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The Impact of How Often Students Use Mobile Devices on Their Perceptions of the Usefulness and Convenience of the Devices

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This paper explores the impact of mobile device usage frequency in the classroom on students' perceptions of their use. To assess this, we created a survey that measured students' perceived frequency, usefulness, and convenience of using mobile devices, using a reversed Technology Acceptance Model. Through the analysis of responses from 781 Korean students, utilizing confirmatory item factor analyses and a structural equation mixture model, we found that the effect of frequent mobile device use on students' positive perceptions is non-linear. As the frequency reaches to a certain level, the effect sizes of the frequency in the positive perceptions diminishes. Additionally, students who used mobile devices less frequently in class reported higher levels of difficulties in using the devices. This study introduces a tool for evaluating multiple aspects of students' perceptions regarding mobile device use and offers a framework for understanding the relationship between usage frequency, usefulness, and convenience.

Keywords : Mobile device, Frequency of use, Usefulness, Convenience, Perception of technology use

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Introduction

With the rapid development of information and communication technology (ICT) over the past decade, a considerable literature has recently grown up around the theme of incorporating ICT into teaching and learning environments. Several studies reported many benefits of embedding ICT in creating effective classroom learning environments, for example, a positive impact on student achievement, attitudes, and engagement in learning (Baker et al., 1994; Ball & Stacey 2019; Bray & Tangney, 2017; Kozma, 2003; Maor & Fraser, 1996). Among a variety of ICT tools, mobile devices have been found to be more effective in education than desktop computers or laptops (Crompton & Burke, 2018; Sung et al., 2016). Due to the portability of the devices that enable immediate internet access, mobile devices provide students with greater convenience in collecting and sharing information (e.g., live classroom polling) and make implementation of cooperative learning easier in classrooms. This learning aided by mobile devices has been reported to lead to positive achievement in reading and mathematics (Lan et al., 2007; Roschelle et al., 2010).

Despite positive perspectives on potential of mobile devices, some studies report drawbacks. For example, students are more easily distracted when using mobile devices during classes (Campbell, 2006), and using mobile devices for sending and receiving messages has a negative impact on student learning (Kuznekoff et al., 2015). However, most of the reported negative effects were mainly occurred when the devices are used for the content unrelated to class (Gajdic & Jagodics, 2021). This has given rise to questions about the actual use of the devices in class, for example, what their use in class looks like and what factors influence their impact. One possible factor contributing to the benefit might be that the effect on the use may depend on whether the purpose (range from searching for information to collaborating with peers) is aligned with targeted student learning. A second factor may be that the effect may depend on students' or a teacher's experience in using the devices. For example, novice students with little experience may be unable to fully utilize the available functions, resulting in no impact on their learning until they get used to the device. A third impact on learning may be students' perceptions of the use of mobile devices such as the extent to which students perceive convenience or usefulness. In other words, students' attitudes towards the usefulness of the devices might determine whether students learn with them. However, the research conducted so far has primarily focused on the effect of usage on student achievement, without considering factors such as students' attitudes or perceptions toward the use.

Some studies have incorporated other factors, such as students' attitudes or teachers' experience with device usage, but they have not specified the types or frequency of usage that these factors account for. For example, it is unclear whether devices are used for class activities and what specific activities they are used for. The use of mobile devices for peer discussions during class may positively impact students' learning or perceptions, while using mobile devices for non-class related chatting with peers may not. These possibilities indicate the importance of measuring the actual usage of mobile devices for various specific purposes, such as uploading materials or communicating with peers or a teacher. Therefore, in this study, we developed survey items to create a frequency scale that represents the usage of mobile devices for different purposes, particularly for learning-related activities, while in class.

This study aims to investigate the association between mobile device usage and students' perceptions. Our hypothesis is that students' perceptions of mobile device usage play a crucial role in determining its effect on student learning. A future study will examine whether student perceptions mediate the relationship between usage frequency and student achievement. In this study, to scale specific constructs associated with students' perceptions on the use of device, we used TAM model that illustrates that the actual usage of the technology system is determined by perceived usefulness and perceived ease of use. In particular, the TAM model was aligned with our hypothesis on the multidimensional nature of students' perceptions regarding their experience. Specifically, we hypothesized distinction between perception of usefulness and easy or use (in our study, perception on convenience). Considering the context of our study, where students were not given the option to use their own mobile devices and instead had to use devices provided by the district, we employed a reversed TAM (Technology Acceptance Model) approach. In other words, we predicted students' perceptions based on the frequency of device usage, rather than assuming the causal relationship presented in the traditional TAM model. We conducted this examination using data collected from grade 1 to 12 Korean students.

