The effectiveness of the blended learning approach on digital literacy of middle school students with different daily Internet usage patterns

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Abstract: This study examined changes to middle school students' digital literacy after engagement in a blended, technology-rich, project-based learning (BTP) environment. Guided by the social constructivist epistemology and the European Union's DigComp 2.0 framework, this study attempted to understand how students' digital literacy changes in a BTP environment differed, with respect to participants' levels of daily Internet access time, and daily Internet usage purposes. Thus, this study applied a cross-sectional case study approach to middle-school participants of a BTP after-school program, across the spring and fall semesters of 2017 and 2018. Eighty middle school students completed the whole program and provided valid pre- and post-digital literacy questionaries' responses, which presented different degrees of digital literacy changes. To investigate such variation, 58 out of the 80 students further completed an Internet use questionnaire and indicated a non-significance between (1) the students' daily Internet use (access time and usage purposes) and digital literacy changes as well as (2) the students' daily Internet usages purposes and digital literacy changes.

Introduction and literature review

As information communication technologies (ICT) are rapidly changing society, several researchers have been drawn to investigate how best to impart digital literacy to middle school students (Colwell, Hunt-Barron, & Reinking, 2013; Kimbell-Lopez, Cummins, & Manning, 2016; St. John & Von Slomski, 2012). Digital literacy refers to a set of knowledge and skills required to use ICT to effectively perform specific tasks, either in independent or collaborative settings, in order to solve a problem or create a product (Ferrari, 2012). As the technology-rich and project-based learning (TPBL) approach enables a learning experience that largely overlaps with the core elements of digital literacy in information search and evaluation, communication, creation, and problem solving, an array of studies have been conducted to explore how to employ the TPBL approach to facilitate digital literacy in mid-level education by enabling students to practice and develop digital literacy authentically in collaborative learning environments (Detra, A., & Emily, 2015; Kimbell-Lopez et al.; Petrucco, 2013). Although previous studies have indicated that students could effectively develop digital literacy in TPBL environment contexts, students in these prior studies mainly applied digital literacy to perform tasks in face-to-face settings rather than online environments. However, digital literacy refers to competencies required to use ICT fluently in both face-to-face and online environments (Vuorikari, Punie, Carretero Gomez, & Van Den Brande, 2016; Tang & Chaw, 2016). Applying TPBL approach in digital literacy education should concurrently consider both face-to-face and online settings. The current study accordingly aimed to investigate how middle school students practice and change digital literacy in a blended, technology-rich, project-based learning (BTP) environment.

Along with the popularity of the blended learning approach were some discussions centered around the digital divide in ICT accessibility and its influences on students' online learning experience and outcomes (Basitere & Ivala, 2017; Lynch, 2016). The focus on this digital divide is gradually extending from the gap in ICT accessibility to the gap in digital literacy levels (Buzzetto-Hollywood, Wang, Elobeid, & Elobaid, 2018; Mirazchiyski, 2016). Such extension has raised a debate on the association between students' Internet accessibility/usage patterns and their digital literacy levels. For instance, Livingstone and Helsper (2007) found that middle-class students aged 11 to 19 in the UK had more Internet accessibility and were more skillful at using the Internet compared to their working-class cohorts. By contrast, Li and Ranieri (2010) found that ninth graders' digital literacy was not significantly influenced by their frequency of computer and Internet use. Thus, the debate awaits more empirical studies. Therefore, this study not only investigated students' changes in digital literacy influenced by a BTP environment, but also explored the impact of students' daily Internet usage patterns on their digital literacy changes.

The first purpose of this study was to investigate how middle school students' digital literacy levels were impacted after their involvement in a BTP environment. The second purpose was to identify how the students' daily Internet access time and usage purposes influenced their digital literacy changes by the environment. We accordingly initiated an after-school program featuring a BTP instructional innovation in a Taiwanese middle school. The research questions guiding this study were as follows:

1. How do students' digital literacy change after engagement in the BTPII program?
2. Do changes, if any, differ with respect to levels of students' daily Internet access time?
3. Do changes, if any, differ with respect to the students' daily Internet usage purposes?

