Educational Technology International
2023, Vol. 24, No 2, 263-293

https://doi.org/10.23095/ETI.2023.24.2.263

Examining High School Students' BYOD Use under Office of Education-led Policy: Insights from the Technology Acceptance Model*

Songhee KIM Jaejin LEE**
Korea National University of Education
Korea

Offices of Education in Korea is planning and implementing the BYOD (bring your own device) policy. In particular, the Seoul Metropolitan Education Office promoted the 'Dibud' (digital buddy) policy. Due to the relative newness of the policy, coupled with opposition from the council, it hasn't been fully implemented. This study focuses on a rare example of a high school that experienced BYOD under the Office of Education-led policy in all three grades. This study adapted key variables from the Technology Acceptance Model (TAM). The regression results showed that both perceived usefulness (PU) and perceived ease of use (PEOU) significantly influenced intention to use Chromebooks and students' perceived learning outcomes. Analysis of the open-ended questionnaires revealed that students perceived positive benefits from using Chromebooks, such as easier data retrieval, improved academic performance, and increased learning productivity. Although the majority of respondents said there were no negative aspects to Chromebooks, negative factors included non-academic use, wireless network inconvenience, and device performance issues. The results of this study can provide data and understanding for future BYOD policies, specifically Chromebooks.

Keywords : Office of Education-led BYOD policy, Chromebook, TAM

---

* This work is revised and updated from the presentation in the 2023 Annual Conference of Korean Educational Research Association.

** Corresponding author: Graduate School of Educational Policy and Administration, Korea National University of Education, jjlee@knue.ac.kr

Introduction

In February 2023, the Korean Ministry of Education announced a plan for digital-based education innovation. The policy includes AI digital textbooks, fostering leader teachers for digital classroom innovation, and digital leading schools (Korean Ministry of Education [MOE], 2023a), and a prerequisite for this is the distribution of 1:1 devices (BYOD). Although all 17 Offices of Education across the country are preparing and implementing various plans to distribute smart devices, there have been various issues in implementing the policy regarding the distribution and utilization of BYOD in education.

In the case of the Seoul Metropolitan Office of Education, the 'Dibud (Digital-Buddy)' policy to support BYOD was planned, disseminating devices to middle school and high school freshmen starting in 2022, but the budget was completely cut by the city council. A member of the Seoul Metropolitan Assembly's Education Committee raised the issue that the educational effectiveness of the Dibud policy has not been sufficiently verified, and concerns about internet addiction have been centered on the situation (Song & Yoon, 2022). As a result, though the city council partially passed the budget, the original policy plan to distribute the devices to high school students starting in 2023 has been stalled (Nam, 2023), and deployment for high school students remains unclear to date.

While it is important to obtain empirical evidence through the perceptions of students who have experienced educational office-led BYOD policy to support its validity, it is exceedingly difficult to find school-level examples of such policies due to their postponement. In this educational setting, it is essential to examine the empirical impacts of policy and educational pros and cons by prioritizing the perceptions of students who have personally undergone the BYOD policy. This approach is crucial in providing substantial evidence to aid in policy decision-making.

In this study, we aimed to empirically examine the rare case of high school students' perceptions of smart devices who experienced the BYOD policy led by the

Office of Education in all three grades. To accomplish this, we utilized the perceived ease of use (PEOU) and perceived usefulness (PU) variables of Davis' Technology Acceptance Model (TAM), which are frequently used to elucidate users' adoption of information technology (Kim et al., 2007). PU refers to the extent to which an individual believes that using a new technology can enhance their job performance while PEOU refers to the extent to which an individual believes that using a new technology does not require any additional effort (Venkatesh et al., 2003).

As for the independent variables, the core variables of TAM, PU, and PEOU, have been proven as antecedent factors influencing the acceptance of learning through technology (Granić & Marangunić, 2019). By analyzing these factors, TAM aims to understand user acceptance and predict whether individuals will continue to use a technology. Also, in the educational context, previous studies (Jeong & Cho, 2011; Kim, 2022; Mohammadi, 2015; Nugraha et al., 2022) have used TAM models to examine student learning outcomes. Therefore, given the context of this study and the fact that the students are students in the Office of Education-led BYOD policy, the dependent variables were set as intention to use (IU) and perceived learning outcomes (PLO).

It's also worth noting the characteristics of the Chromebooks distributed to high school students in the study. Chromebooks are laptop-like devices that run on Chrome OS and are cloud-based. They are suitable for educational use in several ways: access can be restricted to school Google accounts, only school-approved apps are installed, and they support multi-user logins. In particular, it can be used in conjunction with a learning platform called Google Classroom. Especially with the implementation of the BYOD policy led by the Ministry of Education in Korea, the share is expected to increase significantly (Kwon, 2022).

Given the current education policy trend, the anticipated increase in BYOD implementation led by the Ministry of Education, the adoption of Google Workspace by all 17 municipal education departments, and the worldwide popularity of Chromebooks as educational tools, this study could hold significant implications for

the policy of BYOD, especially Chromebooks, as it supplies practical findings on high school students who have been at the forefront for three successive years.

Therefore, this study merits investigation, and the research aims are as follows: Firstly, how do high school students' PU and PEOU of Chromebooks impact their perceived academic achievement and intention to use them? Secondly, what are the favorable and unfavorable factors of Chromebooks?

Theoretical Background and Hypothesis

Trends in South Korea's Office of Education-led BYOD Policy

BYOD, which stands for "Bring Your Own Device," is a term originally coined in the corporate context, where bringing one's device has resulted in increased productivity and reduced costs (Cheng et al., 2016). In other words, BYOD refers to the policy or practice of bringing and using one's own digital devices directly to a work or learning site, and in education, it is achieved by allowing students to bring their own electronic devices such as smartphones, tablet PCs, and laptops to school (Lim et al., 2014). The benefits of BYOD policies include not only cost savings, but also improved student academic achievement levels by enabling personalized and individualized learning, increased engagement, access to resources outside the classroom, expanded learning opportunities, facilitated collaborative activities, student monitoring, and increased communication between schools, students, and parents (Lim et al., 2014). In addition, Do and Kim (2021), who studied the domestic and international research trends of BYOD, identified the benefits as reducing the cost of using technology, applying various teaching strategies, promoting learner engagement, acquiring skills needed for the future society, accessing learning materials anytime and anywhere, improving responsibility for using digital devices, creating a personal learning environment, securing various communication channels,

motivating learning, supporting collaboration, and ensuring continuity of learning (Do & Kim, 2021).

