# Evaluating Teachers’ Perceptions on the Effectiveness of Google Solutions

2021. 8.

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# Abstract

❍ With the development of technology, the integration of ICT into school classes is expected to significantly improve the quality of education. Accordingly, this research tried to explore the educational benefits of Google Solutions when used in classes of a middle school in Korea and to seek improvement points for optimizing the use of classroom technology.

❍ Teachers with various subjects, work experiences, and technology use levels, and second-grade students in a middle school used Google Solutions in their classes, and then they were surveyed and interviewed. in order to investigate changes in their perceptions.

❍ The research results show that Google Solutions helped teachers in terms of time efficiency in work and teaching activities, brought positive changes to students' learning activities, and effectively supported class management, feedback and communication.

❍ There were, however, still barriers for the application of Google Solutions, such as additional workload such as device management, unintentional distraction and novelty effect, and the incompatibility with HWP documents of Korea.

❍ The possibility of using technology such as Google Solutions in classes was confirmed, and the direction for improvement was suggested to overcome the barriers to using technology in classes.

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# I. Introduction

The aim of this research is to explore the educational benefits of Chromebooks and Google Workspace for education (hereinafter called Google Solutions) when applied in Korean classroom settings. Google Solutions is a generic term for Google Chromebook, a laptop-type mobile device equipped with Chrome OS, and Google Workspace for Education, which provides cloud-based software (e.g. Google Classroom, Google Drive, Google Docs, Google Spreadsheet). By using Google Solutions, teachers and students can easily access Google apps through Chromebooks. Also, teachers can provide students with immediate monitoring and feedback, thereby achieving an effective one-on-one learning environment based on ICT. The previous studies of classes integrated with technology have focused mainly on the learner aspects, such as their academic achievements and learning attitudes (Hussaini et al., 2020; Iftakhar, 2016; Wang, Yang, & Chen, 2020). However, changes in the attitudes and perceptions of teachers using ICT are the key factor that can lead to changes in the overall educational environment together with changes in learner aspects. Therefore, this research aims to focus on changes in teachers' perceptions in applying ICT in classes. A pre-survey was conducted on teachers' responses, perceptions, and attitudes to classes using ICT. After conducting the pre-survey, teachers and students started to use Google Solutions in both online and offline classes, and then teachers' perceptions were investigated. This research intended to identify the positives and obstacles to the use of Chromebooks in classes based on the teachers' perceptions changed through the experience of using Google Solutions. The two detailed research questions are as follows.

First, is there any change in teachers' perceptions of classes using Google Solutions?

Second, what is the teacher's opinions on the merits and improvements of classes using Google Solutions?

## II. Theoretical background

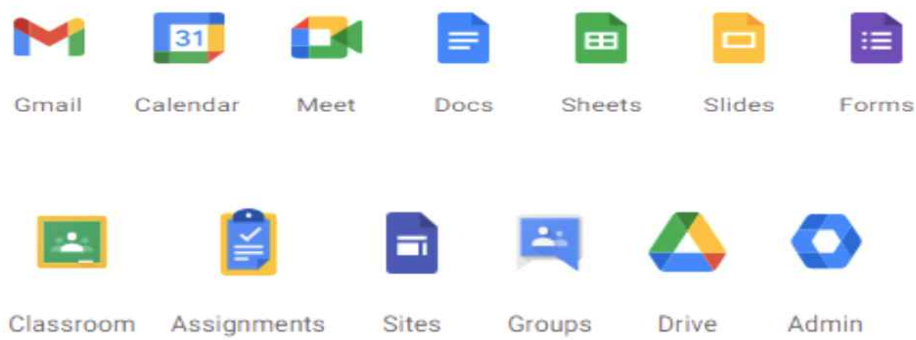
### 1. Concepts and Features of Google Solutions

Google Solutions (GS) includes the hardware Chromebooks and the system Google Workspace for Education. Google Chromebooks are laptop-type mobile devices equipped with a web OS (Chrome OS) developed by Google in 2011 (see [Figure 1]). When folded, a Chromebook can be used as a tablet, and since it is touch-sensitive, it can be used more effectively if a user has a pen. In addition, unlike the desktop, there is no redundant elements in the booting process, which makes the device fast, and the security is strengthened through security key authentication and tampering (Yoon & Lee, 2018).

