

## **A Study on Middle School Students' Smart Media Literacy and Learning in a Context of Online Inquiry-based Mathematics and Science Learning**

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This study was designed to investigate the relationship between middle school students' smart media competency and online learning outcomes. The context of this study was on online inquiry-based mathematics and science learning environment, and four-hundred and fifty-five (455) 7<sup>th</sup> to 9<sup>th</sup> grade students in Korea participated in this research. To assess students' smart device competency, Smart Media Literacy Quotient (SMLQ) which consisted of 18 items regarding the operation ability of smart media and its application (14 items) and positive beliefs of smart media (4 items) was administered to each student. The findings of this study first showed that students' smart media literacy varied according to their characteristics such as gender, grade, class (subject), and socio-economic status. Female students' scores were higher in overall smart media literacy operation and learning ability of smart media than male students. 7<sup>th</sup> grade middle school students represented lower smart media literacy scores, compared to 8<sup>th</sup> and 9<sup>th</sup> graders. Also, minority students were significantly lower in smart media literacy, operation and learning ability of smart media, and positive belief of smart media than the non-minority students. Second, overall smart media literacy and operation and learning ability of smart media varied among high, medium, and low score achievers in inquiry tasks. Low scored students in inquiry tasks were significantly lower in overall smart media literacy and operation and learning ability of smart media than medium scored students. Lastly, smart media literacy also varied by students' dropout/completion. Students who dropped out reported significantly lower scores in overall smart media literacy, operation and learning ability of smart media, and positive belief of smart media.

*Keywords : Smart media literacy, Online learning, Gender, Grade level, Socio-economic status, Achievement, Dropout*

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## Introduction

In the era of 21<sup>st</sup> century, the digital media society, humans are now required to expand their notion of new competencies beyond traditional basic literacy skills such as reading, writing, and arithmetic, with the advent of increasing role of technology. The new competencies include not only accessing, organizing, and evaluating information, but also creating new knowledge based on the variety of information and communications technologies and digital media.

In the context of the 21<sup>st</sup> century's skills and competencies, the importance of information competencies, ICT competencies, and digital media competencies have been highlighted worldwide (European Commission, 2007; KERIS, 2013; OECD, 2010, 2011; Partnership for 21st century skills, 2009; USDOE, 2010). For instance, the European Commission (2007) included digital competencies as one of its eight key competencies required for 21<sup>st</sup> century learners, and Korea Education and Research Information Service (KERIS) posited technology literacy as a key competency. Furthermore, OECD PISA 2009 assessment introduced digital literacy, defined as “evaluating information on the Internet, assessing its credibility, and navigating web page” (OECD, 2009).

Various terms, such as digital competencies, technology competencies, and digital literacy, are used to refer ICT-related competencies, with a slight variation in each of the definitions. ICT Literacy Panel (2007) defined ICT literacy as “using digital technology, communication tools, and/or networks to access, manage, integrate, evaluate, and create information in order to function in a knowledge society” (p. 2). European Commission (2007) defined digital competency as the confident and critical use of Information Society Technology (IST) for work, leisure and communication. It is underpinned by basic skills in ICT: the use of computers to retrieve, assess, store, produce, present and exchange information, and to communicate and participate in collaborative networks via the Internet” (p. 7). Also, KERIS (2013) defined technology competency as the ability to recognize the

problem, to explore and collect necessary information, to critically analyze information based on the collected data, to manage and use information efficiently, to create new information for a purpose, and to communicate with others with information using ICT. The aforementioned definitions highlight not only the ability to retrieve and organize information, but also the ability to actively create new knowledge and to effectively communicate with others. That is, ICT-related competencies are concerned with high-order thinking such as critical thinking and problem solving, and the creative use of digital technology, beyond simply mastering IT skills (Aesaert, van Braak, van Nijlen, & Vanderlinde, 2015).