The potential and challenges of BYOD in the field of education have received considerable attention in recent years (Cheng et al., 2016), especially as it is an essential prerequisite for the previously announced comprehensive plan for digital human resources development plan (Joint Report by Multiple Government Departments, 2022), and the digital-based education innovation plan (MOE, 2023a) as well as artificial intelligence (AI) digital textbooks (MOE, 2023b). In its 2023 Annual Work Report, the Ministry of Education announced that it will have a BYOD system by 2025 (MOE, 2023c). However, it is important to note that though policy support for BYOD adoption in South Korea is accelerating, it is somewhat different from BYOD in the educational context mentioned above, where students bring different types of devices as they are distributed by the school.

Seoul Metropolitan Office of Education's BYOD policy: 'Dibud.'

The 17 Offices of Education nationwide are presently devising and carrying out smart device deployment plans. The ratio of one device per student continues to increase gradually in each department. By 2023, the Ministry of Education anticipates an additional 900,000 devices supplied within the year, thereby achieving approximately 0.69 devices per student by year-end (MOE, 2023d). The Seoul Metropolitan Office of Education is implementing the "Dibud" policy, which aims to use smart devices in school education to innovate teaching and learning activities and lay the foundations for creating a new school culture. "Dibud" is a combination of the words "digital" and "bud(friend)" and means "smart devices are my digital learning friends". The name of the policy was selected through a public name contest for smart learning. According to the Smart Device Mobile Learning "Dibud" Plan released by the Seoul Metropolitan Office of Education, educational "smart devices" in this policy refer to educational devices with similar functions, such as tablet PCs

or laptops, that can be utilized for teaching and learning (Seoul Metropolitan Office of Education [SMOE], 2023).

The policy aims to support the development of effective teaching strategies and blended learning as a stable and reliable future education by utilizing digital technology; to create a democratic digital education environment that is "for all" and "for only one" where each student can participate in learning activities as a subject of education; to create a foundation for future education based on an intelligent learning management and efficient work management platform that provides individualized learning services through the use of various edtechs; and to support the fulfillment of educational responsibilities and faithful operation of curricula by strengthening online and offline connectivity amid digitally-driven social changes and climate and ecological environment changes (SMOE, 2023).

Five devices (Android-based Galaxy Tab, iOS-based iPad, Windows-based Surface, Chrome-based Chromebook, and Naver Whale-based Whalebook) were planned for distribution with school-chosen options (Lee & Seo, 2023). Schools that are part of the policy will have a choice of one of these devices, and devices of the chosen type are distributed uniformly. The device distribution started in 2022 for all first-year middle school students and 12 Hyukshin high schools[1)] and was planned to be expanded sequentially in line with the Ministry of Education's digital education innovation policy.

However, initially slated for implementation in 2022, the policy met with resistance from the city council, leading to a partial derailment of its preliminary plans. As the study unfolds in 2023, only first-year middle school students from the 2022 academic year and only 12 Hyukshin high schools have reaped the benefits of the policy. This scenario has resulted in a conspicuous lack of empirical precedent research regarding the deployment and utilization of digital devices within high school (or broader school) educational settings. However, according to the device distribution plan

1) Hyukshin high schools are schools that are intended to disseminate progressive and democratic practices in Seoul Metropolitan school district (Sung & Lee, 2018).

(figure 1), a substantial expansion in device dissemination is anticipated in Seoul, and research is expected to expand to explore and understand the implications of this policy.

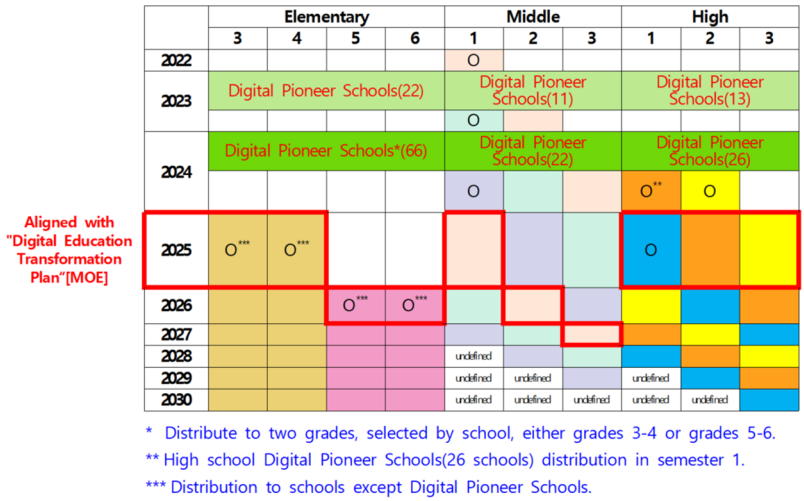

Figure 1. "Dibud" Distribution Plan (SMOE, 2023)

Main variables of the Technology Acceptance Model and its use in BYOD

The Technology Acceptance Model (TAM) is considered to be the most influential and commonly used theory to explain an individual's acceptance of information systems. First proposed by Davis (1986), TAM posits that an individual's acceptance of an information system is determined by two main variables: Perceived Usefulness and Perceived Ease of Use (Davis, 1986). The TAM is founded upon the hypothesis that technology acceptance and use can be explained in terms of a user's internal beliefs, attitudes, and intentions. As a result, it should be possible to predict future technology use by applying the TAM at the time that a technology is introduced. The original TAM gauged the impact of four internal variables upon the actual usage of the technology. The internal variables in the original TAM were perceived ease of use

(PEU), perceived usefulness (PU), attitude toward use (A), and behavioral intention to use (BI). The original TAM used BI as "both a dependent variable and an independent variable, with BI being used as a dependent variable to test the validity of PU and PEU variables and as an independent variable when predicting actual usage" (Turner et al., 2010, p. 464). The original model is shown in Figure 2.