[Figure 1] Google Chromebooks

Google Workspace for Education is a cloud-based service that provides Google Drive and software to educational institutions in many countries (see [Figure 2]). Cloud computing refers to a service in which the service provider offers information and communication resources for information processing as a service, and the user does not actually own it, but uses it at a cost as much as it is used. From the perspective of schools, the cloud is in the spotlight as an educational tool because it reduces costs, and it has the advantage that it can be easily accessed and used anytime, anywhere.

Chromebooks allow teachers to implement a very effective 1:1 learning experience, and by giving each learner access to a Chromebook, teachers and all learners can use many web-based communication tools (Loveless, 2003). Additionally, with Chromebooks, the teacher's monitoring of the learner's activity can be maintained in real-time, and the teacher's feedback reaches the learner immediately, which is very productive (Centofranchi, 2014). Learners can build up information searching skills, typing skills, and web-based programming knowledge while using Chromebooks individually (Sun, Zimmer, Jone, & Reinauer, 2015). Learners can also easily share their contents with classmates, enabling real-time discussions based on various topics (Dadashzadeh, Saber, & Saber, 2002). The technology included in Google apps is secure because every learner has login information to access Google apps, email and other important learning tools. Plus, Chromebooks boot up in less than 8 seconds in addition to a quick wireless connection, saving a lot of time (Raizen, 2005).

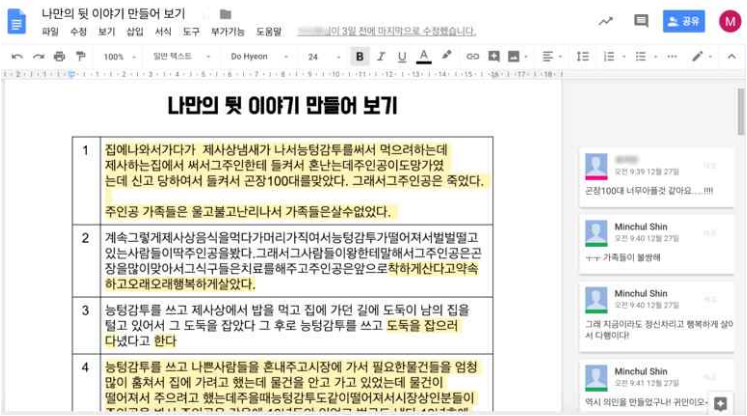



[Figure 2] The Various Services of Google Workspace for Education

Google Workspace for Education includes services such as Google Classroom, Google Docs, and Google Meet. Google Classroom is a learning management platform and a kind of LMS (Learning Management System) for classes, supporting interaction between students and teachers. In short, the teacher and the student can use various learning tools systematically, through Google Workspace for Education (see [Figure 3]). Seo (2019) summarized the features of Google Classroom as follows. First, Google Classroom is cloud-based, so it is possible to save work files without a separate storage medium and it can be used with Chromebooks, PCs, tablets, and smartphones. Second, class opening and invitations are simple in Google Classroom, and user access is easy. By using the service of Google Classroom, teachers can easily invite students by email or code after opening a class. Third, immediate feedback is possible and students' learning progress can be checked. If students log in and enable notifications, they can immediately check the results of performance and get feedback. Lastly, it can be used together with various applications. Teachers and students can use Google Docs, Sheets, and Forms, and they can also use apps developed by companies other than Google. Through this, teachers can upload assignments or videos before class and use them for flipped learning, and interaction between teachers and students is possible using reply function in the bulletin board in Google Classroom.

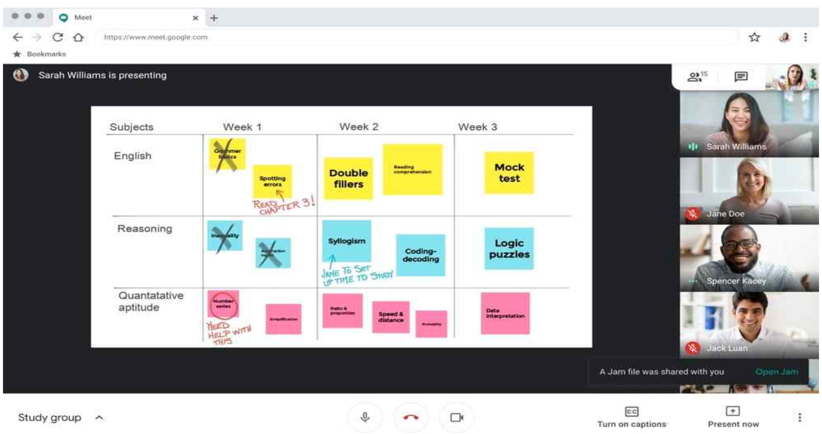

[Figure 3] A Flipped Learning Case of Math Using Google Classroom

Google Docs is a cloud-based document sharing program that allows multiple users to collaborate in real-time to create and share documents. One case used in class is the activity to complete a relay story in which students take turns adding stories (see [Figure 4]).