ICT-related competencies of learners are now referred to as one of the crucial factors in determining learning process and its output, for the current expansions of technology is abruptly changing the learning environment, such as digital textbook, technology-embedded smart classroom, ICT education, and e-Learning. Owing to its significance of ICT, prior studies have attempted to investigate the relationships between students' competencies in ICT and their learning. It has been reported that students' ICT competencies are related to a variety of student learning variables such as self-directed learning (Kim, Bang, Shin, Kang, Gwan, & Kim., 2011), academic self-efficacy (Kang, Lee, Kim, & Yoon, 2011; Lee & Huang, 2014), learning motivation (Lee, Moon, & Cho, 2015), critical thinking (Byun, 2013) and reflective thinking (Jang, 2014), performance and effort expectations (Mohammadyari & Singh, 2015), learning achievement (Hitomi & Kazuhisa, 2007; Kim et al., 2005; Lee et al., 2015), and retention in e-learning (Ferro, Helbig, & Gil-Garcia, 2011). These results show that ICT-literate students are likely to perform better in learning.

ICT competencies in the literature have a very broad scope, ranging from ICT literacy to smart media literacy. Particularly in Korea, with its skyrocketing number of smart devices and applications, over 90% of the early adolescence have and use mobile devices (Korea Ministry of Gender Equality & Family, 2014). Along with the usage of smart devices, application on the field of education is also increasing,

and the term smart learning is coined to refer to such education. Utilization of smart learning is now gaining attention in all kinds of area, from elementary to university, and even lifelong education (Leem, 2012; Lim, Leem, & Sung, 2013). Ministry of education, in 2013, have decided to utilize digital textbook based on smart media in classes of 3<sup>rd</sup>, 4<sup>th</sup>, and 7<sup>th</sup> graders. Usage and competencies smart devices among adolescence are now being emphasized given the change in learning environment these days. Therefore, researchers have defined smart media literacy as “the abilities to obtain basic technological skills to handle a smart device, judge an assess the value of information provided in a smart environment, creatively solve a problem by sharing knowledge with others through smart media, and practice social responsibility” (Jun & Hong, 2013, p. 61). They also have attempted to develop and validate a measure of smart literacy. Moreover, prior studies tried to find the relationship between learning and smart literacy. Heavy smartphone users have shown less study achievement than the normal students (Kim 2005; Kang, 2005; Choi, 2008), and level of smartphone dependency may cause low study achievement (Sung & Jin, 2012). Frequency and period of smartphone usage do not generate any meaningful impact on individual’s study achievement (Yang, 2002; Jung, 2005). Heavy Smartphone users show lower behavior regulation in self-regulated learning ability (Kim, 2007), and smart media literacy has valid impact on students’ subject attitude in Language, Science and Mathematics and achievement (Sung 2014; 2015) are few of the examples of prior studies by researchers. Moreover, some researchers reported positive relationship between level of students’ ICT usage and achievement in Science course (Ziden, Ismail, Spain, & Kimutha, 2011), and science literacy (Papanastasiou, Zembylas, & Vrasidas, 2003). In this regard, Julien & Barker (2009) stated that inquiry-based science learning requires students to involve in problem solving through scientific procedure and decision-making. If ICT-related competencies can be viewed as the ability to effectively search, organize, and evaluate necessary information, then there exists great amount of similarities between the principles of scientific literacy and the

skills needed to be a scientifically literate person. Based on Julien & Barker's argument, it could be assumed that smart media literacy plays crucial role more in science courses in that course offers students to follow scientific inquiry procedure such as generating hypothesis, searching data, and producing evidence based on information easily with the help of smart media.

However, there is still a lack of knowledge on students' smart media literacy and its relationship with learning, especially in the context of online learning. Therefore, this study is aimed at investigating how middle school students' competencies in smart device use affect online learning, particularly in the context of online inquiry-based science learning.

This study is conducted to address the following questions:

- 1) Does smart media competency differ according to students' characteristics?
- 2) Does smart media competency differ according to students' inquiry task scores?
- 3) Does smart media competency differ according to dropout/completion?

In this study, smart media literacy is defined as the ability to collect, manage, and create information using hardware and software of smart media with positive belief of smart media according to the definition by Sung (2014; 2015). This definition of smart media literacy particularly focuses on operating ability of smart media and application, learning ability with using smart media, and positive belief of smart media.

When taking into account the increasing use of smart devices among students, the finding of this study would suggest practical implication for smart media literacy education.