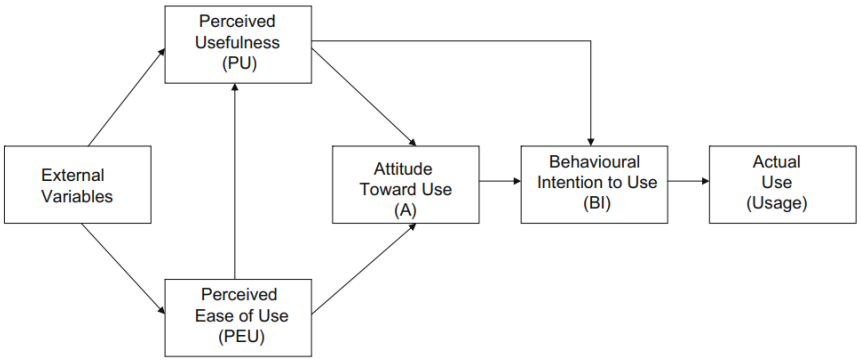

Figure 2. The original TAM model (Turner et al., 2010, p. 472)

The model has not remained in its original form but has continuously evolved. In a study of 101 TAM models from 1986 to 2003, Lee et al. (2003) reported four stages of evolution: Model Introduction-Model Validation-Model Extension-Model Elaboration. As such, the model of TAM is not static but constantly changing. In educational contexts, TAM is a leading scientific paradigm and a reliable model that facilitates the evaluation of various technology adoption, along with its variant model called TAM++, and its core variables, perceived ease of use and perceived usefulness, have been proven to be antecedent factors that influence the acceptance of learning through technology (Granić & Marangunić, 2019). Various models have been developed to explain technology acceptance, including TAM, and Venkatesh et al., (2003) synthesized them and proposed the Unified Theory of Acceptance and Use of Technology (UTAUT) model. The model suggests that there are three key factors that determine the intention to use (performance expectancy, effort expectancy, and social influence) along with two factors directly influencing usage behavior (intention

and facilitating condition) (Venkatesh et al., 2003).

Given the widespread use of the technology acceptance model, some studies have examined BYOD acceptance in education using variables from the TAM. The following studies have utilized the Technology Acceptance Model (TAM) to examine the acceptance of BYOD. First, Cheng et al. (2016) utilized two variables of TAM, perceived usefulness and perceived ease of use, to measure user acceptance of a BYOD learning environment through a pre-and post-test, and found that learners not only perceived the BYOD learning environment as useful and easy, but also reported that the learning environment enhanced their independence and agency (Cheng et al., 2016). Aggarwal et al. (2018) predicted university students' acceptance and utilization of BYOD based on TAM variables such as perceived ease of use, usefulness, and intention to use, and adopted the external variables of teacher influence, facilitating conditions, and peer influence to examine user acceptance. The results showed that these variables influenced BYOD acceptance and supported the traditional TAM model (Aggarwal, 2018). Both employed the Technology Acceptance Model (TAM) to validate that perceived usefulness, ease of use, and external factors like teacher and peer influence significantly affect the acceptance and utilization of BYOD in educational settings. The present study differs in that it examines a BYOD policy implemented by the Office of Education that distributes a single-device model to all students and examines its acceptability, thus providing a nuanced examination of technological acceptance in educational contexts.

Research hypothesis

This study aimed to conduct empirical scientific verification of the effects of students' perceived usefulness and perceived ease of use of Chromebooks on their intention to continue using the devices and perceived learning outcomes in relation to Chromebooks distributed to high school students. In particular, given the common use of PU and PEOU as independent variables in previous studies of BYOD in educational contexts using TAM, and the fact that these two variables have

been shown to be antecedents of technology-enhanced learning (Granić & Marangunić, 2019), we set them as independent variables in this study. For the dependent variables, we measured intentions to use (IU) as suggested by the original technology acceptance model, and outcome expectations as proposed by Venkatesh et al. (2003), adapted to the educational context and modified as perceived learning outcomes (PLO). We set up a research model as shown in Figure 3, centered on the research problem, and set up four research hypotheses centered on the relationship between the variables in the research model.

H1. PU will have a positive effect on intention to use.

H2. PU will have a positive effect on perceived learning outcomes.

H3. PEOU will have a positive effect on intention to use

H4. PEOU will have a positive effect on perceived learning outcomes.

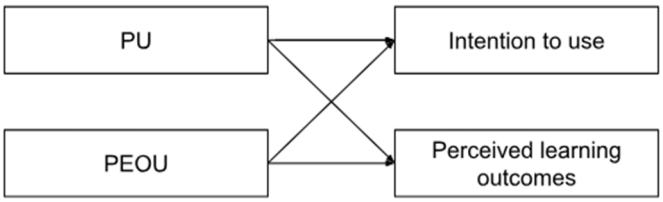

Figure 3. Research Model

Research Methodology

Research Context

The high school in the study is a school that has continuously experienced the BYOD policy led by the Office of Education. In 2021, Chromebooks were distributed to all first-grade students(n=160) via the Online Content Leader School policy (MOE), and then in 2022, Chromebooks were distributed to all incoming students(n=160) through the Dibud policy (SMOE), as this school was one of the

12 Hyukshin high schools in Seoul. The devices in 2022 were distributed only to first graders in middle school, but this high school was one of 12 Hyukshin schools that benefited from the policy in advance. In 2023, the Dibud policy was not implemented in high schools due to the Seoul City Council's budget cut, but the Chromebooks of the third-grade students in 2023 were collected and distributed to the incoming students of 2023. As of 2023, all three grades have experienced the BYOD policy and have used their Chromebooks for a minimum of six months and a maximum of two years. In addition to the use of Chromebooks, Google Classroom is actively used all subjects. All students and teachers have been issued Google accounts via Google Workspace, which is continuously used throughout the school years. Students and faculty members interact with each other through Google Chat, which is a messaging tool from Google Workspace. The school is a good candidate for the study due to its full utilization of Chromebooks with these tools.

Participants

This study distributed questionnaires to all students in a general education high school that had experienced BYOD policies in all three grades, including the Seoul Metropolitan Office of Education's BYOD policy (Dibud). In the end, 367 respondents out of 447 students at the high school participated in the survey for statistical analysis. By gender, 196 male students accounted for 53.41% of the total respondents, while 171 female students accounted for 46.58%. By grade level, 145 first graders participated in the survey, followed by 125 second graders, and 97 third graders. As this is a survey about students' experience of using Chromebooks, which are provided to students individually, we did not analyze the data by grade level, but by combining all students from 1st to 3rd grade.