Because of all the reported benefits and support, the Korean government has established a policy supporting the use of mobile devices in the classrooms (Leem & Sung, 2019) and the majority of South Korean schools are equipped with high-speed internet and smart devices. By using the survey data, we established scales of students' perceptions on usefulness and convenience of mobile devices. We then examined the associations between the perceptions and the frequency of using mobile devices. After evaluating the psychometric properties of our survey instrument consisting of multiple-choice items, we report our findings derived from a semi-parametric approach.

Literature: Studies in integrating ICT and mobile device into classrooms

ICT refers to diverse devices, applications, systems, and networking components that allow people to interact digitally. The education field has been interested in integrating ICT into the classroom in the belief that it has potential for improving the quality of instruction and student achievement by providing authentic learning and meeting the needs of students in a digital world (Kember, 2008). For instance, in the case of computerized classrooms, Maor and Fraser (1996) argue that this environment could improve inquiry learning because of the potential of such an environment in terms of catering to students' different prior knowledge and engaging them in class discussions and sense-making. The study provided a computerized database consisting of curriculum materials about science to 120 students and seven teachers across four schools, and the students had opportunities to build their understanding by exchanging ideas while interacting with the database. The database enabled them to engage in scientific inquiry, and consequently, teachers and students perceived the ICT learning environment positively. In a later study, Maor (2017) raised the issue that many teachers do not effectively incorporate ICT into their instruction and emphasized the importance of enhancing teachers' ability to use technology in their learning and teaching. In the study, teachers learned how to integrate technology and pedagogy through participating e-learning courses where they experienced using mobile devices, e.g., using ePortfolios and eBooks on iPad. As such, studies have reported benefits of integrating ICT for teaching and learning and aspects of the needs to be considered. However, until now, the question of whether there is an actual effect of ICT use on the improvement of teaching and learning has been controversial. Some studies reported skepticism given the gap between the high cost of ICT implementation and in-school technology usage (e.g., Cuban, 2001; Lim et al., 2013).

The use of ICT as a learning tool involves multiple components to consider, such as the frequency of the use, student attitudes or perceptions toward the use, types of devices or apps, and quality of pedagogy with the use of ICT in instruction. Several studies have examined the associations between frequency of use and student achievement, but the association was found to be mixed. The relation between the frequency of computer use at home and primary student reading achievement was reported to be positive, whereas the relation between such use at school and primary student reading achievement was negative (House, 2007; Lorenz & Gerick, 2014). Moreover, the relation between the frequency of the use of computer in secondary school and student achievement in science and mathematics was negative (Papanastasiou & Paparistodemou, 2007; Papanastasiou et al., 2003). However, Fütterer et al. (2022) reported mixed findings in the effect of frequent use of tablets in class on the students' attitude toward their learning. This research collected from

1363 students in 28 schools and found that the more frequent use of tablets in German class led to more students' academic efforts in short-term, but such association was not found in learning mathematics. Regarding the association between students' perception on the use of ICT and their achievement, Petko et al. (2017) analyzed the data in PISA 2012 with around 230,000 students in 39 countries and reported that students' beliefs about digital technologies as a learning tool were positively related to their achievement in reading, mathematics, and science in most countries. Based on this result, the authors emphasized the importance of students' positive experience in the use of ICT in schools, highlighting the quality of educational software and pedagogy as critical factors influencing students' attitudes in learning with the use of ICT. Andrew et al. (2018) analyzed about 1100 students' attitudes towards the use of the tablets and smart phones for learning. They reported that students enjoyed learning with such mobile devices with traditional resources, such as books and paper, rather than relying solely on one or the other.

With the advancement of internet technology and ICT, mobile devices like tablets and smart phones, which are smaller and more portable than computers, have been used in typical classrooms learning. No (2022) analyzed a writing picture card task on a tablet screen of 108 six-year-old preschool children and reported a significant correlation between young children's graphomotor skills. Ohm et al. (2023) installed three tablets in a preschool classroom for seven weeks and analyzed how 25 5-year-old children engaged in art play. They played freely without recognizing boundaries between the digital and non-digital in the classroom, for example, not distinguishing between tablet PCs and traditional toys. Lee and Hyeon (2020) analyzed the user effectiveness of the therapist and parents of children using the cognitive training game with 20 non-disabled children aged 6 to 11 years old and 20 children with intellectual disabilities. This research reported that cognitive training games using tablets have helped children with intellectual disabilities to improve game performance, as well as working memory and perception reasoning. Therapists and parents of children using tablets also said that cognitive training using tablets was more interesting and effective than the existing treatments. In terms of teachers' perception related to use of tablets in classroom, Lee et al. (2023) collected 151 secondary teachers' responses. They reported that the teachers believed the use of smart device improve students' learning motivation and satisfaction, but preferred laptop PCs than tablets for class-related work.

