Profile Analysis of Elementary School Students’ Smart Device Usage

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Smart devices have a variety of affordances to foster meaningful learning in elementary school. For the design of smart learning environments, more research is needed to understand students’ smart device usage and their perception of learning with smart devices. In order to capture smart device usage profiles among elementary school students in South Korea, this study carried out Latent Profile Analysis with three constructs: information search, communication, and study. Participants (n=253), who ranged from the fourth to the sixth grade students, were classified into three profiles of smart device usage: low-activity, communication, and high-activity groups. The smart device usage profiles varied depending on smartphone usage experience, and the profiles were significantly related with smart device addiction, not with smart device usage ability. Perceptions of smart education were also significantly associated with the profiles. The high-activity group showed more positive attitudes toward smart education than the others, but no significant difference was found in regard to negative attitudes. Based on the findings, this study discussed implications for the use of smart devices in elementary school.

Keywords: Elementary school students, Smart education, Latent profile analysis, Technology usage, Smart device usage

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Introduction

In recent years, there has been growing interest in using smart devices for learning across the world. Smart education is defined as a teaching and learning system that enables collaborative interaction, intelligent adaptation, and self-directed knowledge construction through easy access to information in various network services using proper smart devices and information and communication technology (ICT) (Lim, Leem, & Sung, 2013). Smart education can be effective in solving problems individually or cooperatively, motivating students, and improving their learning performance and capabilities (Leem, & Kim, 2013). Despite these benefits, many parents are concerned with students’ smart device addiction, particularly for elementary school students (Joo, 2013). In addition, some teachers and students have negative attitudes towards smart education because the use of smart devices in classrooms can cause unexpected problems in learning and health (Han, 2014).

Although a growing number of educators have interests in smart education, few studies have investigated how students use smart devices and how they perceive smart education. It is important to understand the benefits and drawbacks of using smart devices in class from the perspective of students. Smart education can be successfully implemented only when students actively participate in learning activities with smart devices and make sense of their experience. Without understanding students’ perspectives and needs, teachers cannot design an effective learning environment for smart education. Although previous studies investigated students’ usage of the Internet and computers (Eynon & Malmberg, 2011; Park, Ha, & Park, 2011; Park & Kim, 2009), little concern has gone toward understanding how students use smart devices. Because smart devices have different affordances from computers and other digital devices, it is expected that students’ profiles of smart device usage do not perfectly match those of other digital devices. Thus, more research is needed to explore students’ usage patterns of smart devices.
As part of making sense of the heterogeneity in students’ smart device usage, another important issue is to examine why students use smart devices in different ways and how they perceive smart education. Although students are recently regarded as digital natives who are familiar with ICTs from an early age, they showed digital divides, having different perceptions of technology and instructional methods (Warschauer, Knobel, & Stone, 2004; Waycott et al., 2010). Research on digital divide showed that students from economically advantaged families were more likely to use technology for the development of 21st century skills than those from disadvantaged families (Reich, Murnane, & Willett, 2012). In addition, individual differences in the experience and ability of smart device usage may be associated with how students use smart devices in their everyday life, which will in turn influence their perception of smart education. However, this prediction on smart devices is seldom investigated through empirical research. In addition, the relationship between the addiction to smart devices and the profiles of smart device usage was rarely investigated, although many parents and teachers have concerns about the addiction issue particularly for children.

For an in-depth understanding of students’ smart device usage, this study intends to investigate the following questions:

(1) What are latent profiles in smart device usage of students?

(2) How are the smart device usage profiles related to individual differences in smart device usage experience, ability, and addiction?

(3) How are the smart device usage profiles related to students’ perceptions of smart education?

**Literature Review**

**Profiles of ICT usage**

Smart devices refer to electronic devices like smartphones, tablet PCs,
smartwatches, and smart bands, which work interactively and autonomously in the connection with other devices or networks via Wi-Fi, Bluetooth, and other wireless protocols (Poslad, 2011). Although smart devices include such a large-size device as smart TV, this study focuses on smartphones and tablet PCs that are more frequently used in education than other smart devices. The small and portable devices share many properties with mobile devices that can be used anytime and anywhere. Previous research has demonstrated that the affordances of mobile devices are different from those of computers (Chan et al., 2006; Sung & Mayer, 2012). Sung and Mayer (2012) revealed that students perceived a computer as “a faithful, stable, concentrative, and essential tool”, while they regarded a mobile device as “an accessible, portable, and new tool”.