Table 1
Analysis of survey respondents(n=367)

Basic information	Gender		Grade			Total
	Male	Female	1	2	3	
	196 (53.41%)	171 (46.59%)	145 (39.51%)	125 (34.06%)	97 (26.43%)	367 (100.00%)
Key utilized devices	Chromebook	Smartphone	Tablet	Laptop	Other	
	311 (84.74%)	9 (2.45%)	95 (25.88%)	17 (4.64%)	9 (0.00%)	

In terms of device usage, nearly 85% of participants reported that their current Chromebooks are the primary device used by their students, along with students using tablet devices such as Galaxy Tabs and iPads in class. Conversely, less than 5% of students use smartphones or personal laptops.

Measurement Tools

The devices used in this study to explore the acceptance of BYOD policies are Chromebooks. We used key variables from TAM to explore the acceptance of the device. Two independent variables are PU and PEOU, and the dependent variables are IU and PLO. Given that the technology acceptance model (TAM) is influential in analyzing individuals' acceptance of information systems, with its core variables, perceived ease of use and perceived usefulness, proven to be antecedent factors that affect the acceptance of learning through technology (Granić & Marangunić, 2019), our study was inspired on this model. Kim (2022)'s measurement tool, which assessed the relationship between the perceived usefulness, perceived ease of use, intention to use, and learning utilization of smart learning devices recognized by college students, was adapted to this study's variables.

With the proliferation of mobile devices, advancements in web technology, and the increasing use of cloud computing, there is a demand for an internet-based web

operating system that is not reliant on the device. Chromebook fills this gap by serving as an internet-enabled terminal optimized for cloud environments. Developed by Google, the Chromebook is a convertible laptop that runs a web operating system. It features a keyboard and supports touchscreen functionality. It has the benefit of storing and sharing cloud-based data. In contrast to desktops, it boots up rapidly, around 7 seconds, and users log in using their registered Google account (Yoon & Lee, 2018). Multi-user access on the same device via Google account makes Chromebooks ideal for the school environment, where a small number of teachers must manage a large number of devices. If a user logs out of the device and another user logs in with their Google account, the cloud-based nature of the device ensures that the device's settings will correspond with the newly logged-in user's settings. According to Google for Education, Chromebooks offer benefits in collaboration, user-friendliness, adaptability, and security (Google for Education, 2023).

Figure 4. Samsung Galaxy Chromebooks distributed by Dibud Policy

Although this previous study targeted college students, we found Kim (2022)'s measurement tool analyzing the structural connections among perceived usefulness, ease of use, intention to use, and learning utilization of smart learning devices via TAM's core variables, to be relatively consistent with this study's context, as this study looked at the acceptance of BYOD by high school students. In particular, the study's inclusion of the variable of learners' learning utilization to promote the adoption of smart learning devices is noteworthy. What distinguishes this study from

others is the addition of a learning use variable to the core variables of the technology acceptance model (Kim, 2022). The survey questions of the technology acceptance model's core variables (PU, PEOU, and IU) presented by Kim (2022) were modified to be suitable for high school students. The variable of 'learning utilization', motivated by Venkatesh et al. (2003), was adapted to the educational context and modified as perceived learning outcomes(PLO). The questionnaire was created with a 5-point scale per question. In addition, open-ended questions were used to collect qualitative results. The open-ended questionnaires consisted of questions about the positive and negative factors of utilizing Chromebooks.

First, we used a modified version of Venkatesh and Davis's measurement tool (Venkatesh et al., 2003) for Perceived Usefulness (PU). Perceived usefulness is defined as "the degree to which a person believes that using a particular system would enhance his or her job performance" (Davis, 1989, p. 320). The usability of Chromebooks consisted of four items: overall learning, learning speed, learning productivity, and opportunity provision.

Second, perceived ease of use (PEOU) refers to "the degree to which a person believes that using a particular system would be free of effort." This follows from the definition of "ease": "freedom from difficulty or great effort" (Davis, 1989, p. 320). Based on the factor and the adapted measurement tool mentioned above, we measured the perceived ease of use of Chromebooks. The Chromebook's perceived ease of use consisted of four items to measure communicability, proficiency, ease of learning, and device comfort.

Third, we measured whether students intended to continue using Chromebooks in the future. According to TAM, one's actual use of a technology system is influenced directly or indirectly by the user's behavioral intentions, attitude, and perceived use of the system (Park, 2009). Given this point, to measure students' behavioral intentions on Chromebooks, we set variables for intention to use Chromebooks. It consisted of three items: intention to use Chromebooks, predicted use, and planned use.

Table 2

Questions of the measurement tool

category	the content of the question
PU	Using Chromebooks, you will learn more effectively.
	The use of Chromebook is improved by improving the productivity of learning.
	Learning through Chromebooks makes understanding of learning faster.
	I think Chromebooks are useful for learning.
PEOU	I can learn easily through Chromebooks.
	Learning through Chromebooks is convenient.
	When learning through the Chromebook, it is easy to know the contents of the learning.
	I can quickly get the necessary learning information through the Chromebook.
IU	I am willing to use Chromebook for future learning.
	I am expected to learn using Chromebooks in the future
	I have a plan to learn using Chromebooks in the future.
PLO	I think learning using Chromebooks helps improve grades.
	Learning ability was improved by utilizing Chromebooks.
	I feel like I'm achieving something by learning using Chromebooks.
	I gained confidence in learning by using Chromebooks.
Open-ended survey	1) Please tell us what you like about using Chromebooks in class 2) If you don't like using Chromebooks or don't think they help you learn, please tell us why

Fourth, given that this study was conducted in the context of education, we changed the term "outcome expectations" (Venkatesh et al., 2003, p. 448) to "perceived learning outcomes". A common method for measuring outcomes involves asking students' evaluations of their learning achievements across various

variables, which can frequently fall within distinct dimensions such as knowledge, overall competence, and skills (Caspersen et al., 2017), and adapted to measure students' perceived learning outcomes in the context of education. The survey items consisted of grade improvement, learning ability improvement, achievement level, and learning confidence.

In addition, open-ended survey questions were given out to further explore the factors of Chromebook acceptance as perceived by the students. The open-ended questionnaire consisted of two sections: please tell us what you like about using Chromebooks in class, and if you don't like using Chromebooks or don't think they help you learn, please tell us why.