[Figure 4] Completing a Relay Story with Google Docs

Jamboard is a Google cloud-based whiteboard that allows users to exchange opinions freely, using post-it notes or drawing tools. Through collaboration in Jamboard, a variety of group activities such as brainstorming, artwork, and production of newspaper are possible. Students or teachers can also draw graphs or diagrams in Math, Science, and Geography (see [Figure 5]).




[Figure 5] The Application Case of Jamboard in Google Meet

## 2. Changes in the Perceptions of Teachers Using ICT

Using ICT in education means actively using ICT for learning and solving problems in daily life based on basic information literacy (Korea Education And Research Information Service, 2002). The main advantage of ICT integration in classes is to support students in achieving learning goals (Hwang, Lai, & Wang, 2015). Also, the integration could make teachers create an effective learning environment that is more independent and individualized, and draw students' engagement by using a variety of educational technologies (Azhar & Iqbal, 2018). Therefore, effective implementation of ICT utilization classes can be seen as one of the biggest challenges for teachers (Azhar & Iqbal, 2018). This research seeks to explore the teacher's change in perception of ICT utilization classes in the context of utilizing Google Solutions in school. The previous studies exploring teachers' awareness in ICT utilization include Mahdum, Hadriana, & Safriyanti (2019), Kwon (2017), and Eom & Yoon (2005).

The research conducted by Mahdum, Hadriana, and Safriyanti (2019) examined the perception and motivation of the integration of ICT in classes among 616 high school teachers in four rural areas of Indonesia and found out that self-efficacy, the value of ICT utilization, the impact of ICT, and training experience are motivators for ICT utilization. 'The impact of ICT utilization on classes' was the most important motivation factor. Other factors hindering ICT utilization were the absence of facilities and the lack of training to enhance relevant expertise.

Kwon (2017) indicated that teachers responded positively to the idea that ICT utilization classes are needed to help students to understand learning contents and concepts, and ICT utilization is effective in achieving learning goals. However, they gave relatively low scores for the idea that ICT utilization classes facilitate learner-centered classes and high-level learning. Obstacles in ICT utilization classes that the teachers perceived include a lack of technology infrastructure and a lack of time and support personnel.

Eom and Yoon (2005) analyzed the factors that affect ICT utilization in middle school classes. Female teachers use ICT more frequently than male teachers, and teachers with less than 10 years of work experience use ICT the most. In particular, teachers' attitudes to ICT and open minds to change have had a significant impact on the change in ICT utilization. A positive attitude toward the use of new instructional media is one of the biggest factors driving changes in teaching methods.

Major components dealing with changes in teachers' perceptions of ICT-using classes include the followings (see <Table 1>). ‘General satisfaction’ is measured through usability evaluation and peer recommendations, and it is based on the Net Promoter Score, which quantifies responses to a single direct survey question: ‘How likely are you to recommend this service? (Hamilton et al., 2014). 'Efficiency' refers to the efficiency perceived by teachers in the use of teaching and preparation time for teaching (Chun et al., 2020). 'Classroom Commands' is one of the characteristics of effective teaching methods that increase students’ responses and participation (Ruthven & Christian, 2015), and it is measured to the extent that it enhances visibility into the learning environment. ‘Teaching and Learning Depth’ is measured by accessibility and learning effectiveness in contents that lead to richer discussion of learning topics, such as encouraging critical thinking, reflection, and reflective thinking (Seyoung Cheon, Deukjun Kim, & Jieun Kim, 2020). ‘Differentiation’ is the degree to which students recognize and teach different levels and learning styles to support learning by level (Morgan, 2014). ‘Communication’ is measured by whether or not it provides feedback more efficiently (Se-Young Cheon, Deuk-Jun Kim, & Ji-Eun Kim, 2020). Lastly, ‘Student engagement’ is a variable that can be defined in various ways depending on the perspective of the researcher, such as the degree of interactivity and self-directed learning (Cha et al., 2010), and it is measured through the teachers' perceptions of the increased student participation.

