. Afflerbach (Eds.), *Comprehension instruction: Research-based best practices* (pp. 321–346). New York, NY: Guilford Press.
- Leu, J., & Kinzer, C. (2000). The convergence of literacy instruction with networked technologies for information and communication. *Reading Research Quarterly*, 35(1), 108–127.
- Leu, D. J., Jr., Kinzer, C. K., Coiro, J., & Cammack, D. W. (2004). Toward a theory of new literacies emerging from the Internet and other information and communication technologies. In R. B. Ruddell, & N. J. Unrau (Eds.), *Theoretical models and processes of reading* (pp. 1570–1613). (5th ed.). Newark, DE: International Reading Association.
- Leu, D. J., McVerry, J. G., O'Byrne, W. L., Zawilinski, L., Castek, J., & Hartman, D. K. (2009). The new literacies of online reading comprehension and the irony of No Child Left Behind: Students who require our assistance the most, actually receive it the least. In L. M. Morrow, R. Rueda, & D. Lapp (Eds.), *Handbook of research on literacy and diversity*. New York, NY: Guilford Press.
- Leu, D. J., Zawilinski, L., Castek, J., Banerjee, M., Housand, B., Liu, Y., et al. (2007). What is new about the new literacies of online reading comprehension. In L. Rush, J. Eakle, & A. Berger (Eds.), *Secondary school literacy: What research reveals for classroom practices* (pp. 37–68). Urbana, IL: National Council of Teachers of English.
- Liu, T. C., & Lin, P. H. (2011). What comes with technological convenience? Exploring the behaviors and performances of learning with computer-mediated dictionaries. *Computers in Human Behavior*, 27(1), 373–383.
- Luu, K., & Freeman, J. G. (2011). An analysis of the relationship between information and communication technology (ICT) and scientific literacy in Canada and Australia. *Computers in Education*, 56(4), 1072–1082.
- MacKinnon, D. P. (2008). *Introduction to statistical mediation analysis*. New York, NY: Erlbaum Psych Press.
- Mahfouz, S. M. (2010). A study of Jordanian university students' perceptions of using email exchanges with native English keypals for improving their writing competency. *CALLICO Journal*, 27(2), 393–408.
- Muthén, L. K., & Muthén, B. O. (2010). *Mplus user's guide* (Sixth Edition). Los Angeles, CA: Muthén & Muthén.
- OECD (2009). *PISA 2009 assessment framework: Key competencies in reading, mathematics and science*. Paris, France: OECD publications.
- OECD (2009). *PISA data analysis manual SAS®* (Second edition). Paris, France: OECD publications.
- OECD (2010). *PISA 2009 results: What makes a school successful? – Resources, policies and practices (Volume IV)*. Retrieved from <http://dx.doi.org/10.1787/9789264091559-en>
- Parsad, B., Jones, J., & Greene, B. (2005). *Internet access in US public schools and classrooms: 1994–2003*. (NCES 2005–015). Washington, DC: US Department of Education, National Center for Education Statistics.
- Prinsen, F., Volman, M. L., & Terwel, J. (2007). The influence of learner characteristics on degree and type of participation in a CSCL environment. *British Journal of Educational Technology*, 38(6), 1037–1055.
- Reinking, D. (1997). Me and my hypertext: A multiple digression analysis of technology and literacy (sic). *The Reading Teacher*, 50(8), 626–643.
- Robertson, S. L. (2005). Re-imagining and rescripting the future of education: Global knowledge economy discourses and the challenge to education systems. *Comparative Education*, 41(2), 151–170.
- Snyder, I. (1997). *Hypertext: The electronic labyrinth*. New York, NY: New York University Press.
- Sobel, M. E. (1982). Asymptotic confidence intervals for indirect effects in structural equation models. *Sociological Methodology*, 13, 290–312.
- Steiger, J. H. (1998). A note on multiple sample extensions of the RMSEA fit index. *Structural Equation Modeling*, 5, 411–419.

- Sweller, J. (2010). Element interactivity and intrinsic, extraneous, and germane cognitive load. *Educational Psychology Review*, 22(2), 123–138, doi:10.1007/s10648-010-9128-5.
- Sweller, J., Van Merriënboer, J. J., & Paas, F. G. W. (1998). Cognitive architecture and instructional design. *Educational Psychology Review*, 10(3), 251–296.
- Tomte, C., & Hatlevik, O. E. (2011). Gender-differences in self-efficacy ICT related to various ICT-user profiles in Finland and Norway. How do self-efficacy, gender and ICT-user profiles relate to findings from PISA 2006. *Computers in Education*, 57(1), 1416–1424.
- Vinagre, M. (2005). Fostering language learning via email: An English–Spanish exchange. *Computer Assisted Language Learning*, 18(5), 369–388, doi:10.1080/09588220500442749.
- Wan, C. S., & Chiou, W. B. (2006). Psychological motives and online games addiction: A test of flow theory and humanistic needs theory for Taiwanese adolescents. *Cyberpsychology & Behavior*, 9(3), 317–324.
- Warschauer, M. (1997). Computer-mediated collaborative learning: Theory and practice. *The Modern Language Journal*, 81(4), 470–481.
- Wayne, A. J., Zucker, A. A., & Powell, T. (2002). *So what about the "digital divide" in K-12 schools*. Menlo Park, CA: SRI International.
- Willson, T. (2000). Human information behavior. *Informing Science*, 3(2), 49–55.
- Wolak, J., Finkelhor, D., Mitchell, K. J., & Ybarra, M. L. (2008). Online "predators" and their victims: Myths, realities, and implications for prevention and treatment. *American Psychologist*, 63(2), 111.
- Wolak, J., Mitchell, K., & Finkelhor, D. (2007). Unwanted and wanted exposure to online pornography in a national sample of youth Internet users. *Pediatrics*, 119(2), 247.
- Wu, J. -Y., & Kwok, O. -M. (2012). Using structural equation modeling to analyze complex survey data: A comparison between design-based single-level and model-based multi-level approaches. *Structural Equation Modeling-A Multidisciplinary Journal*, 19(1), 16–35, doi:10.1080/10705511.2012.634703.
- Yang, X., Li, Y., Tan, C. H., & Teo, H. H. (2007). Students' participation intention in an online discussion forum: Why is computer-mediated interaction attractive? *Information Management*, 44(5), 456–466.
- Yu, F. Y., & Yu, H. J. (2002). Incorporating e-mail into the learning process: Its impact on student academic achievement and attitudes. *Computers in Education*, 38(1–3), 117–126.