## Method

### Research context and participants

This study was designed to investigate the relationship between middle school students' smart media competency and online learning outcomes. The context of this study was on online inquiry-based mathematics and science learning environment, and the subjects were middle school students who voluntarily participated in the online courses.

The online learning program was designed for middle school students who wanted to learn science or mathematics-based concepts and solve real-world problems in a creative way. Such program is not part of a regular school programs nor after-school programs, but a supplementary learning opportunity for those who seek to encounter rather challenging content in their field of interests. The content puts its roots on the Korean national science education curriculum that the country set for middle school students. Owing to the fact that this program aimed to provide more challenging tasks for students who have strong interest and capacity to learn science in depth, the online learning comprised somewhat more challenging contents than that of the national science education curriculum. The program did not cut off students with IQ/Aptitude or achievement test scores, and the contents were mostly apt for top 10 to 15% students, according to the national science education curriculum.

Twelve courses were provided in Mathematics, Physics, Chemistry and Biology respectively. Each course dealt each grade's desired level of Mathematics and Science curriculum. The online contents provided students opportunities to check and elaborate what they have learned through guided inquiry questions, and finally students were asked to get involved in scientific projects or problems that were designed in real-world situation.

Four-hundred and fifty-five (455) 7<sup>th</sup> to 9<sup>th</sup> grade students in Korea participated in this research. Table 1 presents the descriptions of participants.

Table 1. Participant profile

Subject characteristics		Number of subjects	Percent
Gender	Male	314	69
	Female	141	31
Grade level	7 <sup>st</sup> grade	174	40.7
	8 <sup>st</sup> grade	143	33.5
	9 <sup>st</sup> grade	110	25.8
	Mathematics	163	35.8
Subject	Science	292	64.2
	N	430	94.5
Minority	Y	25	5.5

## Instrument

To assess students' smart device competency, Smart Media Literacy Quotient (SMLQ) was administered to each student. The instrument was developed by Sung (2015) that was based on ICT literacy assessment (Lee, Kim, Kim, Suh, Jeon, Han, Kim, & Kim, 2007) and Smartphone Technology Quotient (Choi, Yun, & Lee, 2013). Sung (2015) confirmed that three-factor structure with Smart Media Literacy Quotient (SMLQ) based on the data gathered from 1,188 primary school students. The factors were operation ability of smart media and application, positive belief of smart media, and leaning ability with using smart media. However, in our study, an exploratory factor analysis extracted two factors with Eigen values greater than 1.0 for middle school students; namely, operation and learning ability of smart media, and positive belief of smart media.

Therefore, in this study, SMLQ consisted of 18 items regarding the operation and learning ability of smart media (14 items) and positive beliefs of smart media (4 items). The Cronbach's alpha coefficient of this instrument was .929.

## Data collection and analysis

Data were collected through a survey administered to students and LMS (Learning Management System). First, students' competency in mobile device use was surveyed using Smart Media Literacy Quotient (SMLQ), with 18 items regarding the operation ability of smart media and application use, positive beliefs of smart media, and learning ability using smart media. Second, the data on students' engagement in learning activities, scores in inquiry tasks, and dropout were collected from LMS log files.

Descriptive statistics, such as means and standard deviations of SMLQ, students' engagement in learning activities, and scores of inquiry tasks were analyzed using SPSS 22.0. Also, to investigate differences in smart media by gender, school year, subject, socio-economic status, online learning engagement, inquiry scores, and dropout/completion, analysis of variance was used.

## Results

### Descriptive data

Mean of overall Smart Media Literacy was 4.24 (SD=.80). Mean of operation and learning ability of smart media, a sub-factor of Smart Media Literacy was 4.36 (SD=.84) and mean of positive belief of smart media, another sub-factor was 3.84 (SD=.90). Mean of inquiry scores was 37.47 (SD=38.61).

With regard to learning achievement, low, medium, and high inquiry score group had 228, 111, and 116 students, respectively. Finally, course completion and dropout students were 65 and 390, each.

Table 2 shows means and standard deviations of each of the observed variables used in the analysis, and Table 3 shows the number of participants by the extent of students' learning engagement, inquiry scores and dropout.