<Table 1> Components of Teachers' ICT Perceptions

| Components | Description | Reference |
|---|---|---|
| General Satisfaction | Usability evaluation and peer recommendation | Hamilton et al. (2014) |
| Efficiency | Time saved for teachers in their teaching / 'teaching +' activities<br>(Including reduction of troubleshooting associated with other systems) | Chun et al. (2020) |
| Classroom Commands | Ability to 'see across the classroom' better due to improved visibility into student's work | Ruthven & Christian (2015) |
| Teaching and Learning Depth | Deepening of engagement with students through quicker coverage of basic content leading to richer discussions on subject matter | Chun et al. (2020) |
| Differentiation | Teacher's improved ability to differentiate for students. | Morgan (2014) |
| Communication | Ability to provide richer feedback to students in a more efficient manner | Chun et al. (2020) |
| Student Engagement | Teachers' perception of increased student engagement | Cha et al. (2010) |

# III. Methodology

## 1. Participants

### 1) Teacher and Subject Matter

The participants who used Google Solutions through Chromebooks at school are 11 teachers in charge of the second grade of J middle school in Gyeonggi-do, Korea. They teach Information, History, Korean, Chinese, Social studies, Physical education, Mathematics, English, and Creative Experience Activities and Science. Not only does the number of hours of teaching per week differ for each teacher, but their experiences also vary greatly from low (1 year) to high (32 years). The participant information, including subject matter, teaching experiences, and the teaching hours per week, is shown in <Table 2>.

<Table 2> The Participant Information

| Teacher | Subject Matter | Teaching Experience | Gender | Hour / Week |
|---|---|---|---|---|
| A | Information | 5 | female | 1 |
| B | History | 10 | male | 2 |
| C | Science | 23 | male | 4 |
| D | Korean language | 1 | female | 3 |
| E | Chinese language | 32 | female | 2 |
| F | Social Studies | 18 | female | 3 |
| G | English | 8 | female | 3 |
| H | Physical Education | 2 | male | 3 |
| I | Mathematics | 20 | female | 4 |
| J | Science | 15 | female | 4 |
| K | Creative Experience Activities | 22 | female | 2 |

**2) Characteristics of J Middle School in Gyeonggi-do**

The educational activities of J middle school, the subject of this study, have the following characteristics. First, this school runs a program that induces community participation in the regular school curriculum. For example, the integrated curriculum such as village school program, village tours, and student club activities in connection with the village news papers were planned. Second, a professional learning community for teachers is operated based on cooperative research activities among teachers. This community is operated based on teachers' willingness and fellowship. The community members gather together every Wednesday for cooperative research activities. Also, the school operates the creative curriculum for each grade based on the following philosophy. Specifically, based on the unique educational goals, a philosophy for each grade level is established and then career exploration activities, student-centered clubs, curriculum integration activities, and project-based classes are planned and implemented. Lastly, for student-centered classes and learning-centered classes, all the desks in the classroom are arranged as ‘U’-shaped where discussion and group cooperative activities freely occur. Through this, the school aims to ensure that no students are left behind in class and improve communicating, cooperation, and problem-solving skills (see [Figure 6]).

[Figure 6] Cooperative Group Works in J middle school

**3) Offline/online classes**

Due to COVID-19, the school conducted offline classes for one week and online classes for two weeks in a three-week cycle during the first semester in 2021. However, from June, when social distancing was relaxed, one week of online classes and two weeks of offline were conducted. During online classes, the teacher participated in the class in their offices and the student participated at home. <Table 3> summarizes the offline and online class schedule for the second grade of J middle school during the pilot period (May 10 to July 16) when both students and teachers use the Chromebook.

<Table 3> Offline and Online Class Schedule During the Pilot Period

| | |
|---|---|
| May 2$^{nd}$ week | online class |
| May 3$^{rd}$ week | offline class |
| May 4$^{th}$ week | online class |
| June 1$^{st}$ week | online class |
| June 2$^{nd}$ week | offline class |
| June 3$^{rd}$ week | offline class |
| June 4$^{th}$ week | online class |
| June 5$^{th}$ week July 1$^{st}$ week | offline class |
| July 2$^{nd}$ week | offline class |
| July 3$^{rd}$ week | online class |

## 2. Tools

All 11 teachers and students participating in this research were provided with a Chromebook as a tool for class. The Chromebook model is the Lenovo 500e Chromebook 2nd Gen, with a screen size of 11.6-inch, a 360-degree hinge, and a built-in EMR (electromagnetic resonance) pen (see [Figure 7]). Also, this model has two HD cameras (front and rear), and it is certified for military-grade durability using Corning® Gorilla® Glass 3 with Native Damage Resistance™, Native Damage Resistance™. Also, it is powered by Intel® Celeron® processing and Chrome OS, so various apps from Google Play™ and Chrome Web Store can be downloaded and used.