In terms of the frequency of the use of mobile devices, Sung et al. (2016) analyzed 110 journal articles about the use of mobile devices in education and reported that such use was found to be effective in learning social studies, science, language arts, and mathematics. However, long-term intervention (more than 6 months), using mobile devices did not necessarily lead to positive effects on students' learning. With regard to teaching method, inquiry learning, self-directed learning, and lectures with mobile devices were found to be effective, but cooperative learning and game-based learning were not. Haßler et al. (2015) also reviewed 23 studies about tablet use in schools and reported that tablet use sometimes made neutral outcomes in learning and even ineffective impact on reading performance and writing skills. The authors emphasized that generalizing evidence about the effect of using mobile devices in school is still limited. They elaborated how such use can improve learning. As such, the results regarding the association between frequency of use and its impact on student achievement or learning have been mixed. This variation in results can be attributed to factors such as the level of students, purpose of use, and types of students' attitudes. We believe that one of the reasons for these mixed results is the lack of a specific instrument to measure the frequency of use in real-life examples and capture multidimensional aspects of student perceptions. To bridge this gap, we have developed an instrument that systematically measures usage for specific purposes and captures multiple dimensions of student perceptions. With a solid theoretical foundation, we have explored the relationships between multiple constructs of usage frequency and perceptions.

To better understand the use of ICT including mobile device in schools and its effect on students' perceptions, this current study asks about students' experiences in using mobile devices, a common ICT device, through a survey instrument. In this context, as previous mentioned, mobile devices are defined as smaller and more portable devices, such as tablets and smartphones, in comparison to computers.

Among ICT devices, mobile devices are the most widely used ICT device providing students personalized learning experience. Furthermore, recent education policy in South Korea has strongly encouraged the use of mobile devices in class for all grade levels. In this study, we investigated students' experience in using mobile devices in the chosen schools supported by a district. We then investigated how the support impacted actual use of the device and students' perceptions towards the use.

Conceptual framework: Reversed Technology Acceptance model

Our hypothesis on the relationship between the frequency of using mobile devices and the two constructs reflecting students' perceptions of use was driven by the Technological Acceptance Model (TAM), but in an extended and reversed way. The TAM proposed by Davis (1989) argues that the actual usage of the technology system is determined by perceived usefulness and perceived ease of use. Perceived usefulness can be defined as the extent to which an individual sees a particular system as contributing to their learning and perceived ease of use is defined as "the degree to which a person believes that using a particular system would be free of effort". (Davis, 1989, p.320). In addition to the two factors, several researchers have identified other external factors such as computer self-efficacy, technical support, and perceived convenience as predictors of users' acceptance of technology (Ngai et al., 2007; Wang & Wang, 2009; Yoon & Kim, 2007). Among these external factors, perceived convenience has been reported to have a significant causal relationship with other components such as perceived ease of use, perceived usefulness, and attitude toward using technology (Yoon & Kim, 2007).

Among the components of the TAM model, our study focuses on three factors - actual usage, perceived usefulness, and perceived convenience of mobile devices. We operationalize 1) perceived frequency of mobile device use as the perceived actual usage of the technology referred to in TAM; 2) perceived usefulness as the degree to which students perceive that using mobile devices would enhance their performance in class; 3) perceived convenience as the degree to which students perceive that mobile device use would make their work more convenient. In our TAM model, we modified the causal relationship between the frequency of use and perceptions presented in TAM. Specifically, we hypothesized reversed causal relationships between the frequency of device usage and students' perceptions, meaning that frequency of use predicts students' perceptions on the use. This is because, in our study, mobile device use in class was imposed by the district as a part of a larger project and teachers had to use the mobile devices supported by the project. Thus, the use of mobile devices was inevitable for students rather than being completely controlled by their intent to use them. The possibility of this reverse causality among the components of TAM was also tested in Ishaq et al. (2021) that examined the influences of technology acceptance behaviors on perceived ease of use, perceived usefulness, and attitude toward using technology. The study proposed reversed causality as the "adoption of technology was inevitable and immediate due to COVID-19" and people had no choice about whether to use the technology or not (Ishaq et al. 2021, p.2). Similarly, in our study, students were mandated to accept technology (here, mobile devices) to some extent by their teachers. Thus, we focused on examining the effect of the imposed use of mobile devices on students' perception of usefulness and convenience.