**Table 2. Means and standard deviations of observed variables (n=455)**

Variables	MEAN	SD
Smart Media Literacy(SML)	4.24	0.80
Operation and learning ability of smart media (F1)	4.36	0.84
Positive belief of smart media (F2)	3.84	0.90
Inquiry scores	37.47	38.61

**Table 3. Number of participants by learning engagement, inquiry scores, and dropout**

		Overall		Math		Science	
		Number of participants	Percent	Number of participants	Percent	Number of participants	Percent
Inquiry scores	Low	228	50.1%	91	55.8%	137	46.9%
	Medium	111	24.4%	36	22.1%	75	25.7%
	High	116	25.5%	36	22.1%	80	27.4%
Dropout	No	65	14.3%	13	8.0%	52	17.8%
	Yes	390	85.7%	150	92.0%	240	82.2%

## Differences in smart media literacy according to students' characteristics

### Differences in smart media literacy according to gender

Gender differences were found in overall smart media literacy score ( $F=4.066$ ,  $p<.05$ ), and ability of smart media and application use ( $F=4.794$ ,  $p<.05$ ). Female students' scores were higher in overall smart media literacy operation and learning ability of smart media than male students. Table 4 and 5 show means and standard deviations, and the ANOVA result according to gender.

### Differences in smart media literacy according to grade

There were significant mean differences in positive belief of smart media scores among grades ( $F=3.043$ ,  $p<.05$ ). Post hoc analysis showed that 7<sup>th</sup> graders had lower scores in positive belief of smart media than 8<sup>th</sup> graders. Table 6 and 7 show means and standard deviations, and the ANOVA result according to grades.

**Table 4. Means and standard deviations by gender**

Variables	Male		Female	
	MEAN	SD	MEAN	SD
Smart Media Literacy(SML)	4.19	0.85	4.36	0.66
Operation and learning ability of smart media (F1)	4.30	0.89	4.49	0.70
Positive belief of smart media (F2)	3.82	0.94	3.90	0.80

**Table 5. ANOVA result: Differences in SML according to gender**

Variables	SS	df	MS	F	p
Smart Media Literacy(SML)	2.576	1	2.576	4.066	.044
Operation and learning ability of smart media (F1)	3.321	1	3.321	4.794	.029
Positive belief of smart media (F2)	.713	1		.713	.348

**Table 6. Means and standard deviations according to grade level**

Variables	7 <sup>th</sup> grade		8 <sup>th</sup> grade		9 <sup>th</sup> grade	
	MEAN	SD	MEAN	SD	MEAN	SD
Smart Media Literacy(SML)	4.24	0.76	4.35	0.64	4.21	0.92
Operation and learning ability of smart media (F1)	4.38	0.80	4.45	0.67	4.31	0.96
Positive belief of smart media (F2)	3.75	0.88	3.99	0.82	3.85	0.92

**Table 7. ANOVA result: Difference in SML according to grade level**

Variables	SS	df	MS	F	p
Smart Media Literacy(SML)	1.406	2	.703	1.197	.303
Operation and learning ability of smart media (F1)	1.187	2	.594	.919	.400
Positive belief of smart media (F2)	4.613	2	2.306	3.043	.049

### Differences in smart media literacy according to subject

The differences regarding subjects are also represented. Students who participated in Science courses reported higher scores in smart media literacy ( $F=5.111$ ,  $p<.05$ ), operation and learning ability of smart media ( $F=4.221$ ,  $p<.05$ ), and positive belief of smart media ( $F=5.521$ ,  $p<.05$ ) than the students' who participated in Mathematics courses. The means and standard deviations, and ANOVA result according to subject are shown in Table 8 and 9.