Data Analysis

Multivariate regression was conducted to comprehensively verify the relationship between the independent and dependent variables used in the study, and the SPSS 23 package was used for statistical analysis. There are 447 students enrolled in this high school, and the data of 367 students who responded to the survey were used for statistical verification.

The open-ended questionnaires collected through the survey were interpreted using inductive content analysis, a qualitative research method. First of all, content analysis is a "summarizing, quantitative analysis of messages that relies on the scientific method and is not limited to the types of variables that may be measured or the context in which the messages are created or presented" (Neuendorf, 2002, p. 23). Content analysis is a method that may be used with either qualitative or quantitative data; furthermore, it may be used in an inductive or deductive way. If the researcher has chosen to use inductive content analysis, the next step is to organize the qualitative data. This process includes "open coding, creating categories, and abstraction" (Elo & Kyngäs, 2008, p. 109). The analysis program was Excel, and the survey responses were read several times to identify common categories by the researcher, which were then categorized and agreed upon with a co-researcher.

Results

Reliability of measurement tools

The reliability analysis results for the measurement tools are presented in Table 3. The high internal consistency of the constructs, as demonstrated by their respective Cronbach's Alpha coefficients, supports the reliability of the measurement tools used in the study. Perceived Usefulness (PU) with a reliability of α=0.915 indicates items that effectively measure the concept of perceived usefulness. Perceived Ease of Use (PEOU) has a reliability of α=0.911 and reflects a consistent understanding and perception of the technology's ease of use among participants. Intention to Use (IU) has a reliability of α=0.959 and identifies particularly strong cohesion in items measuring the intention to use the technology. Finally, Perceived Learning Outcomes (PLO) assesses the respondents' perception of learning outcomes. α=0.940, indicating a dependable measure of the perceived educational advantages obtained from employing the technology. To summarize, all constructs showed a high degree of internal consistency, thereby highlighting the reliability of the measuring devices and instilling trust in the accuracy and resilience of the instruments utilized in the investigation.

Table 3
Reliability of Measurement Tools

Variables	PU	PEOU	IU	PLO
Cronbach's α	0.915	0.911	0.959	.0.940

Correlation and multivariate regression results between variables

The means and standard deviations for each variable used in the data analysis were 3.90 (SD=0.89) for PU, 4.12 (SD=0.78) for PEOU, 4.07 (SD=0.99) for IU, and 3.58

(SD=1.03) for PLO. However, their correlations were relatively high (r=0.81 to 0.71). These findings are typical of the TAM model and should be interpreted with caution.

Table 4
Correlation between variables

Variables	M	SD	1	2	3
PU	3.90	.89			
PEOU	4.12	.78	.812**		
IU	4.07	.99	.714**	.751**	
PLO	3.58	1.03	.785**	.728**	.740**

** Correlation is significant at the 0.01 level (two-sided).

To test the hypotheses, we conducted a multivariate regression analysis with the perceived usefulness (PU) and perceived ease of use (PEOU) of Chromebooks proposed in the research model as independent variables and the intention to use (IU) Chromebooks and perceived learning outcomes (PLO) as dependent variables. The model fit (Pillai's trace, Wilks' lambda, Hotelling's trace, and Roy's maximum root) showed that the research models utilizing perceived usefulness and perceived ease of use were all significant ($p<.001$).

In particular, perceived usefulness (PU) is a significant predictor of both intention to use and academic achievement, with PU explaining 7% of intention to use (IU) and 23% of perceived learning outcomes (PLO). On the other hand, perceived ease of use (PEOU) explains 17% of intention to use (IU) and 6% of perceived learning outcomes (PLO), indicating that both independent variables are positive predictors of both dependent variables, but in opposite ways. Finally, the two independent variables explain 59% of the variance in intention to use (IU) and 64% of the variance in perceived learning outcomes (PLO). Therefore, based on the results of the multivariate regression analysis, research hypotheses 1-4 are accepted.

Table 5

Multivariate regression results for IU and PLO

Category		Type III Sum of Square	Degrees of freedom	Mean Square	F	P-value	Partial Eta Squared
Adjusted Model	IU	214.902a	2	107.451	268.718	0.000	0.596
	PLO	253.119b	2	126.560	324.775	0.000	0.640
Intercept	IU	0.245	1	0.245	0.614	0.434	0.002
	PLO	2.391	1	2.391	6.135	0.014	0.017
PU	IU	11.409	1	11.409	28.531	0.000	0.072
	PLO	43.603	1	43.603	111.893	0.000	0.235
PEOU	IU	31.068	1	31.068	77.696	0.000	0.176
	PLO	9.459	1	9.459	24.274	0.000	0.062
Estimate	IU	145.951	365	0.400			
	PLO	142.234	365	0.390			
Total	IU	6470.157	368				
	PLO	5132.560	368				
Adjusted Total	IU	360.853	367				
	PLO	395.354	367				

a. R-squared = .596 (corrected R-squared = .593), b. R-squared = .640 (corrected R-squared = .638)

Inductive content analysis of positive factors in Chromebooks

A total of 315 open-ended questionnaire responses were analyzed, excluding those that participants responded to dishonestly or did not respond, and the results are shown in Table 6, arranged by the frequency of responses in each category. The inductive content analysis revealed that participants' perceived outcomes were mostly related to perceived usefulness, which is consistent with the findings of quantitative research that perceived usefulness explains academic achievement more than perceived ease.

The most frequent outcome from the inductive content analysis was easy and fast data search, with 89 responses (28%). In terms of learning outcomes, two categories emerged: improvement in learning outcomes (53 responses, 17%) and improvement in learning productivity (42 responses, 13%). What was particularly impressive was that learners perceived the change in learning style with Chromebooks to be interesting and meaningful, and a refreshing change from the traditional rigid classroom environment. Improvement in learning productivity was related to the hardware characteristics of Chromebooks, being shaped like laptops, having a larger screen than smartphones and tablets, and having an integrated keyboard, which makes it easier to create documents and presentations.

While respondents did not provide specific reasons regarding the usefulness of Chromebooks, 50 responses (16%) indicated that Chromebooks are generally useful. This factor can be interpreted as encompassing elements of both perceived ease and perceived ease of use. The following factors are improvement of collaboration and communication (29, 9%), ensuring continuity of learning (27, 9%), and preference for Chromebook features (21, 7%). There were also 9 responses (3%) that did not fall into any of the categories. Improvement of collaboration and communication includes both teacher-to-student and student-to-student communication. These characteristics correlate with the characteristics of the school in the study, which heavily utilizes Google Classroom, Google Chat, Google Docs, and various types of shared documents when using Chromebooks. All of the school faculty members and students in this high school have been given Gmail ID via Google Workspace, which allows them to talk to anyone in the school using a messenger service called Google Chat by just typing in their name.