Although usage profiles between computers and smart devices are expected to be different, most of the previous studies on usage profiles have focused on the Internet and computers rather than smart devices. Eynon and Malmberg (2011) revealed that among young people of the age range of 12 to 19 from a nationally representative survey, there were four types of Internet usage profiles: peripheral, normative, all-rounder, and active-participator. The peripheral was a group of the least frequent users for all Internet activities surveyed (i.e., creativity, communicating, participating, information seeking, and entertainment) and the normative showed average or somewhat less Internet uses. The all-rounder used the Internet more frequently when compared to the average, and the active-participator was the most frequent Internet user whose online participatory behaviors were more noticeably than other behaviors.

In addition, Park et al (2011) found four types of ICT usage profiles of students aged 15 regarding game, entertainment, and communication activities; the four groups include high usage, low usage, relatively high game usage, and relatively low game usage groups. The low usage group indicated the least frequent users in ICT activities, and the high usage group exhibited the most frequent users. Compared to the two groups, the remaining groups showed the middle levels of ICT activities.
The difference between the relatively high and low game usage groups came from the frequency of participating in game activities.

These different profiles of technology usage should be carefully considered when instructors design and implement technology-enhanced learning in school. Given this, identifying heterogeneity in usage patterns of smart devices is of importance in designing smart education, and yet most studies have focused on the Internet and computers. To advance smart education, more research is necessary in regard to how students use smart devices.

Implication of ICT usage profiles in education

To better understand the diversity in students’ smart device usage, it is important to capture why they use ICT in different ways. Many researchers have emphasized the importance of individual characteristics in understanding ICT usage patterns in everyday life. For example, male students tend to spend time on playing online games (Wallenius et al., 2009), whereas females in higher grades tend to use social networking services more than males of the same age (Lenhart et al., 2007). In addition, ICT usage profiles tend to be associated with ICT literacy because heterogeneous distributions in participating in various ICT activities could make a significant difference in the levels of ICT literacy. It is plausible that students who use ICTs for a variety of purposes have higher levels of ICT literacy than those who use ICTs for a single purpose. Previous studies also found that the levels of ICT literacy were closely associated with ICT usage time and experiences (Bang, & Lee, 2006; Kim et al., 2014). The more students use smart devices for diverse purposes, the more they will learn about how to use smart devices for searching for, managing, evaluating, and creating information. Despite the expected benefits of actively using smart devices, there is a legitimate concern about addiction to smart devices, which may be closely related to smart device usage time. Previous studies revealed that students who used a smartphone for a longer time in a day tended to
have a higher level of smartphone addiction (Ju & Cho, 2015; Choi, 2014).

The ICT usage profiles can be related to students’ perception of technology-enhanced learning. A few studies have investigated how ICT usage profiles are associated with students’ perception of subjects. Park and Kim (2009) found that students who actively used computers were more likely to have interest in, enjoyment of, and instrumental motivation toward science than those who did not. However, high usage of ICT can be negatively associated with learning when the former hinders the latter. Park et al. (2011) revealed that the high ICT usage group showed lower achievement and less positive attitude in reading than the low ICT usage group. It is not conclusive that active usage of ICT is beneficial or harmful to school education. In addition, previous studies have investigated the relationship between students’ ICT usage profiles and their perception of ICT. Aoki and Downse (2003) found that students with positive attitudes towards technology tend to easily adopt new technology. This result supports the study of Helsper and Eynon, (2010), which found that positive attitudes towards the Internet was associated with users’ range of Internet-related activities.

Although previous studies addressed how students’ ICT usage profiles were associated with their perception of subjects and ICT, the studies rarely paid attention to students’ perception of learning with technology. Smart education assumes active use of smart devices for learning and teaching. It is important to understand how students perceive learning with smart devices, which may vary depending on how they use smart devices in everyday life. In order to maximize the merits of smart education, it is important to understand how students perceive smart education and what determines their perception.
Methods