**Table 8. Means and standard deviations by subject**

Variables	Mathematics		Science	
	MEAN	SD	MEAN	SD
Smart Media Literacy(SML)	4.13	.87	4.31	.75
Operation and learning ability of smart media (F1)	4.25	.92	4.42	.78
Positive belief of smart media (F2)	3.71	.94	3.92	.87

**Table 9. ANOVA result: Difference in SML according to subject**

Variables	SS	df	MS	F	p
Smart Media Literacy(SML)	3.231	1	3.231	5.111	.024
Operation and learning ability of smart media (F1)	2.928	1	2.928	4.221	.040
Positive belief of smart media (F2)	4.409	1	4.409	5.521	.019

### Differences in smart media literacy according to socio-economic status

Minority students were significantly lower in smart media literacy ( $F=5.503$ ,  $p<.05$ ), operation and learning ability of smart media ( $F=4.932$ ,  $p<.05$ ), and positive belief of smart media ( $F=4.610$ ,  $p<.05$ ) than the non-minority students. Table 10 and 11 show the means, standard deviations, and ANOVA result according to socio-economic status.

**Table 10. Means and standard deviations according to socio-economic status**

Variables	Non-minority		Minority	
	MEAN	SD	MEAN	SD
Smart Media Literacy(SML)	4.27	.76	3.89	1.23
Operation and learning ability of smart media (F1)	4.38	.80	4.00	1.28
Positive belief of smart media (F2)	3.87	.88	3.47	1.14

**Table 11. ANOVA result: Difference in SML according to socio-economic status**

Variables	SS	df	MS	F	p
Smart Media Literacy(SML)	3.476	1	3.476	5.503	.019
Operation and learning ability of smart media (F1)	3.416	1	3.416	4.932	.027
Positive belief of smart media (F2)	3.688	1	3.688	4.610	.032

## Differences in smart media literacy according to inquiry scores and dropout/completion

### Differences in smart media literacy according to inquiry scores

Students were grouped by their inquiry scores (low, medium, high), then the mean differences among the groups in Smart Media Literacy and each sub-factor were analyzed. The analyses were conducted for all courses and the courses by each subject as well. The significant differences were found in overall smart media literacy score ( $F=.047$ ,  $p<.05$ ) in Mathematics course and in overall smart media literacy ( $F=4.688$ ,  $p<.05$ ), and operation and learning ability of smart media ( $F=5.178$ ,  $p<.01$ ) in Science courses. The results showed that among low, medium, and high score achievers, overall smart media literacy and operation and learning ability of smart media differ. Particularly, in Science course, there were significant differences in operation and learning ability of smart media, whereas no significant difference was found in Mathematics courses.

Post hoc analysis showed that students with low scores in inquiry scores were significantly lower in both overall and Science courses than students with medium scores in overall smart media literacy scores and operation and learning ability of smart media.

**Table 12. Means and standard deviations of smart media literacy according to the levels of inquiry scores and subject**

Level of inquiry scores		Overall			Math			Science		
		SML	F1	F2	SML	F1	F2	SML	F1	F2
Low	Mean	4.15	4.25	3.79	4.11	4.26	3.73	4.17	4.27	3.82
	SD	0.89	0.93	0.95	0.94	0.85	0.89	0.86	0.91	0.90
Medium	Mean	4.37	4.49	3.92	4.17	4.36	3.83	4.46	4.59	4.01
	SD	0.68	0.71	0.83	0.93	0.88	0.75	0.50	0.48	0.77
High	Mean	4.32	4.45	3.88	4.14	4.13	3.56	4.40	4.52	4.00
	SD	0.68	0.71	0.86	0.61	1.14	1.18	0.70	0.72	0.89
Total	Mean	4.24	4.36	3.84	4.13	4.25	3.71	4.31	4.42	3.92
	SD	0.80	0.84	0.90	0.87	0.92	0.94	0.75	0.78	0.87

**Table 13. ANOVA result: SMLQ differences in subject according to inquiry scores**

		Sum of squares	df	Mean square	F	Sig.
Overall	SML	4.458	2	2.229	3.534	.157
	F1	5.671	2	2.836	4.115	.186
	F2	1.385	2	.693	.858	.242
Math	SML	.073	2	.036	.047	.042
	F1	.991	2	.496	.576	.843
	F2	1.427	2	.714	.812	.619
Science	SML	5.116	2	2.558	4.688	.016
	F1	6.076	2	3.038	5.178	.012
	F2	2.461	2	1.230	1.637	.218