Lim et al. (2014) set out the positive factors of BYOD derived from analyzing domestic and international cases. These factors are academic achievement, cost reduction, digital literacy acquisition, increased communication, resolution of psychological inequality, and resolution of functional inequality, which are mostly consistent with the results of the open-ended survey above. In particular, the study

Table 6

Inductive content analysis of positive factors in Chromebooks

Major Responses	Category	Counts
It is very convenient because it is easy to search for data and you can display various screens	Easy and fast data search	89(28%)
Unlike using a personal device, it was a device distributed by the school for public use, so it could be used only for learning.	Improvement in learning outcomes	53(17%)
(majority of responses) It is comfortable & useful	Useful and easy to use in general	50(16%)
It was nice to be able to quickly and effectively create presentations on the spot when looking for materials or making presentations on my Chromebook. In the past, if you didn't have a Chromebook, it was almost impossible to get credit for the next day's performance unless you made it at home the day before, but now you can improvise because you don't have to make the presentation the day before.	Improvement of learning productivity	42(13%)
It was good that it was efficient that I could share it with my teacher and give feedback on my work in real-time.	Improvement of collaboration and communication	29(9%)
When I was in middle school, it was a little uncomfortable because I brought electronic devices myself or taught on my cell phone, but I always had a Chromebook, so it was convenient to use it in any class.	Ensuring Continuity of learning	27(9%)
It was useful for searching for data and watching video media by connecting AirPods or Earbuds through Bluetooth. I think it was as convenient and efficient as it had a pressurized keyboard and a screen touch	Preference for Chromebook features	21(7%)
compatible with other ed-tech tools, solves device inequality, etc	Other	9(3%)

identified the following factors as contributing to the improvement in academic achievement: first, unlike traditional lecture-based teaching methods, the implementation of a BYOD policy provides a variety of learning methods; second, it

allows learners to participate in learning as agents of their learning; third, while traditional classes are limited to the classroom, classes with BYOD can utilize a wider range of resources based on the Internet network; fourth, it allows students to overcome time and space constraints, learning can be done anytime, anywhere, overcoming time and space constraints; fifth, information sharing, discussion, and collaboration through common tasks; and sixth, teachers can check learning status by utilizing a learning management system. All of these factors are consistent with the results of the inductive research analysis of the open-ended survey. In particular, the response that having the same device in class created an atmosphere where everyone participated together, is consistent with the aspect of reducing psychological inequality derived from the above categories. And unlike other BYOD situations, this can be interpreted as a benefit of the BYOD policy led by the Office of Education.

Inductive content analysis of negative factors in Chromebooks

The open-ended question was answered by all respondents (n=367), with 269 students (73%) saying that using Chromebooks does not hinder their learning. Next, 66 students (18%) said that they use their Chromebooks for non-academic purposes. Most of these respondents said they frequently saw students playing games and watching YouTube in class. They also reported using Google Chat to chat with others and watch class-unrelated videos. Most importantly, students reported that distractions from other students on their Chromebooks interfered with their ability to focus on learning. Poor Wi-Fi connectivity and slow device performance were also reported by 17 (5%) and 13 (4%) students, respectively. The results of the inductive content analysis of the open survey responses are shown in Figure 5.

Two open-ended survey responses were not included in the above categories. First, there were two responses from students who reported that their teachers' excessive reliance on their smartphones led to poorer learning outcomes due to less information available to the teacher, and a response from a student who reported a

gap between those with good computer skills and those without. This phenomenon can be described as a digital divide, which supports the research of (Gabriel et al., 2022) that the implementation of BYOD can solve this problem, but at the same time, it can deepen existing inequalities as a downside.

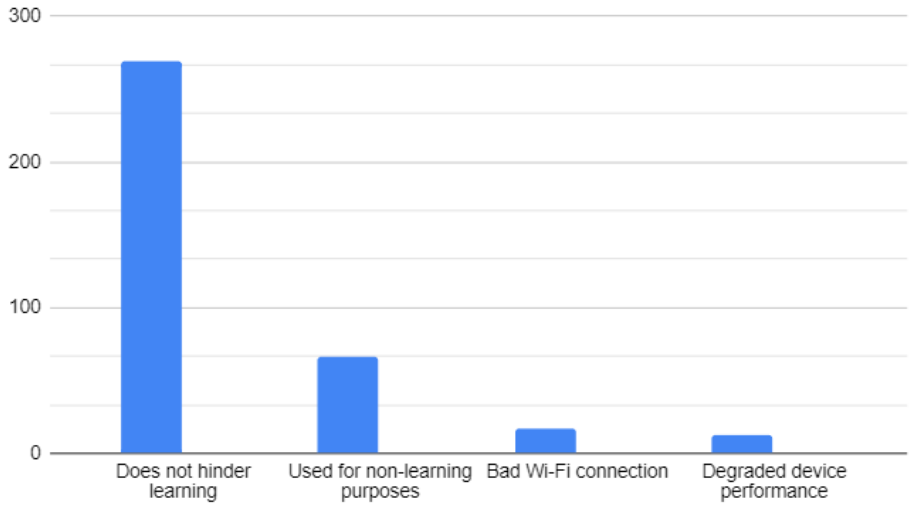

Figure 5. Reasons for non-preference of Chromebooks (Open-ended)

Discussions and Implications

The findings of the study show that both independent variables, PU and PEOU are positive predictors of both dependent variables, IU and PLO. Specifically, the two independent variables explain 59% of the variance in intention to use (IU) and 64% of the variance in perceived learning outcomes (PLO). This suggests that for BYOD policies to be effectively embedded and implemented in schools, educators and policymakers need to consider the perceived usefulness of the device and how to increase its perceived ease of use. Although this study focused on Chromebooks, it is worth exploring whether the same findings apply to other devices. Further

research is needed to identify the factors that contribute to the effective adoption of not only Chromebooks but also other devices introduced through BYOD policies. To maximize the effectiveness of the BYOD policy, it is essential to promote device training and increase the perceived usefulness and ease of use for teachers along students. It is also necessary to disseminate teachers' expertise, particularly regarding improved learning outcomes, and offices of education should propose a plan for sharing and collaborating on classroom cases, in addition to distributing devices. Given the sharing and collaboration-friendly nature of the web cloud-based features, this should be rather easy to accomplish.