[Figure 7] Lenovo 500e Chromebook 2nd Gen

In addition, 7 variables were set as a measuring tool for changes in teachers' perceptions as shown in <Table 4> (Google, 2021), and they were modified according to the context of the research and used in questionnaires and interviews.

<Table 4> 7 Variables for Measuring Changes in Teachers’ Perception

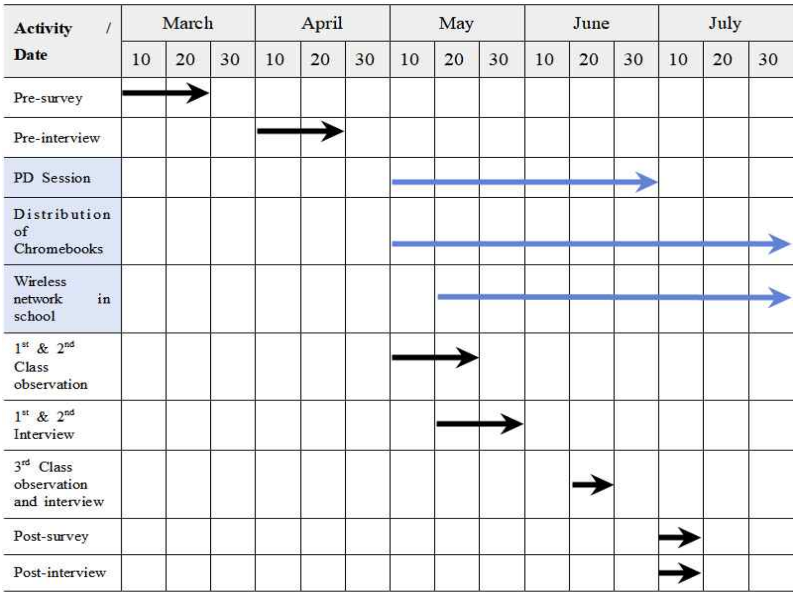
| | Variables | Definitions |
|---|---|---|
| 1 | General Satisfaction | Usability evaluation and peer recommendation |
| 2 | Efficiency | Time efficiency for teachers in their teaching / ‘teaching +’ activities<br><br>(Including reduction of troubleshooting associated with other systems) |
| 3 | Classroom Command | Supporting and managing the class better due to improved visibility in to student’s work |
| 4 | Teaching and Learning Depth | Deepening of engagement with students through quicker coverage of basic content leading to richer discussions on |

| | | |
|---|---|---|
| | | subject matter |
| 5 | Differentiation | Supporting teachers to help students with level-differentiated learning |
| 6 | Communication | Providing richer feedback to students in a more efficient manner |
| 7 | Student Engagement | Perception of increased student engagement |

### 3. Schedule and Procedure

This research was conducted for about 4 months from March to July 2021 (see [Figure 8]). In March, a pre-survey was carried out on teachers' perceptions of Google Solutions, the first interview for each teacher was conducted in April. Due to the delay in supply of Google Chromebooks, they were distributed to all students in the second week of May, but teachers were given Chromebooks earlier than students and tried various functions in advance. The researchers observed the online class first time for 4 subjects (Korean, Social studies, English, Science) from May 13 to 14. However, as the installation of wireless Internet work in J Middle school was delayed, offline class with Chromebook started on May 17 and the researchers conducted the offline class observation for 5 subjects (Social studies, Science, Physical education, Math, English) on May 20.

In order to examine changes in teachers' perceptions, the researchers interviewed teachers after class observation. After the second survey on June 3, the third class observation was conducted. Finally, from July 12 to 16, the post-survey and interview were conducted and the researchers investigated how teachers' perceptions of technology-used classes changed.