### Differences in smart media literacy according to dropout/completion

Finally, the relationships between dropout/completion of the online courses and smart media literacy were analyzed. The significant differences were found in overall smart media literacy scores ( $F=6.373$ ,  $p<.05$ ), operation and learning ability of smart media ( $F=5.843$ ,  $p<.05$ ), and positive belief of smart media ( $F=4.931$ ,  $p<.05$ ) in all courses, and in smart media literacy scores ( $F=8.470$ ,  $p<.01$ ),

Table 14. Means and standard deviations of smart media literacy according to dropout

Dropout		Overall			Math			Science		
		SML	F1	F2	SML	F1	F2	SML	F1	F2
No	Mean	4.01	4.13	3.62	4.27	4.09	3.33	4.04	4.14	3.69
	SD	1.00	1.06	1.01	0.57	1.13	0.99	0.99	1.05	1.02
Yes	Mean	4.28	4.40	3.88	4.12	4.27	3.75	4.37	4.48	3.97
	SD	0.76	0.79	0.87	0.89	0.91	0.93	0.67	0.69	0.83
Total	Mean	4.24	4.36	3.84	4.13	4.25	3.71	4.31	4.42	3.92
	SD	0.80	0.84	0.90	0.87	0.92	0.94	0.75	0.78	0.87

Table 15. ANOVA result: SMLQ differences in subject according to dropout/ completion

		Sum of squares	df	Mean square	F	Sig.
Overall	SML	4.017	1	4.017	6.373	.012
	F1	4.038	1	4.038	5.843	.016
	F2	3.943	1	3.943	4.931	.027
Math	SML	.266	1	.266	.348	.556
	F1	.355	1	.355	.414	.521
	F2	2.091	1	2.091	2.405	.123
Science	SML	4.621	1	4.621	8.470	.004
	F1	5.028	1	5.028	8.547	.004
	F2	3.331	1	3.331	4.465	.035

operation and learning ability of smart media ( $F=8.547$ ,  $p<.01$ ), and positive belief of smart media ( $F=4.465$ ,  $p<.05$ ) in Science courses. The results showed that according to dropout/completion status, overall smart media literacy, operation and learning ability of smart media, and positive belief of smart media differ. Particularly in Science course, there were significant differences in all scores, whereas no significant difference was found in Mathematics courses.

## Discussion

This study examined the relationships between students' smart media competency and learning in the context of online inquiry-based learning. The findings of this study are as follows;

First, students' smart media literacy varied according to their characteristics such as gender, grade, class (subject), and socio-economic status. Gender differences were found in overall smart media literacy, and operation and learning ability of smart media, and female students tend to show better results. It is an interesting result because previous ICT related research studies showed that male students possess higher ability and self-efficacy in using computer, thereby indicating less female students in field computer-related major. In addition, a number of studies reported that boys spend much more time on computer and have positive attitudes toward computers, compared to female students (Colley & Comber, 2003; Hargittai & Shafer, 2006; Imhof, Vollmeyer, & Beierlein, 2007; Ritzhaupt, Liu, Dawson, & Barron, 2013; Shashaani, 1997). The discrepancy between the current study and previous studies may exist due to the difference of device and purpose of its use. In other words, in this study, we examined smart media literacy, rather than ICT literacy. According to Sung and Jin (2014), and Sung (2014), female students have more mobiles, use more smart media, and are more affected by media. Therefore, female students may have more experiences in using smart media and such

experiences affect their perceived smart media literacy positively. Sung (2014) discussed that female students showed higher scores on smart media literacy, subject attitude, and achievement. In case of learning ability of smart media, it could be related to subject attitude and achievement. Even though male students' score of smart media literacy was lower than females' in the current study, result shall be difference when literacy related to playing games are taken into account. Future study needs to be designed to investigate whether gender difference exist differently on specific areas' smart media literacy, such as learning or games.