In particular, perceived usefulness (PU) is a significant predictor of both intention to use and academic achievement, with PU explaining 7% of intention to use (IU) and 23% of perceived learning outcomes (PLO). On the other hand, perceived ease of use (PEOU) explains 17% of intention to use (IU) and 6% of perceived learning outcomes (PLO), indicating that both independent variables are positive predictors of both dependent variables, but in opposite ways. These results suggest that while both perceived usefulness and ease of use are important factors in determining students' intention to use Chromebooks, they have different effects on academic achievement. Therefore, educators and policymakers should consider the relative importance of these factors when implementing BYOD policies in schools.

Another implication of the study's findings is that the use of Chromebooks may have a positive impact on students' academic achievement. The study found that the perceived usefulness of Chromebooks was a significant predictor of academic achievement, and the results of the open-ended survey are in line with the results. Future research should investigate the specific mechanisms through which Chromebooks affect academic achievement, the extent to which specific educational gains were made, what factors mediated them, and how the lessons were designed to trigger them.

Notably, a very large number of respondents (73%) to the open-ended survey said that Chromebooks were not a barrier to learning. This raises the possibility that

current media reports and city council arguments against the policy, that the devices are a barrier to learning, may not be a true reflection of the actual educational environment. Nevertheless, it is worth noting that 18% of respondents (n=66) reported using or witnessing devices for non-learning purposes. In particular, watching videos and playing games in class was reported as being shared with other learners. The content analysis results are in line with previous research (Lim et al., 2014) on negative factors (learning disruption, infrastructure, and network issues), and educational offices should consider improving this aspect of their BYOD policy for future developments.

However, we suggest improvements that can be implemented immediately at the school level. It can be assumed that the disadvantages mentioned above are more pronounced in lecture-style teaching, where the teacher is in front of the class and cannot see the students' screens. Previous research has shown that the use of smart devices is limited to some activities in the course of specific curriculum development, and not in all subjects and class periods (Lee & Suh, 2023). Therefore, it is assumed that the aforementioned inhibiting factors are mainly manifested in teacher-based lecture classes, and it is essential to design and change the relevant teaching methods when using devices.

Office of Education-led BYOD policy has already begun and will continue to spread. However, it is important to recognize that the mere proliferation of devices can also serve as a precondition for widening the digital divide, as evidenced in this study, by Chromebooks being used for non-learning purposes or acting as a distraction from learning. Given that this study suggests that both PU and PEOU are associated with actual use and perceived learning outcomes, policymakers and teachers using them in the classroom need to empirically identify how BYOD is useful and facilitative. Various approaches can be considered, including device-specific training, facilitating teacher user groups per device, and training in partnership with device provider big-tech groups.

The significance of this study is that it examines intention to use and perceived

learning outcomes using variables from TAM, to learners who have experienced three consecutive years of educational office-led BYOD policy, which is extremely difficult to find now. Given the current trends in education policy, such as digital education transformation and AI textbooks, as well as the massive technological innovation unleashed by generative AI, adopting BYOD is not an option, but a necessity. Despite these trends, there is a lack of research based on learners who have directly experienced the policy. This study can be used as the basis of a scale to evaluate the operationalization of future BYOD policies, particularly the introduction of Chromebooks in schools.

Limitations and future research

Although this study was conducted on high school students who experienced an Office of Education-led BYOD policy (Dibud) in all three grades, which is rare to find at this time. The study was conducted in a single school and should be interpreted with limitations based on the different contexts. The study is also based on self-reported data, which may be subject to response bias and social desirability bias. Regarding the variable of perceived learning outcomes, future studies should compare empirical academic outcomes across groups to explore how the use of devices, especially Chromebooks affected learning outcomes.

In addition, to overcome the limitations of quantitative analysis, this study used inductive content analysis, which is one of the qualitative analysis methods, but due to the nature of the open-ended questionnaire, responses were short or did not prompt further questions. Therefore, future research should adopt a mixed methods approach to empirically explore the effectiveness of BYOD, specifically Chromebooks, and use qualitative research methods such as interviews and observations to explore what points are perceived as useful and easy, and how the actual use of the device affects the intention to use and perceived learning outcomes.

References

Aggarwal, D. (2018). Using the technology acceptance model to understand the use of bring your own device (BYOD) to classroom. *Journal on Today's Ideas-Tomorrow's Technologies*, *6*(2), 83-91. https://doi.org/10.15415/jotitt.2018.62007

Caspersen, J., Smeby, J.-C., & Olaf Aamodt, P. (2017). Measuring learning outcomes. *European Journal of Education, 52*(1), 20-30. https://doi.org/10.1111/ejed.12205

Cheng, G., Guan, Y., & Chau, J. (2016). An empirical study towards understanding user acceptance of bring your own device (BYOD) in higher education. *Australasian journal of educational technology*, *32*(4). https://doi.org/10.14742/ajet.2792

Davis, F. D. (1985). A technology acceptance model for empirically testing new end-user information systems: Theory and results [Unpublished doctoral dissertation]. Massachusetts Institute of Technology.

Davis, F. D. (1989). Perceived usefulness, perceived ease of use, and user acceptance of information technology. MIS *Quarterly*, *13*(3), 319-340. https://doi.org/10.2307/249008

Do, J., & Kim, S. (2021). Exploring the research trend and concept of BYOD for the use of BYOD as a teaching strategy for school classes with protracted COVID-19. *Journal of Field-based Lesson Studie*s, 2(1), 1-21. https://doi.org/10.22768/JFLS.2021.2.1.1

Elo, S., & Kyngäs, H. (2008). The qualitative content analysis process. *Journal of Advanced Nurs*ing, 62(1), 107-115. https://doi.org/10.1111/j.1365-2648.2007.04569.x

Gabriel, F., Marrone, R., Van Sebille, Y., Kovanovic, V., & de Laat, M. (2022). Digital education strategies around the world: Practices and policies. *Irish Educational Studies, 41*(1), 85-106. https://doi.org/10.1080/03323315.2021.2022513

Google for Education. (2023). *Explore Chromebooks for schools*. Google for Education. https://edu.google.com/intl/ALL_kr/chromebooks/overview/

Granić, A., & Marangunić, N. (2019). Technology acceptance model in educational context: A systematic literature review. *British Journal of Educational Technology*, *50*(5), 2572-2593. https://doi.org/10.1111/bjet.12864

Jeong, H., & Cho, W. G. (2011). The effect of perceived usefulness and perceived ease of use on web based distance learning: Focused on Korean high school students. *The e-Business Studies*, *12*(2), 255-272. https://doi.org/10.15719/geba.12.2.201106.255

Joint Report by Multiple Government Departments. (2022, September 15). *Digital Human Resources Development Comprehensive Plan 2022*.