Participants

The participants (n=253) in the study were the fourth to the sixth grade students aged 9 to 11 at an elementary school in Seoul, South Korea. We chose the participants because it was controversial to use smart devices in a classroom particularly for elementary school students in South Korea. Despite the educational benefits of smart devices, many teachers and parents have concerns about the detrimental effects of smart education on children's health and learning. Lower grade students were not chosen as participants because they lacked the experience of using smart devices. In the school, teachers (n=29) did not frequently use smart devices in their classrooms; more than a half had no experience using smartphones and tablet PCs in class (51.7% and 79.3%, respectively). Among the participants, there were 127 males and 126 females; 85 fourth grade, 85 fifth grade, and 83 sixth grade students. Students had smartphone usage experiences for one to two years on the average (M=3.03, SD=1.32; no-experience 15.4%, less-than-1-year 21.7%, 1-2-year 25.3%, 2-3-year 19.8%, more-than-3-year 17.8%), but they had tablet PC usage experiences for less than a year on the average (M=1.95, SD=1.23; no-experience 50.2%, less-than-1-year 25.3%, 1-2-year 10.7%, 2-3-year 7.1%, more-than-3-year 6.7%). They participated in the survey about (1) smart device usage, (2) individual differences in smart device usage experience, ability, and addiction, and (3) the perception of smart education. The survey was conducted for 30 minutes.

Measures

In this study, smart devices included smartphones and tablet PCs. The former meant phones with wireless Internet services such as the iPhone and Galaxy, and
the latter refers to mobile computers with a touch screen such as the iPad and Galaxy Tab. Apart from demographic information and smart device usage experience and ability, all responses were rated on a Likert-type 5-point scale. The content validity of the survey items was rated and confirmed by three professors of education. They evaluated the validity of questions and provided specific advice on revising the survey items.

Smart device usage was measured by using survey items modified from the research of Eynon and Malmberg (2011). In this study, twenty items with the 5-point Likert scale (1: never, 2: less than 1 day per week, 3: 2-3 days per week, 4: 4-5 days per week, 5: almost every day) were designed to capture the frequency of using smart devices for five types of activities: communication (i.e., text message, social network service, e-mail, and calling), information search (i.e., word search, search for purchase, news article reading, and location search), entertainment (i.e., drama/movie watch, music listening, webcomic reading, and game play), construction (i.e., writing of ideas, photo taking and editing, video making, and webpage/blog making), and study (i.e., lesson preparation and review, information search for homework, class activity, and online lecture). In an attempt to better capture the heterogeneity in students’ smart device usage, some of the items were then chosen on the basis of the results of exploratory factor analysis (EFA). EFA was carried out using the principal axis factoring analytical procedure applying the varimax orthogonal rotation technique. After several trials, the final EFA was conducted with nine items of smart device usage. Three factors whose eigenvalues were above 1 were extracted through EFA. This study inspected the appropriateness of the factor structure (loading>0.5) and the lack of cross-loadings. The first factor, consisting of three items (i.e., search for purchase, news article reading, and location search), indicated information search and explained 43.3% of the total variance (Cronbach’s alpha =0.778). The second factor, consisting of four items (i.e., lesson preparation and review, information search for homework, class activity, and online lecture), was study, and explained 14.4% of the total variance
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(Cronbach’s alpha=0.820). The last factor, including two items (i.e., text message, and calling), indicated communication and explained 11.8% of the total variance (Cronbach’s alpha=0.759).

Smart device usage experience was measured in regard to smartphone and tablet PC usage periods (1: never, 2: less than one year, 3: one to two years, 4: two to three years, 5: three years or above). Twelve items of smart device usage ability were adopted from the study by Cheon et al. (2013). They developed a national smart literacy test for elementary and secondary students. The twelve items measured students’ ability of using smart devices, and the reliability of the items (Cronbach’s alpha) was 0.635. In addition, smart device addiction was measured by using ten survey items (e.g., my school grades go down due to the excessive use of smart devices) adopted from the study of Shin et al. (2011). The reliability of the survey items was high (Cronbach’s alpha=0.895).

Attitudes towards smart education were measured by considering positive and negative aspects of attitudes. The first four items were developed to measure positive attitudes towards smart education (e.g., the class will be more interesting), and the reliability was high (Cronbach’s alpha=0.940). Negative attitudes towards smart education were measured with the other four items (e.g., it will be hard to concentrate on studying), and the reliability was high (Cronbach’s alpha=0.920).