Methodology

Research site and participants

This study conducted a cross-sectional case study in the BTP after-school program and involved 80 student participants across spring and fall semesters in 2017 and 2018 in a middle school in Taoyuan City, Taiwan.

Conceptual framework of the BTP instructional innovation

The conceptual frameworks for learning and developing digital literacy guided the design of the BTP activities throughout the pre-class, in-class, and post-class intervention phases. Building on Reynold's (2016) concept of task-driven, social constructivist digital literacy, the BTP instructional innovation aimed to involve students in task-driven learning activities in order to practice digital literacy, thus, weaving face-to-face (classroom) and online (Edmodo, a learning management system) settings in a synergistic manner. In this way, what students contextually learned online would prepare them for in-class TPBL activities. Students' digital literacy developed during the in-class TPBL experience would in turn empower their subsequent learning activities online.

Data resources

Pre- and post-program Self-reported questionnaire on digital literacy

This questionnaire was designed based on the EU's digital competency 2.0 framework (Vuorikari et al., 2016) and measured students' digital literacy based on the following digital literacy elements: information and data literacy, communication and collaboration, digital content creation, safety, and problem solving. Each element was measured using pre- and post-test questionnaires with identical items. Items were extracted from the surveys used in the Ikanos project of the Basque Government (Spain) (2017), Jeng and Tang (2004) study, and Lin and Wang (1994) study. The survey was constructed using a five-point Likert scale. To secure internal consistency, a pilot test was issued to 32 K-5 and K-6 students and resulted an average Cronbach's alpha value of 0.89 (Authors, 2019). In the end, I collected eighty valid responses: 15 questionnaire responses from the spring 2017 semester, 19 questionnaire responses from the fall 2017 semester, 29 questionnaire responses from the spring 2018 semester, and 17 questionnaire responses from the fall 2018 semester.

Internet use questionnaire

An Internet Use and Self-learning Questionnaire was issued to students to investigate students' daily Internet access time and Internet usage purposes. The survey items were extracted from the 2015 National K-12 Student Digital Behaviors Survey administered by the Taiwan Ministry of Education (Ko, 2015). This questionnaire's items related to Internet usage purposes did not include any items regarding the safety element present in the EU digital literacy framework, because the original safety element mainly emphasized the cognitive aspects of using digital tools, such as being aware of physical and psychological well-being or knowing how to adjust settings to prevent social media networks from sharing personal data. However, students' perceptions of safety were investigated using the student self-reported Digital Literacy Questionnaire described above. In the end, from the eighty participants, we collected 58 valid responses: Four questionnaire responses from the spring 2017 semester, 13 questionnaire responses from the fall 2017 semester, 24 questionnaire responses from the spring 2018 semester, and 17 questionnaire responses from the fall 2018 semester.

Data analysis

The eighty students' pre- and post- digital literacy questionnaire data were analyzed using the Wilcoxon Signed Ranks Test to understand if students' mean changes in the five elements of digital literacy were statistically significant. Effect sizes for each element of digital literacy were calculated by the formula proposed by Rosenthal (1994) rather than Cohen's d.

To answer the second and third research questions, the changes in the 58 students' mean digital literacy were further compared by using the Kruskal-Wallis Test among groups with different levels of daily Internet access time: low-use group (neither weekday Internet access time under two hours nor weekend Internet access time of less than 5 hours), medium-use group (either weekday Internet access time over two hours or weekend Internet access time over 5 hours) and high-use group (both weekday Internet access time over two hours and weekend Internet access time over 5 hours). The same method was applied to compare the changes in the 58 students' mean digital literacy among groups with three levels of Internet usage purposes related to the application of information search and management, communication and collaboration and problem solving (low, medium and high), and two levels of Internet use for creation (low and high).