Given the rationale for using the reversed Technology Acceptance Model (TAM), this study aims to investigate the impact of mobile device usage on students' perceptions of usefulness and convenience. To measure device usage and perceptions, we developed a survey instrument based on the reversed TAM model and used specific examples of usages. We then applied a mixed model to identify subgroups that show differences in the impact of device use on perceptions.

The decision to use a mixed model was motivated by previous studies that showed inconsistent results regarding the effect of device use on student learning, depending on student characteristics such as grade level or attitudes. By examining different subpopulations, we aimed to understand the factors that characterize each group and how these factors are associated with the differences between the groups.

By using the data collected via the instrument consisting of sets of items designed to measure the three components of the reversed TAM model, we aim to answer the following research questions:

(1) How are the three components of our modified TAM model - perceived frequency, usefulness, and convenience - related to each other?

(2) How does the identified effect of frequency of mobile device use on students' perception (usefulness and convenience) apply to a whole group of students. In other words, are there subpopulations that show different patterns in the effect of frequency on their perceived usefulness or convenience (e.g., regarding the size or direction of the effect).

(a) If there are subpopulations, to what extent do the identified student subgroups differ in the association between the frequency of device use and their perceptions (convenience and usefulness) or in the difficulties they experienced in mobile device use?

Methodology

Participants

The participants of the current study were 798 first to twelfth grade students from nine schools located within the same province-sized district in South Korea. The schools were chosen to be supported by a district in setting up their schools' wireless networks and providing students with mobile devices, which were tablets, for their use in class. All schools volunteered to participate in this study, our developed survey was distributed by the district, and the students were asked to respond to each item of the survey instrument via Qualtrics. Total 798 students from 9 different schools participated in the survey and 762 students completed all survey items. The number of students for each school varies, ranging from 19 to 224.

Among the 798 students, 55%, 42%, and 3% were self-identified as elementary, middle, and high school students, respectively.

Survey Instrument

According to our target constructs based on the components of the TAM model, we developed survey items that measure three constructs: students' perceived frequency of using mobile devices, perceived usefulness, and perceived convenience of use. We also developed items that ask the extent to which students experienced difficulties in the use. The last set of difficulty-related items were used at item level rather than at a construct level because the difficulties involved not only the device itself but also environmental or individual factors. Thus, we did not hypothesize a construct emerged from this set but rather aimed to use each item to examine the effect of a specific challenge related to the use of the device. The set of frequency items asked participants to indicate how frequently they do a given activity by using mobile devices (e.g., I use digital textbooks in the classroom) in terms of a 6-point Likert scale ranging from "Never"(1) to "Very Frequently"(6). The sets of perceived usefulness (e.g., Using mobile devices in class increases my participation in class discussion), convenience (e.g., Using mobile devices gives me convenience in sharing materials with my peers in class), and difficulty (e.g., I often get distracted by my mobile device in class) items asked participants to indicate the extent to which they agree or disagree with given statements in terms of 6-point Likert scale ranging from "Strongly Disagree"(1) to "Strongly Agree"(6).

Analysis

To test whether each set of items separately measure each construct and examine the correlations among the three hypothesized factors, we conducted confirmatory item factor analysis. MLR (Maximum likelihood with robust standard errors) estimator was used for the model, and error correlations were allowed to be estimated for the items that ask the use of devices for the same purpose (e.g., item asking frequency of the use of devices for searching information and item asking perception of convenience in the use of devices for searching information). Whether the measured constructs were distinguished or not was tested by computing the chi-square difference test using log-likelihood values and scaling correlation factors obtained with the MLR estimator from the nested models.

Semiparametric approach. After confirming the hypothesized structure of the items, we conducted a mixture model to examine the potentially nonlinear relationship between the frequency and each of the perception factors within an overall population. Specifically, we examined whether the size and direction of the effect of the frequency on the perception of usefulness or convenience is consistent across all students. To assess whether there are different linear patterns, we conducted a semiparametric approach. We used this approach as the approach allows us to examine the potentially nonlinear relationships between the frequency and the factors of usefulness and convenience using a mixture of linear structural equations (Pek et al., 2009). A Structural Equation Mixture Model (SEMM) is known to relax the assumption of linear relationship between a latent predictor and latent outcomes and instead assume that "the observed data were obtained from a mixture of K multivariate normal distribution" (Pek et al. 2009, p.412). This advantages of using SEMM enabled us to estimate the distribution of latent factors and the relationships among them for each identified class of participants. To determine whether the model identifying two subgroups is better than the model assuming homogeneity in a whole student population, we conducted a likelihood ratio test using log-likelihood values and scaling correlation factors obtained from the one-class and two-class models.