The items for preference of smart education were developed in regards to four constructs: search, play, construction, and collaboration. Search included three items (e.g., I want to search materials for class), and the reliability of the items was very high (Cronbach’s alpha=0.925). Play consisted of three items (e.g., I want to play educational games), and the reliability of the items was high (Cronbach’s alpha=0.869). Construction included two items (e.g., I want to write my ideas) which had high reliability (Cronbach’s alpha=0.750). Collaboration included three items (e.g., I want to do group activities), and the reliability was also high (Cronbach’s alpha=0.882).
Data analysis

For the first research question, latent profile analysis (LPA) using Mplus 7 was carried out to understand how students are different from each other in the ways they use smart devices. This method is used for identifying unknown heterogeneous groups of individuals based on measures of interest. Compared to traditional cluster analysis, LPA has a model-based approach to uncovering clusters. It determines heterogeneous groups based on posterior membership probabilities rather than using dissimilarity measures (e.g., Euclidean distance), thus allowing results more interpretable. In addition, this probability model provides model fix indices (e.g., 2 log-likelihood, AIC, BIC, ABIC, and entropy), so researchers can conduct statistical tests (e.g., Lo-Mendell-Rubin likelihood ratio test) for finding the optimal number of clusters (Wang, & Wang, 2012). In order to distinguish coherent profiles of students’ smart device usage, we first calculated the averages of the items for each construct that was drawn from the results of EFA. Based on model fix indices we secondly chose the most plausible number of profiles emerging from the data. In particular, smaller values in 2 log-likelihood, AIC, BIC, and ABIC indicate a better model. As the entropy, ranging from 0 to 1, is close to 1, the model is regarded as a better model (Wang, & Wang, 2012). For the second and third research question, technically, we carried out one-way ANOVAs in attempts to understand the relationship between smart device usage profiles and student-related variables.

Results

Profiles of elementary school students’ smart device usage

Elementary school students were more likely to use smart devices for calling ($M=4.26, SD=1.35$) and text message ($M=3.49, SD=1.54$) when compared to other functions: information search for homework ($M=2.56, SD=1.42$), news article
reading ($M=2.28$, $SD=1.50$), search for purchase ($M=2.15$, $SD=1.51$), location search ($M=1.98$, $SD=1.35$), class activity ($M=1.86$, $SD=1.26$), lesson preparation and review ($M=1.85$, $SD=1.25$), and online lecture ($M=1.60$, $SD=1.24$). In order to capture students’ smart device usage profiles, we first calculated the averages of the corresponding items to the three constructs (information search, communication, and study) and then explored the latent classes behind their smart device usage with the three constructs. Among a profile solution from one to four, the AIC, BIC, and ABIC were the lowest in a three profile solution and its Entropy was 0.901. The Lo-Mendell-Rubin likelihood ratio test also showed a significant advantage for the three-class model, $p=0.005$. The results led the three-latent subgroups to be the best option this study selected. As shown in Table 1, the participants were well classified into three classes: the average posterior probability of being included in each class was much higher than that of being included in another class.

<table>
<thead>
<tr>
<th>Table 1. Class size and average posterior probabilities</th>
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<tbody>
<tr>
<td>Class 1</td>
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<td>Class 2</td>
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<td>Class 3</td>
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</tbody>
</table>

There were three different profiles of smart device usage: low-activity, communication and high-activity groups (see Figure 1). The low-activity (n= 44) was characterized by relatively low levels of all three types of smart device usage: information search ($M=1.29$, $SD=0.51$), communication ($M=1.57$, $SD=0.71$), and study ($M=1.37$, $SD=0.44$). The communication (n=160) was likely to use smart devices more than the low-activity but less than the high-activity: information search ($M=1.68$, $SD=1.24$).
Figure 1. Three profiles of smart device usage

SD=0.83), communication (M=4.31, SD=0.80), and study (M=1.88, SD=0.89). Particularly, there was a large difference in the expected means of communication between the communication and the low-activity. The communication was close to the high-activity in the aspect of communication, whereas the communication was close to the low-activity in the aspect of information search and study. The high-activity (n=49) used smart devices most frequently for all three activities: information search (M=4.21, SD=0.99), communication (M=4.63, SD=0.80), and study (M=2.76, SD=1.41).

Smart device usage profiles and individual differences in smart device usage experience, ability, and addiction

As shown in Table 2, smartphone usage experience had a significant relationship with the smart device usage profiles, F(2, 250)=31.560, p<0.001. As a result of post hoc tests (Bonferroni), students in the low-activity had less smart phone usage experience than students in the communication and the high-activity, p<0.001. However, there was no significant difference in tablet PC usage experience among the profiles, p>0.05. In addition, there was no significant difference in smart device
usage ability among the profiles, $F(2, 250) = 2.172, p > 0.05$, whereas smart device addiction varied depending on the profiles, $F(2, 250) = 3.093, p = 0.047$. As a result of post hoc tests (Bonferroni), the high-activity had a higher degree of smart device addiction than the low-activity, $p = 0.05$. Nevertheless, the addiction levels of the three profile groups were low; means of smart device usage addiction ranged from 1.47 to 1.8 in the 5-point Likert scale.