However, running a categorical mean comparison with limited samples from a single semester was problematic. For instance, the 13 samples from the fall 2017 semester were categorized by their levels of daily Internet access time, into the low-use group (N=1), a medium-use group (N=1) and a high-use group (N=11). Thus, we combined the 58 valid responses and standardized respondents' digital literacy changes in each semester. The standardization involved converting each student's original digital literacy changes to z scores using the following formula:

$$z = \frac{x - \mu}{\sigma}$$

x = observed value (digital literacy changes)

μ = mean of all respondents' values in the same semester

σ = standard deviation of all respondents' values in the same semester

T scores were later calculated based on the z scores, as it would be awkward to explain why a student had a negative z score in his/her digital literacy change. The formula used to calculate a *T* score was: $T = 10z + 50$. Digital literacy changes in different semesters became comparable after converting all respondents' digital literacy changes into *T* scores. The standardized digital literacy changes were then used to conduct a cross-sectional comparison analysis using the Kruskal-Wallis Test with respect to the students' levels of daily Internet access time and daily Internet usage purposes.

Results

How do students' digital literacy change after engagement in the BTPII program?

This study investigated students' digital literacy changes after participation in an after-school program that featured a BTP environment throughout the fall and spring semesters of 2017 and 2018. Participants of the spring and fall 2017 semesters displayed a significant development in digital literacy. However, participants of the spring and fall 2018 semesters showed no significant difference in their digital literacy (Table 1). The participants of the spring 2017 semester had statistically significant changes and large effect sizes in almost every element of digital literacy (excluding the creation element with a medium effect size of 0.58), whereas those in the fall 2017 semester only exhibited a statistically significant change and a medium effect size in overall digital literacy. Both groups of participants in the spring and fall 2018 semesters had no statistically significant changes and small effect sizes in every element of digital literacy.

Table 1. Results of the Wilcoxon Signed Ranks Test and Effect Size for Mean of Each Element of Pre- and Post-Digital Literacy in the Spring and Fall 2017 and 2018 Semesters

Test Statistics[b]						
	Information and data literacy	Communication and collaboration	Creation	Safety	Problem solving	Overall digital literacy
Spring 2017 (N = 15)						
Pre-	4.13	3.94	2.86	4.35	3.82	3.82
Post-	4.43	4.33	3.22	4.63	4.26	4.18
p value	.001	.001	.026	.001	.001	.001
Effect size	0.83	0.84	0.58	0.85	0.84	0.85
Fall 2017 (N = 19)						
Pre-	4.29	4.12	3.14	4.49	4.10	4.03
Post-	4.41	4.31	3.28	4.60	4.27	4.17
p value	.091	.051	.147	.107	.064	.046
Effect size						0.46
Spring 2018 (N = 29)						
Pre-	4.30	4.14	3.18	4.50	4.08	4.04
Post-	4.36	4.19	3.26	4.54	4.20	4.11
p value	.214	.425	.274	.247	.147	.085
Fall 2018 (N = 17)						
Pre-	4.04	3.95	3.08	4.37	3.95	3.91
Post-	4.11	4.00	3.07	4.34	4.00	3.92
p value	.813	.463	.670	.522	.344	.523

This outcome might be explained by the differences in curricula across semesters and the potential effects of social interaction on students' development of digital literacy, although all the curricula was designed and implemented based on the BTP instructional innovation.

Do changes, if any, differ with respect to levels of students' daily Internet access time?

Table 2 shows the descriptive analysis results of *T* scores of mean changes in digital literacy for low-use, medium-use and high-use groups. The amount of the students' Internet access time was not significantly associated with their *T* scores of digital literacy mean changes (p = .899).

Table 2. Descriptive Statistics for Participants' T Scores of Mean Changes in Digital literacy at Three Levels of Daily Internet Access Time

Descriptive Statistics			
Internet_time	N	DL change	Std. Deviation
Low level	8	51.29	6.29
Medium level	13	50.71	10.47
High level	37	51.31	8.51
Total	58	51.17	8.59

Do changes, if any, differ with respect to the students' daily Internet usage purposes?