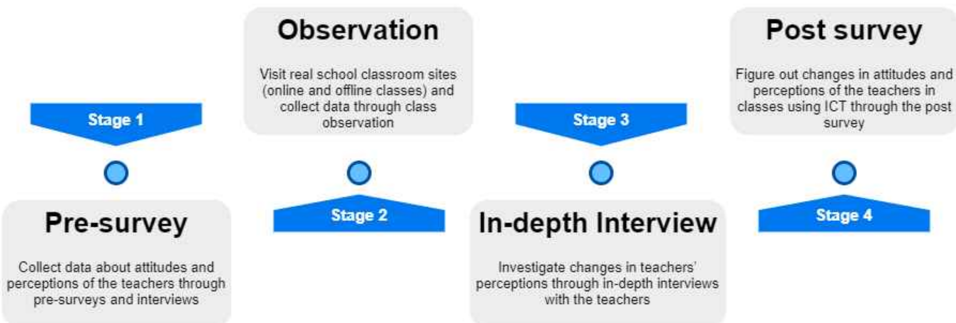

[Figure 8] Research Schedule

The study procedure is as follows (see [figure 8]). The pre-survey was conducted for the 2nd grade teachers of J middle school who would use Chromebooks from March 3 to 16, the initial stage of the study, and additional interviews were conducted with each teacher based on the result of pre-survey. The survey contents included items such as the frequency of technology use in class and teachers' level of comfort and difficulty with devices and Google Solutions to confirm the teachers' overall perceptions and attitudes. Five-point Likert scale was used to measure the degree of perceptions.

The online and offline class observations were conducted for ten days from May 13, when both teachers and students were using Chromebooks. By observing the offline and online classes, the use of Chromebooks in both environments was observed, and the status and perceptions of the teachers using technology identified in the pre-survey were checked. Questions for in-depth interview were extracted during the class observation, and observation notes were recorded based on research measurement variables.

In-depth interview based on the class observation was done at the end of May. Through the interview, an interim check was implemented in the change in the teachers' perceptions and attitudes toward using Google Solutions. A 1:1 customized training program by Google Solutions experts was conducted for teachers from May to July. During the training session, teachers were educated about how to utilize Google Solutions in order to increase the effect of them.

In order to capture the changes in teachers' perceptions and attitudes on Google Solutions, the post survey and interview were conducted from July 12 to 19, just before the vacation after the end of the first semester of J middle school. The survey and interview included items such as overall satisfaction with the use of Google Solutions for a semester, efficiency in preparation for teaching and overall class activity, class management, depth of teaching and learning, communication and feedback. .




[Figure 9] Research Procedure

# Ⅳ. Results

## 1. Changes in teachers’ perceptions of classes using Google Solutions

### 1) Teachers’ Perceptions Before Using Google Solutions

#### (1) Survey Results

In March, a survey was conducted to find out the actual situation of classroom technology use with 11 teachers in charge of the second grade. Through the survey, teachers' perceptions of classes using technology, the perceptions of classes using Google Solutions, the familiarity with Google Solutions, the expectations of using Google Solutions in classes, and the limitations of using Google Solutions in classes were identified.

First, in the case of teachers’ perceptions of classes using technology, to the question 'How often do you use technology in the classroom?', 54.5% of teachers answered that they use 'everyday' and 27.3% answered they use '3 or more times a week’. '1-2 times per week' and ‘1-2 times per month’ accounted for 9.1% respectively and there were no teachers who answered 'Not at all'. Also, it was found that J middle school teachers used classroom technology frequently (see <Table 5>). In addition, to the question of 'What do teachers think about the use of technology in the classroom?', all the teachers answered 'I see benefits but there are obstacles' and 'I see the benefits and try to use technology wherever I can'.  In light of this, it was confirmed that all J middle school teachers had a positive attitude toward the use of technology in classes (see <Table 6>).

<Table 5> Frequency of Classroom Technology Use

| Answer | Frequency(N) | Percentage(%) |
|---|---|---|
| Not at all | 0 | 0 |
| 1-2 times per month | 1 | 9.1 |
| 1-2 times per week | 1 | 9.1 |
| 3 or more times a week | 3 | 27.3 |
| Every day | 6 | 54.5 |
| Total | 11 | 100 |

<Table 6> Attitudes toward classroom technology use

| Answer | Frequency(N) | Percentage(%) |
|---|---|---|
| I see technology as being harmful. | 0 | 0 |
| I see no benefit from it. | 0 | 0 |
| I am indifferent. | 0 | 0 |
| I see benefits but there are obstacles. | 7 | 63.6 |
| I see the benefits and try to use technology wherever I can. | 4 | 36.4 |
| Total | 11 | 100 |

Second, teachers were asked the question, “What is your comfort level when it comes to integrating Google Solutions into your lesson plan?”, regarding the perceptions teachers have of classes using Google Solutions. As a result, 'Mostly not comfortable, I might experiment' and 'Basic level of comfort, I could use them' accounted for 36.4% respectively, and 'Very confident, I know the them well' accounted for 18.2%. Also, 'Extremely confident, I am well trained in them' made up 9.0%. Overall, it was found that the level of comfort for classes using Google Solutions varied among teachers, but they showed a positive attitude toward classes using Google Solutions (see <Table 7>).