Perception of difficulty in using devices. After identifying classes revealing a different linear pattern between the frequency factor and the other two perception factors, we compared the responses of the students in the different classes regarding their responses to the questions asking difficulties in using devices. The types of difficulties asked in the items included internet connection, device malfunction, growing reliance on devices, and a distraction problem. Considering that each item asks for a different aspect of difficulties, we conducted a t-test for each item response to examine if there is a significant difference in the mean of their response rating between the two classes. All the analysis were performed using Mplus 7 (Muthén & Muthén,1998–2015).

Results

Measurement model

Before testing a measurement model, we conducted classical test theory-based procedures and examined psychometric properties of the items in terms of reliability and item difficulty. All the point-biserial correlations between each item and total score with each factor (i.e., a target construct) were above 0.30, and Cronbach's alpha used as an index for reliability for each factor was greater than 0.80, indicating that a set of items are highly correlated to each other as a group. Table 1 presents descriptive statistics of the averaged item scores for each factor presented by the 781 students who responded to at least one item in the questionnaire. Out of 21 items, 15 items have missing responses, and the rate of missing values ranged from 0.1%

(N=1) to 2.2% (N=17). To handle these missing values, we utilized the full information maximum likelihood (FIML) approach provided by Mplus as the default method.

Table 1
Descriptive statistics and alpha coefficients for average scores

Construct	*N*	Number of items	Mean	*SD*	Min	Max	Alpha
Frequency	781	8	3.24	1.19	1	6	0.86
Convenience	769	9	4.60	1.16	1	6	0.94
Usefulness	764	4	4.51	1.29	1	6	0.91

*Scale of frequency: 1-Never, 2-Very rarely, 3-Rarely, 4-Occasionally, 5-Frequently, 6-Very frequently. Scale of convenience and usefulness: 1-Strongly disagree, 2-Disagree, 3-Somewhat disagree, 4-Somewhat agree, 5-Agree, 6-Strongly agree.

After confirming the acceptable properties of the items, we applied a measurement model to test our hypothesis on the structure of the instrument (3 separate factors - frequency, usefulness, convenience). In the model, error correlations between frequency items and convenience items were allowed to be estimated if the items ask about the same activity. In addition, an error between the item of convenience in viewing multimedia material and the item of convenience in searching for information was suggested to be correlated by modification indices. We examined the item contents and decided to allow the error to be correlated in that perceived convenience in searching for information on mobile devices would be likely to be associated with convenience in browsing multimedia content on mobile devices.

The item factor analysis results suggested that the three-factor model where each set of items are loaded on each of the three hypothesized factors fit the data well (RMSEA=0.050, CFI=0.953, TLI=0.945). This indicates that each of the three latent traits (frequency, usefulness, and convenience) was able to predict the pattern of correlations among the items within each set. The measurement model and item factor loadings are presented in Figure 1.

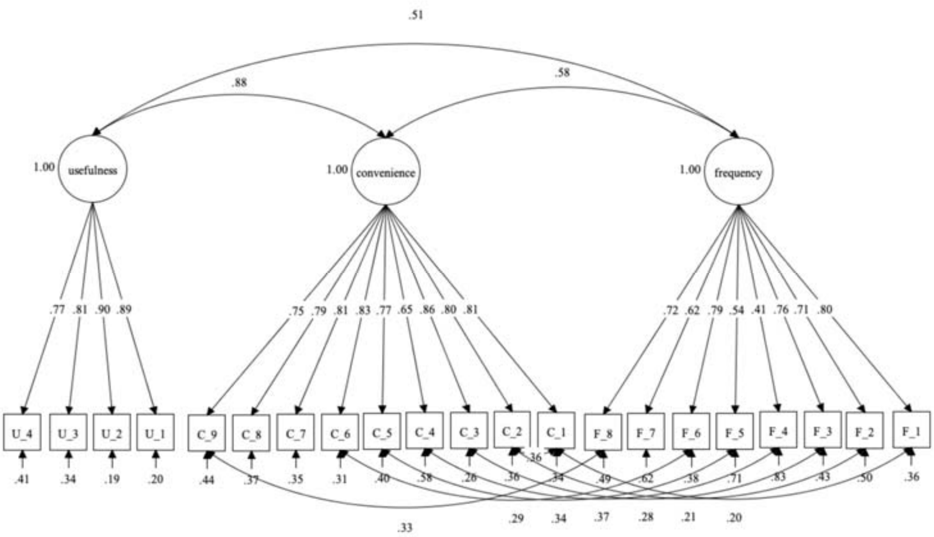

Figure 1. Measurement diagram presenting the three-factor model (only significant associations at 0.05 level are presented)

As shown in the diagram, all standardized item factor loadings were estimated to be greater than 0.5 and significant at the 0.05 level. The relationships among the hypothesized factors were also examined under the three-factor model and the correlations among the estimated factors are presented in Table 2.