Table 2. Results of one-way ANOVAs for smart device usage experience, ability, and addiction by smart device usage profiles

<table>
<thead>
<tr>
<th></th>
<th>Low-activity</th>
<th>Communication</th>
<th>High-activity</th>
<th>$F$</th>
<th>Post hoc test</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Experience</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Smartphone</td>
<td>1.75 (1.06)</td>
<td>3.24 (1.19)</td>
<td>3.47 (1.29)</td>
<td>31.560***</td>
<td>L&lt;C, H</td>
</tr>
<tr>
<td>Tablet PC</td>
<td>1.82 (1.08)</td>
<td>1.90 (1.13)</td>
<td>2.22 (1.57)</td>
<td>1.625</td>
<td></td>
</tr>
<tr>
<td><strong>Ability</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>7.64 (2.63)</td>
<td>8.33 (2.27)</td>
<td>8.61 (2.34)</td>
<td>2.172</td>
<td></td>
</tr>
<tr>
<td><strong>Addiction</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>1.47 (0.61)</td>
<td>1.59 (0.62)</td>
<td>1.80 (0.81)</td>
<td>3.093*</td>
<td>L&lt;H</td>
</tr>
</tbody>
</table>

*Note. L: low-activity, C: communication, H: high-activity; * $p \leq 0.05$, *** $p \leq 0.001$*

Smart device usage profiles and students’ perceptions of smart education

From Table 3, this study found that there was a significant difference in the positive attitude towards smart education among the smart device usage profiles, $F(2, 250) = 11.195, p < 0.001$, while there was no significant difference in the negative attitude, $F(2, 250) = 0.197, p > 0.05$. As a result of post hoc tests (Bonferroni), the high-activity had more positive attitudes than the others, while the low-activity had less positive attitudes than the others, $p < 0.05$. 
In regards to preference towards types of smart education, there were significant differences among the profiles in regards to the four types of smart education. Preference towards search-related smart education differed among the profiles, $F(2, 250)=4.707$, $p=0.010$, and students in the low-activity particularly had lower preference towards search than students in the other groups, $p<0.05$. For play, students showed different preference depending on the profiles, $F(2, 250)=7.501$, $p=0.001$. Post hoc tests (Bonferroni) revealed that the high-activity preferred play-related smart education more than the low-activity and the communication, $p<0.05$. In addition, preference for construction varied significantly depending on the profiles, $F(2, 250)=11.237$, $p<0.001$. As a result of post hoc tests (Bonferroni), the high-activity was more likely to prefer construction-related smart education than the others, $p<0.05$. For collaboration, the preference levels were significantly different among the three profiles, $F(2, 250)=5.683$, $p=0.004$. Post hoc tests

### Table 3. Results of one-way ANOVAs for students’ perception of smart education by smart device usage profiles

<table>
<thead>
<tr>
<th></th>
<th>Low-activity</th>
<th>Communication</th>
<th>High-activity</th>
<th>$F$</th>
<th>Post hoc test</th>
</tr>
</thead>
<tbody>
<tr>
<td>Attitude</td>
<td>Positive</td>
<td>2.74 (1.51)</td>
<td>3.37 (1.31)</td>
<td>4.06 (1.31)</td>
<td>11.195***</td>
</tr>
<tr>
<td></td>
<td>Negative</td>
<td>3.07 (1.54)</td>
<td>3.21 (1.24)</td>
<td>3.17 (1.36)</td>
<td>0.197</td>
</tr>
<tr>
<td>Preference</td>
<td>Search</td>
<td>3.22 (1.61)</td>
<td>3.85 (1.15)</td>
<td>3.93 (1.35)</td>
<td>4.707**</td>
</tr>
<tr>
<td></td>
<td>Play</td>
<td>2.77 (1.50)</td>
<td>3.30 (1.25)</td>
<td>3.84 (1.43)</td>
<td>7.501***</td>
</tr>
<tr>
<td></td>
<td>Construction</td>
<td>2.43 (1.49)</td>
<td>2.66 (1.27)</td>
<td>3.59 (1.39)</td>
<td>11.237***</td>
</tr>
<tr>
<td></td>
<td>Collaboration</td>
<td>2.79 (1.48)</td>
<td>3.13 (1.31)</td>
<td>3.71 (1.42)</td>
<td>5.683**</td>
</tr>
</tbody>
</table>

Note: L: low-activity, C: communication, H: high-activity; ** $p\leq0.01$, *** $p\leq0.001$
(Bonferroni) demonstrated that the high-activity preferred collaborative learning with smart devices more than the others, $p < 0.05$.