<Table 7> Comfort Level of Using Google Solutions in the Classroom

| Answer | Frequency(N) | Percentage(%) |
|---|---|---|
| Not comfortable at all, I would not try. | 0 | 0 |
| Mostly not comfortable, I might experiment. | 4 | 36.4 |
| Basic level of comfort, I could use them. | 4 | 36.4 |
| Very confident, I know them well. | 2 | 18.2 |
| Extremely confident, I am well trained in them. | 1 | 9.0 |
| Total | 11 | 100 |

Third, in the case of the familiarity with Google Solutions, the familiarity of the teachers is shown in <Table 8> below. The average level of familiarity is 2.7 for Chromebooks, the hardware of Google Solutions, but the familiarity level was 3 or higher for other 'software' items. This means that the teachers feel familiar with using Google Apps more than average level, but not so familiar with the hardware.

<Table 8> Comfort Level of Google Solutions

| Options | Average (5 Levels) |
|---|---|
| Chromebook | 2.8 |
| Google Classroom | 3.7 |
| Google Drive | 3.4 |
| Google Docs | 3.2 |
| Google Sheets | 3.2 |
| Google Forms | 3.5 |
| Google Slides | 3.0 |
| Google Search | 3.8 |
| Gmail | 3.7 |
| Calendar | 3.0 |
| YouTube | 4.3 |
| Google Maps | 3.6 |
| Average | 3.4 |

Fourth, as the limitations of using Google Solutions in the classroom, many teachers pointed out some obstacles like 'Not enough time to learn how to use technology', 'Lack of training' and 'Lack of Awareness of what tools to use' as shown in <Table 9>. Judging from this, there seems a lack of learning opportunities for teachers to use Chromebooks, and it is the main barrier to using Google Solutions in classroom settings. Another issue pointed out by teachers was that technological errors sometimes occurred while using software (applications). There were also concerns over whether various functions of applications can be used effectively in class and over hardware failure and maintenance (see <Table 10>).

<Table 9> Obstacles to Using Technology in the Classroom (Check any)

| Answer | Frequency (N) | Percentage (%) |
|---|---|---|
| Non-supportive administration | 0 | 0 |
| Lack of confidence | 1 | 4.5 |
| Students' immaturity in using technology | 1 | 4.5 |
| No problems | 1 | 4.5 |
| Lack of Access to Technology | 2 | 9.1 |
| Lack of Internet Access | 3 | 13.6 |
| Lack of Awareness of what tools to use | 3 | 13.6 |
| Lack of Training | 5 | 22.7 |
| Not enough time to learn how to use technology | 6 | 27.3 |

<Table 10> Disruptions in the Technology You Use Today on a Weekly Basis (Check any)

| Answer | Frequency (N) | Percentage (%) |
|---|---|---|
| Technical interruptions with hardware | 2 | 16.7 |
| Technical interruptions with apps | 2 | 16.7 |
| Bandwidth limitations and outages | 8 | 66.7 |

### (2) Interview Results

Based on the survey conducted in March, pre-interviews were carried out in April to obtain in-depth opinions on teachers' perceptions of classroom technology and Google Solutions. First, as to the technology used by teachers in classes, devices like PCs, tablets (iPad), and smartphones, and programs like Google Classroom, Google Maps, Google Docs, Google Forms, Google Drive, smartphone applications(word games, quizzes, etc.), AR programs, and ICanNote were used in classes. In particular, teachers often used PCs or tablets, while students often used smartphones to work with applications. When students used PCs, they often worked in school computer labs.

Regarding the use of classroom technology, there were positive opinions like increasing students' participation, concentration and interest, potential to individualized classes and better efficiency and mobility. On the other side, there were negative opinions that point out difficulty to control students against distractions and the poor network (see <Table 11>).

<Table 11> Advantages and Disadvantages of Using Classroom Technology

| Advantages | Disadvantages |
|---|---|
| • (AR) increased student participation<br>• (Using smartphone apps) Increased concentration and interest<br>• (Tablet) High efficiency and mobility<br>• Individualized classes | • Decreased concentration due to difficulty in controlling distraction factors<br>• Network environment is not established |

Given the expectations teachers have for the use of Google Solutions in their classroom, the teachers expected that Google Solutions could increase efficiency as Google Solutions provides convenient functions such as assignment submission, auto-save, automatic generation of statistics and simultaneous tasks. The teachers also expected that Google Solutions would facilitate students' collaborative activities and support presenting materials immediately to students and sharing data between teachers (see <Table 12>). Teachers also expected Google Solutions to enhance student engagement through visualization and encouragement of learner participation and to provide support for personalized learning by making it easier to check each student's level and provide feedback. Moreover, there were expectations for the usefulness of the characteristics of Chromebooks, and expectations for the improvement of teachers' expertise by participating workshops.