The students daily Internet usage purposes was not significantly associated with their digital literacy changes. Table 3 shows the descriptive analysis results of *T* scores for the digital literacy changes among three groups of students with low, medium, and high levels of daily Internet use for information search and management. There was no significant difference (Chi square = 2.301, p = .316, df =2) found among the three groups for information search and management.

Table 3. Descriptive Statistics of the Participants' T Scores for Digital literacy Changes at Three Levels of Daily Internet Use for Information Search and Management Purposes

Descriptive Statistics			
	N	DL change	Std. Deviation
Low level	18	51.67	9.66
Medium level	9	54.54	8.16
High level	31	49.91	8.02
Total	58	51.17	8.59

Table 4 below shows the descriptive analysis results of *T* scores for digital literacy changes among three groups of students with low, medium, and high levels of daily Internet use for the purpose of communication and collaboration. There was no significant difference (Chi square = 5.331, p = .070, df =2) found among the three groups for communication and collaboration.

Table 4. Descriptive Statistics of the Participants' T Scores for Digital literacy Changes at Three Levels of Daily Internet Use for Communication and Collaboration Purposes

Descriptive Statistics			
	N	DL change	Std. Deviation
Low level	18	51.16	9.19
Medium level	23	53.01	8.33
High level	17	48.71	8.13
Total	58	51.17	8.59

Table 5 shows the descriptive analysis results of *T* scores for digital literacy changes of two groups of students with low and high levels of daily Internet use for the purpose of creation. There was no significant difference (Chi square = .630, p = .427, df =1) found between the two groups for creation.

Table 5. Descriptive Statistics of the Participants' T Scores for Digital literacy Changes at Two Different Levels of Daily Internet Use for Creation Purposes

Descriptive Statistics			
	N	DL change	Std. Deviation
No	36	51.6989	7.60156
Yes	22	50.3164	10.12635
Total	58	51.1745	8.58592

Table 6 shows the descriptive analysis results of *T* scores for digital literacy changes of three groups of students with low, medium, and high levels of daily Internet use for the purpose of problem solving. There was no significant difference (Chi square = 3.479, p = .176, df =2) found among the three groups for the purpose of problem solving.

Table 6. Descriptive Statistics of the Participants' T Scores for Digital literacy Changes at Three Levels of Daily Internet Use for Problem Solving

Descriptive Statistics			
	N	DL change	Std. Deviation
Low level	9	54.21	5.34390
Medium level	33	49.84	8.16238
High level	16	52.22	10.59145
Total	58	51.17	8.58592

Discussion and Conclusion

This no-significant association between Internet access time and digital literacy changes, after engagement in the BTP environment, found in this study is aligned with results in a study by Li and Ranieri (2010). Li and Ranieri indicated that 9th graders' digital literacy was not significantly influenced by their frequency of Internet use. This study identified that middle students' Internet use purposes had no significant influence on their digital literacy changes after engagement in the BTP environment, particularly for the purpose of information and data literacy. Our finding empirically extended the research findings of Šorgo and Boh Podgornik (2017) from the college to middle school setting. According to Šorgo and Boh Podgornik (2017), college students' Internet use experience did not statistically predict their information and data literacy levels. On the other hand, Alkan and Meinck (2016) articulated that 8th graders' frequent use of ICT for communication contributed to statistically significant development of information and data literacy. Such variation in the research finding might be explained by the difference in measurement tools. In their study, they relied on a test to evaluate students' information and data literacy, while this study relied on students' self-reported questionnaire. Porat, Blau, and Barak (2018) statistically indicated that middle school students were likely to over-estimate their actual digital literacy. In other words, this is a deviation between middle school students' objective and subjective digital literacy. On comparing the findings of this study with those of the three previous studies (Alkan & Meinck, 2016; Li & Ranieri, 2010; Šorgo & Boh Podgornik, 2017), we can conclude that the debate on students' Internet use pattern's relation to development of digital literacy awaits further research efforts. More studies are needed to investigate how other individual difference factors influence the association between middle student's Internet use patterns and digital literacy levels, such as gender, social economic status, or parenting mediations.

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