**Discussion**

This study sought to broaden understanding of how elementary school students use smart devices and how they perceive smart education. This study found that elementary school students were categorized into three profiles in their smart device usage: the low-activity, the communication, and the high-activity. The low-activity and the high-activity were also found in other studies about ICT usage profiles (Eynon & Malmberg, 2011; Park et al., 2011; Park & Kim, 2009). In this current study, the number of students in the communication was three times more than that of students included in the other groups. This result shows that smart devices especially play an important role in communication, which supports the study of Gikas and Grant (2013) that mobile computing devices enable students to engage in active communication using social media. It is also possible that elementary school students frequently use smart devices for communication in order to develop friendship. Quinn and Oldmeadow (2013) revealed that more intensive users of SNS among male children aged 9–13 years had stronger bonds with their friendship group than non-users or less intensive users.

The smart usage profiles were closely related to smartphone usage experience, not tablet PC usage experience. In this study, most students (84.6%) had experience of using a smartphone, but more than a half of students never used a tablet PC. According to the Korea Communications Commission (2014), Korea’s tablet PC penetration rate was 3.5%, which was much lower than that of other leading digital markets in Asia-Pacific, while its smartphone penetration rate was 76.9%. These different penetration rates might affect students’ experience with smartphones and tablet PCs.
This study also found that smart device usage ability was not significantly different depending on the smart device usage profiles. In other words, the low-activity, the communication, and the high-activity showed similar levels of smart device usage ability. Through this result, we do not have to be overly concerned with potential difference in the practical capacities of using smart devices among the groups. In regard to smart device addiction, the profiles had a significant relationship with the degree of smart device addiction; the high-activity had a higher addiction level than the low-activity. This result could be explained by the study of Ju and Cho (2015). They pointed out that daily average usage time of a smartphone was the most important factor of adolescents’ smartphone addiction. Although the smart device addiction levels of elementary school students were not high in this study, teachers need to help students, particularly the high-activity, to monitor and regulate their smart device usage behaviors for themselves.

The perceptions of smart education varied depending on the smart device usage profiles. The profiles were closely related to positive attitudes to smart education. In specific, the high-activity showed more positive attitudes compared to the other groups, and the communication had more positive attitudes than the low-activity. This result is consistent with the study of Park and Kim (2009) that revealed that a high-activity group had more interest in, enjoyment of, and instrumental motivation toward science than a low-activity group. However, in this current study, there was no significant difference in negative attitudes among the profiles. This could be partly explained by the fact that students, considered as digital natives, are more familiar with using technology in their everyday life, thus not having resistance to learning with new technology. In regard to preference towards types of smart education, there were differences in the four types of smart education: search, play, construction, and collaboration. The high-activity showed higher preference for all smart education types than the low-activity. This result is in agreement with the study of Aoki and Downse (2003) in which students with positive attitudes towards technology were more likely to take advantage of a new technology. For the success
of smart education, teachers should provide the low-activity with learning opportunities of using smart devices for diverse purposes in a meaningful way. In addition, smart devices and other ICTs should be used for tasks requiring higher-order thinking and collaboration skills. Reich et al. (2012) found that low-income students were less likely to use wikis for 21st century skill development (e.g., collaborative student presentations and workspaces) in school than high-income students. To prevent digital divide, inequalities in technology-based educational opportunities, teachers should pay attention to the quality of smart education as well as the access to ICT resources.

This study provides a few implications for educators who are interested in smart education. First of all, teachers need to consider the diversity of smart device usage profiles among elementary school students and their perceptions of smart education when they design smart education. Understanding how students use smart devices enables educators to implement adaptive instruction to meet students’ different needs. For instance, more instructional supports should be provided to the low-activity students who have less positive attitudes towards smart education. It will be helpful in motivating students to use smart devices for authentic problem solving in and out of school (Wong, Milrad, & Specht, 2014). In addition, more attention should be paid to the high-activity in regards to smart device addiction. Because students in the high-activity group were more likely to suffer from smart device addiction, instructors should help them to monitor and regulate using smart devices. To prevent smart device addiction, teachers can explain adverse effects of smart device addiction with specific examples or cases. In addition, students can use applications to collect and analyze log data of their smart devices in order to monitor their smart device usage.
References


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