Table 2
Correlations between the factors of students' use of devices

	frequency	convenience	usefulness
frequency	-	-	-
convenience	0.58***	-	-
usefulness	0.51***	0.88***	-

As shown in the table above, convenience and usefulness were correlated as high as 0.88, indicating that students who perceive convenience in using the device are highly likely to agree with the stated usefulness of using mobile devices in class. Considering the high correlation 0.88 between the factor of convenience and usefulness, we conducted a test comparing the model fit of this three-factor model with the two-factor model where the two factors are combined into a single factor. The test was conducted by following the steps suggested by Satorra et al., (2010) to compute a chi-square difference test appropriate for MLR. The result suggested that the three-factor model is significantly better than the two-factor model, $\chi 2(2) = 92.39$, $p<0.001$, indicating that the factors of convenience and usefulness are statistically distinguishable. Regarding the correlations between the frequency factor and the two perception factors, both convenience and usefulness factors were shown to be positively correlated with the factor of frequency, meaning that how often students use mobile devices in class is associated with the degree to which they perceive usefulness or convenience in the use of mobile devices in class. The degree of each correlation was large according to Cohen's convention (1988) of interpreting effect size (small, medium, or large of r=0.10, 0.30, and 0.50, respectively).

Nonlinear relationships between frequency and usefulness & convenience

The two-class mixture model was conducted under the three-factor model where each factor presents perceived frequency, usefulness, and convenience in using mobile devices in class. In the model, the frequency factor was set to be predicted by two latent predictors - usefulness and convenience, based on our second research question asking the effect of using mobile devices on students' perceptions. The fit of the two-class mixture model hypothesizing two different groups of students was compared to that of one-class model in terms of BIC, log-likelihood values, and scaling correlation factors obtained with the MLR estimator. The result of fitting Structural Equation Mixture Model (SEMM) to the data suggested that a two-class model constraining equal variance on the latent factors across the classes fit the data significantly better than one-class model assuming univariate normal distribution for the entire student ($\chi 2(7) = 262.19$, $p<0.001$). Table 3 presents the parameter estimates for the effect of frequency on usefulness and convenience for the whole sample in one class model and for each class in the two-class model. This result indicates that the size or direction of the effect of the frequency on the perception of convenience (and usefulness) is not consistent between the two classified groups of students. Specifically, the effect of frequency on usefulness was stronger in Class 2 (0.548) than in Class 1 (0.300). Similarly, the effect of frequency on convenience was stronger in Class 2 (0.827) than in Class 1 (0.351) and the difference between the two classes in the effect size for convenience was greater than that in the effect for usefulness. According to these results, we examined the characteristics of each identified class in terms of its frequency distribution. The examination suggested that Class 1 students tend to use mobile devices more often than Class 2 students. Specifically, on average, Class 1 students "frequently" use mobile devices in class (mean of the frequency factor is 3.881), whereas Class 2 students "occasionally" use mobile devices (3.03 mean).

Figure 2 presents plots visualizing nonlinear relations among the estimated latent variables. The plots present the marginal mixture densities, the two locally linear regression estimates, the bivariate contour plot, and the nonlinear regression of convenience and usefulness on frequency, respectively. The top and right of the main graph area present marginal distributions of the latent predictor (frequency) and outcomes (left: usefulness, right: convenience), respectively. As shown in the distribution, the averages of predictor and outcome level in Class 2 are lower than that of Class 1.

Table 3

A Structural Equation Mixture Model estimation

Parameters	One class model	Two class SEMM model	
BIC	49730.778	49536.157	
	one class	class 1	class 2
Correlation between convenience and usefulness	0.756	0.378	0.118
Probability of class membership		0.843	0.157
Effect of the Frequency on the perceived usefulness			
	one class	class 1	class 2
Mean of the frequency	3.748	3.881	3.034
Intercept for the linear regression of the usefulness on the frequency	2.801	4.012	0.868
Slope for the linear regression of the usefulness on the frequency	0.523	0.300	0.548
Variance of the frequency	1.406	1.302	1.302
Residual variance for the linear regression of the usefulness on the frequency	1.122	0.469	0.469
Effect of the Frequency on the perceived convenience			
	one class	class 1	class 2
Mean of the frequency	3.748	3.881	3.034
Intercept for the linear regression of the convenience on the frequency	2.814	3.770	0.752
Slope for the linear regression of the convenience on the frequency	0.541	0.351	0.827
Variance of the frequency	1.406	1.302	1.302
Residual variance for the linear regression of the convenience on the frequency	0.740	0.430	0.430