Kim, D. (2022). The Structural Relationship among the Usefulness, Ease of Use, Intention to Use, and Learning Utilization of Smart Learning Devices Recognized by College Students. *The Journal of the Korea Contents Association, 22*(9), 667–677. https://doi.org/10.5392/JKCA.2022.22.09.667

Kim, H., Chan, H., & Gupta, S. (2007). Value-based adoption of mobile internet: An empirical investigation. *Decision Support Systems, 43*(1), 111-126. https://doi.org/10.1016/j.dss.2005.05.009

Korean Ministry of Education. (2023a). *Digital based education innovation*. https://www.moe.go.kr/boardCnts/viewRenew.do?m=060209&s=moe&page=1&boardID=409&boardSeq=94072&lev=0&opType=N

Korean Ministry of Education. (2023b). *Artificial intelligence (AI) digital textbooks usher in the era of 1:1 personalized education.* https://www.moe.go.kr/boardCnts/viewRenew.do?boardID=294&boardSeq=95261&lev=0&searchType=null&statusYN=W&page=1&s=moe&m=020402&opType=N

Korean Ministry of Education. (2023c). E*ducation reform, the beginning of Korea's Rebirth-Ministry of Education annual work report 2023* -. https://www.moe.go.kr/boardCnts/viewRenew.do?boardID=294&boardSeq=93596&lev=0&searchType=null&statusYN=W&page=1&s=moe&m=020402&opType=N

Korean Ministry of Education. (2023d). *The landscape for digital device distribution for digitally enabled education transformation is improving.* https://www.moe.go.kr/boardCnts/viewRenew.do?boardID=295&boardSeq=94527&lev=0&searchType=null&statusYN=W&page=1&s=moe&m=020401&opType=N

Kwon, B. (2022). The Chromebook boom is over...but shipments are starting to fall. *ZDNET Korea.* https://zdnet.co.kr/view/?no=20220217143322

Lee, J & Seo, S. (2023). Settlement of the smart device mobile learning policy in the classroom. *Korean Education Inquiry, 41*(2), 33-57. https://doi.org/10.22327/kei.2023.41.2.033

Lee, Y., Kozar, K. A., & Larsen, K. R. (2003). The technology acceptance model: Past, present, and future. *Communications of the Association for information systems*, *12*(1), 50. https://doi.org/10.17705/1CAIS.01250

Lim, G., Jang, Y., & Lee, E. (2014). Research on BYOD (Bring Your Own Device) policy guidelines with the extension of the "SMART Education" in Korea based on the analyses of the U.S. cases. *Journal of Digital Convergence, 12*(7), 21-36. https://doi.org/10.14400/JDC.2014.12.7.21

Mohammadi, H. (2015). *Factors affecting the e-learning outcomes: An integration of TAM and IS success model.* Elsevier. https://doi.org/10.1016/j.tele.2015.03.002

Nam, J. W. (2023, March 17). City Council cuts budget—Seoul high school students won't get smartphones this year. *The Kyunghyang Shinmun.* https://m.khan.co.kr/article/202303171824011

Neuendorf, K.A. (2002). *The Content Analysis Guidebook.* SAGE. https://us.sagepub.com/en-us/nam/the-content-analysis-guidebook/book234078

Nugraha, U., Ekawarna, E., Ali, M., & Adhanegara, T. A. (2022). The effect of teachers' perceptions of the TAM learning model seen on the student's learning outcomes in high school. *Jurnal Keolahragaan, 10*(2), 282-291. https://doi.org/10.21831/jk.v10i2.47810

Park, S. (2009). An analysis of the technology acceptance model in understanding university students' behavioral intention to use e-learning. *Journal of Educational Technology* & *Society, 12*(3), 150–162.

Seoul Metropolitan Office of Education[SMOE]. (2023). *2023 middle school smart device mobile learning "Dibud" basic plan.*

Song, B., & Yoon, Y. (2022). Playing mobile games, watching YouTube... Parents complain about "Dibud."*ChosunBiz*. https://cbiz.chosun.com/svc/bulletin/bulletin_art.html?contid=2022070501612

Sung, Y., & Lee, Y. (2018). Politics and the practice of school change: The Hyukshin school movement in South Korea. *Curriculum Inquiry, 48*(2), 238-252. https://doi.org/10.1080/03626784.2018.1435976

Turner, M., Kitchenham, B., Brereton, P., Charters, S., & Budgen, D. (2010). Does the technology acceptance model predict actual use? A systematic literature review. *Information and software technology, 52*(5), 463-479. https://doi.org/10.1016/j.infsof.2009.11.005

Venkatesh, V., Morris, M. G., Davis, G. B., & Davis, F. D. (2003). User acceptance of information technology: Toward a unified view. *MIS Quarterly*, 425-478. https://doi.org/10.2307/30036540

Yoon, Y., & Lee, S. (2018). The study on forensic techniques of Chromebook. *Journal of Digital Forensics, 12*(3), 55–69. https://doi.org/10.22798/KDFS.2018.12.3.55

Songhee Kim
Teacher, Hankook Sahmyook High School
Doctoral Student, Depart of Educational Policy, Korea National University of Education
Interests: BYOD, Chromebooks, AIED, EdTech, Digital-based learning innovation
E-mail: t07@sahmyook.hs.kr

Jaejin Lee
Assistant Professor, Depart of Educational Policy, Korea National University of Education
Interests: Learning technologies, Game-based learning, Policy for future education environment, Virtual learning environment
E-mail: jjlee@knue.ac.kr

Received: September 13, 2023 / Peer review completed: September 24, 2023 / Accepted: October 9, 2023