Second, 7<sup>th</sup> grade middle school students represented lower smart media literacy scores, compared to 8<sup>th</sup> and 9<sup>th</sup> graders. It was reported that the percentages of Korean adolescent smart phone users out of all smart phone users are 82% (Ministry of Gender Equality and Family, 2013), while elementary school students take up to 48% of adolescent users (Lee, 2014). Considering the fact that many 5<sup>th</sup>, 6<sup>th</sup> or 7<sup>th</sup> graders begin to own and are getting used to smart phones, the result that 7<sup>th</sup> graders' scores were lower than 8<sup>th</sup> and 9<sup>th</sup> graders may be understandable. It can be interpreted that the smart media literacy can increase up to some point, and when students are accustomed to the systems or devices, the difference would no longer exist. Future study shall be required to clarify the reason.

Third, result of smart media literacy scores difference between economically minority and non-minority groups are coherent with other research studies (Attewell, 2001; Ritzhaupt, et al, 2013). The differences may be due to the difficulties in accessing hardware, software, and internet, and parents' supports. Although they may use in class at school, the total amount of time of smart media use must be less than those who are able to use freely at home. This makes differences on ability of using smart media or attitudes towards them. To increase minority students' smart media literacy, school, local community, or student care center should offer opportunities of learning and using of smart media. Once they experience and explore smart media more, they would be more skilled and confident in using them.



Fourth, overall smart media literacy and operation and learning ability of smart media varied among high, medium, and low score achievers in inquiry tasks. Low scored students in inquiry tasks were significantly lower in overall smart media literacy and operation and learning ability of smart media than medium scored students. Similar to our results, most of the studies on relationship between ICT-related literacy and learning showed that ICT-related literacy has positive impact on learning achievement (Hitomi & Kazuhisa, 2007; Kim., 2005; Lee et al., 2015). Studies on Smart media literacy also showed that elementary and middle school students with higher smart media literacy showed better achievement (Sung, 2014; 2015). Moreover, some researchers reported positive relationship between level of students' ICT usage and achievement in Science course (Ziden, Ismail, Spain, & Kimutha, 2011), and science literacy (Papanastasiou, Zembylas, & Vrasidas, 2003), which coincides with the current results that there were significant differences in operation and learning ability of smart media in Science course, whereas no significant difference was found in Mathematics courses. As reported by Sung (2014), that operation ability of smart media has positive effects on subject attitude in Science, application of smart devices in Science classes to promote positive effect on learning achievement may be possible, along with various scientific experiments, and activities related to smart devices. Therefore, it is necessary to investigate the relationship between smart media literacy and achievement through the mediating effect of subject attitude in Science for the future study.

Lastly, smart media literacy also varied by students' dropout/completion. Students who dropped out reported significantly lower scores in overall smart media literacy, operation and learning ability of smart media, and positive belief of smart media. In technology-based online learning environment, it is crucial for subjects to have ICT-related competencies as well as smart media competency. Few studies have been conducted to see relationship between ICT literacy and retention in e-learning (Ferro, Helbig, & Gil-Garcia, 2011). In case of this study, the differences in smart media literacy according to students' inquiry scores and

dropout were only represented in Science courses, whereas no significant difference was found in Mathematics courses. Such result illustrates that smart media literacy plays crucial role more in science courses than mathematics course, in that science course offers students to generate hypothesis, develop a plan for information, and produce evidence based on information easily with the help of smart device. Julien & Barker (2009) stated that information literacy which is the ability to effectively search, select, and evaluate adequate information is embedded in the principles and processes of tasks in science inquiry.

In summary, smart phone usage among adolescents both have positive and negative impacts at the same time. For instance, overuse of smart phone has negative impact on study achievement (Kim, 2005; Kang, 2005; Choi, 2008), while general application of smart devices to educational use and smart media literacy have positive impact on study achievement. This should be duly noted since most adolescents now possess smart devices and proper use of smart devices along with training on smart media literacy must be conducted. In particular, proper training for the students to utilize smart devices and to obtain ability to gather, edit, generate and share the information for knowledge is necessary. This study showed smart media literacy have impacts on continuous learning and study achievement especially in Science course, therefore, science classes should provide smart-device based problem-solving opportunities to strengthen such ability.

Lastly, smart media literacy difference according to subjects' various background variables such as gender, grade, socio-economic status, indicate that each of the sections require specialized education for better performance. It is crucial to reduce the smart media literacy gap among students as smart media literacy is closely related to the learning process and study achievement.

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