*BIC=Bayes Information Criterion

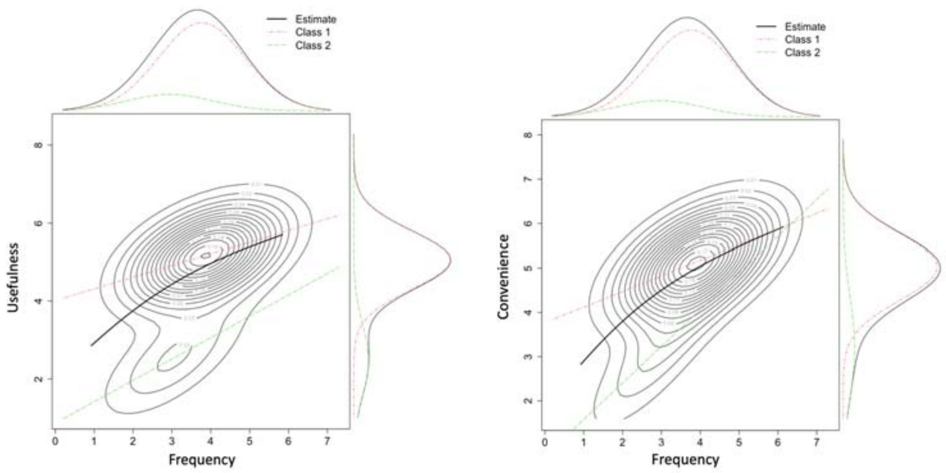

Figure 2. The nonlinear regressions estimated by SEMM with two latent classes (Left: usefulness on frequency; Right: convenience on frequency)

As shown in Figure 2, According to within-class regression estimates, Class 2 (green) has stronger linear relationships between latent predictor (frequency) and outcomes (usefulness and convenience) than Class 1 (red). In other words, the effect of frequency on perceived usefulness or convenience is larger for Class 2 than Class 1. To test the significance of the differences in the estimates presented in Table 3 between Class 1 and Class 2, we conducted a constrained SEM model where the difference parameters are estimated using Mplus. The result suggested significant differences between the classes (estimates for Class 2 - estimates for Class 1) with respect to the slope of the regression predicting usefulness (βclass2 - βclass1 =0.248, $p<0.05$) , the slope predicting convenience(βclass2 - βclass1=0.476, $p<0.001$), the mean of frequency (Mclass2-Mclass1= -0.847, $p<0.001$), the mean of usefulness (Mclass2-Mclass1= -3.144, $p<0.001$), and the mean of convenience (Mclass2-Mclass1= =-3.018, $p<0.001$). Taken together, these results suggest that within the students who do not use devices frequently in class (Class 2), the smaller increase in the frequency of using mobile devices is likely to sharply increase their positive perceptions (convenience and usefulness) towards the use of the devices than within the students who use mobile devices frequently in class (Class 2). The effect sizes of the frequency in the positive perceptions, however, diminishes as the frequency reaches to a certain level.

Perceived difficulties in using mobile devices

We compared Class 1 and Class 2 regarding their responses to the questions asking about difficulties in using mobile devices in class. The types of difficulties asked in the items include internet connection, device malfunction, growing reliance on devices, and a distraction problem. Considering that each item asks for a different aspect of difficulties, we conducted a t-test for each item responses to examine if there is a significant difference in the mean of their response rating between the two classes. Table 4 presents the mean score of each difficulty item and significance of the difference between the classes.

Table 4
Comparison of difficulty-item means

Item measuring difficulty	Class 1	Class 2	Difference (class2-class1)
D_1: internet connection problem	2.46	3.14	0.68***
D_2: technical difficulties with mobile devices	1.92	2.23	0.31**
D_3: distractions in class.	2.14	3.14	1.00***
D_4: too much reliance on device	2.01	1.75	-0.26*

*$p < 0.05$, **$p < 0.01$, ***$p < 0.001$
*Scale of difficulty: 1-Strongly disagree (not difficult), 2-Disagree, 3-Somewhat disagree, 4-Somewhat agree, 5-Agree, 6-Strongly agree (very difficult).

As shown in Table 4, on average, Class 2 students reported a significantly higher level of difficulties across different types of difficulties asked, except the difficulty due to heavy reliance on devices than Class 2 students.

This result implies that the students who use mobile devices less frequently reported higher levels of difficulties in using mobile devices due to internet connection problems, technical problems with devices, and distractions in class than the students who use mobile devices more frequently. On the other hand, the students who use mobile devices frequently agree more on that they rely too much on mobile devices in class than the students who use devices less frequently.

Conclusion and Discussion

The current survey study reports results on the measured students' perceived frequency, usefulness, and convenience of mobile device use in class. The students who participated in this study were supported by their district in using mobile devices as well as setting up a technical environment for their use. After examining the psychometric properties of the survey items, we examined whether the frequency of using mobile devices is associated with students' perceived usefulness and convenience of using them in class. With respect to the first research question about the structure of our survey instrument, we found that the three sets of items measure the intended constructs separately with acceptable reliability. Even though the two factors of usefulness and convenience are highly correlated, the test suggested separating the two factors is preferable to combining them. This result indicates that agreement on the usefulness of using mobile devices does not necessarily imply agreement on convenience in the use of devices, vice versa. The finding of a distinct but high correlation between them accords with another study that found 60% of the variance of perceived usefulness (in the use of wireless LAN) was explained by perceived convenience (Yoon & Kim, 2007).

The second question in this study sought to determine whether there are subpopulations that have different patterns in the effect of the frequency on students' perceived usefulness or convenience. The results suggest that the effect of frequency on usefulness or convenience is not linear, indicating that the effect size of the frequency on the two other factors is different depending on how frequently the group used mobile devices in class. Specifically, the effect was greater for the group of students who rarely used mobile devices frequently (average frequency: 3 - rarely) than the group who used mobile devices occasionally (average frequency: 4 - occasionally). The difference in the effect size between the groups was larger for perceived convenience than perceived usefulness. A possible explanation for this might be that students who had few opportunities to use mobile devices may acknowledge the convenience of the devices much more than the students who already have used the devices frequently in that the functions provided by the devices may not be surprising to frequent users. Rather, as students have more experience in using the devices, they would identify functions that they wish the devices can provide. The same explanation could account for the lower slopes of the effect for the students who frequently use the devices (as shown in Figure 2).

Differences between the two identified classes of students were also identified in the subsequent analysis of the responses to the items asking about difficulties in device use. Students who less frequently used the devices in class reported higher levels of difficulties connecting to the internet, technical problems with the devices, and challenges in concentrating on lessons. Regarding this result, we may need to examine causal relationships between frequency and the difficulties. In other words, there are two possible explanations for the differences: (1) difficulties of using devices discouraged the students from using mobile devices or (2) students who were not familiar with the use of devices had more difficulties in using the devices. Future studies could test these two hypotheses with more items asking about potential difficulties in using mobile devices in class.

While this study successfully established the scales of frequency of use and students' perceptions, there are some limitations. First, the sample consists of students from schools participating in the district-level project that supports mobile devices and strongly encourages teachers to use them in class. Although this unique context enabled us to examine the effects of frequency of use on students' perceptions, the special characteristics of the sample makes these findings less generalizable to a larger sample. In addition, the student sample is limited to schools within one district in Korea; thus, the findings cannot be extrapolated to all students using mobile devices in class. Another limitation is that the results do not rule out the influence of other factors such as grade level, or subjects taught in class. A future study could be conducted with a more balanced sample of students in terms of grade level and school characteristics. Such a study could investigate differences in the relationships among frequency and students' perceptions of the use of mobile devices. Lastly, to develop a full picture of the factors influencing students' positive perceptions on the use of mobile devices and the relationship with their experience, additional studies with qualitative data are needed. For example, observation data revealing how teachers and students use the devices in class or qualitative data reflecting the quality of the instruction that utilizes the devices could be taken into account.

Overall, this study contributes to the field of educational technology by providing insights into the relationship between mobile device usage and students' perceptions. Specifically, the non-linear impact of frequent device use on students' positive perceptions highlights the need to consider the optimal level of device usage and the challenges students face in using them. Additionally, the study offers a tool for evaluating the multifaceted nature of student perception. By distinguishing between usefulness and convenience, it emphasizes the importance of separately considering both factors when assessing the effectiveness of mobile device usage in educational environments.

The results of this study imply that students who have difficulties in using devices would need more opportunities to become familiar with how to use them, considering that a lack of ability to use learning tools could have a negative influence on learning outcomes. Furthermore, teachers and schools should intentionally provide opportunities for students to be accustomed to using mobile devices for their learning. Such additional support would make the use of devices more equitable for all students in learning.

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