<Table 12> Expectations from Using Google Solutions

| Areas | Opinions |
|---|---|
| Overall efficiency | • It will be easier for students to submit their work.<br>• Data will be saved automatically.<br>• It will be more convenient to generate statistics (from Google Forms). |
| Facilitating collaborative activities | • Simultaneous editing will be possible, so it will be easier for each group to edit the text. |
| Efficient data sharing | • Presenting materials to learners will become faster and more convenient.<br>• Data sharing between teachers will become easier.<br>• Worksheets will be shared with students immediately. |
| Promoting learner engagement | • Visualization of students participation levels will lead to increased learner participation. |
| Supporting customized learning | • It will be helpful to check student's level<br>• It will be helpful to provide direct and immediate feedback |
| The usefulness of Chromebooks | • It will make Google Solutions more useful<br>• It will be more useful (than smartphones)because of larger screens.<br>• Its built-in pen will promote better drawing and writing activities |
| Improve class professionalism | • PD Session will help the teachers to use it.<br>• Learning community activities will be expected.<br>• The ability to utilize Chromebooks will be improved. |

On the other hand, teachers expressed concerns regarding the use of Google Solutions (see <Table 13>). First, through Chromebooks, learners could be distracted by using YouTube and Google Search, and many teachers predicted that it would be time-consuming to control students' behavior. In addition, there were worries about the difficulty of device management because students could break the device (due to the distribution of one device per student). Some teachers who are not proficient in devices showed lack of confidence, and concerned that there would be significant level-differences among teachers. Other opinions included experiences that errors occur in Google Docs files, concerns about personal information collection, and restrictions on the usability according to the unique characteristics of a subject.

<Table 13> Concerns about using Google Solutions

| Areas | Opinions |
| --- | --- |
| Difficulty in controlling students | • (by watching YouTube, searching for individual interests, etc.) Significant decrease in students' concentration<br>• Wasted time in explaining about how to use/manage Chromebooks properly to students |
| Difficulty in device management | • Concerns about device damage caused by students |
| Necessity to build a network environment | • Limited Wi-Fi network |
| Teachers' lack of ability to use | • Low self-confidence due to lack of proficiency in using the device<br>• Significant level-differences among teachers |
| Others | • Frequent errors in files.<br>• Concerns about personal information collection<br>• Limited utilization according to the subject characteristics (physical education). |

### 2) Teachers' Perceptions While Using Google Solutions

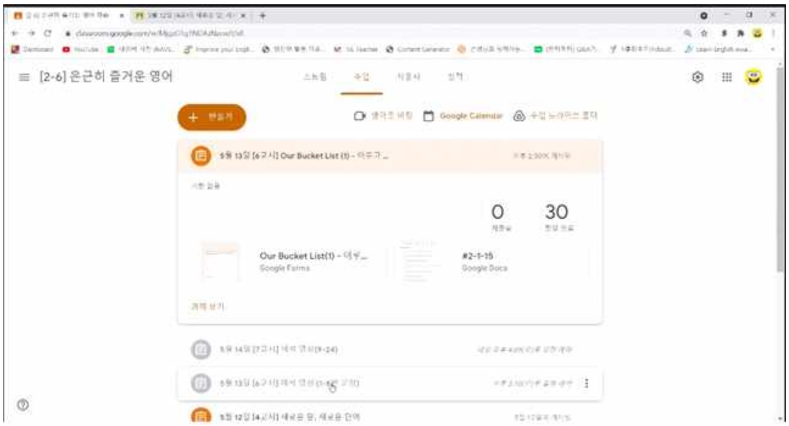
#### (1) First Online Class observation and Interview Results

Four teachers (Korean, English, Social studies, History) were asked to open their classes for class observation for two days (May 13th to May 14th) and interview was followed. Among the teachers who attended, the teachers in charge of Korean, English, and Social studies had a moderate level of comfort in using Google Solutions, and the History teacher was at the low level. According to the opinions of the four teachers, the positive aspects of using Google Solutions for online classes are as follows.

First, the built-in pen of Chromebooks was very convenient in class. In general, both teachers and students used the built-in pen for their convenience. For example, in the case of History and Social studies classes, as shown in [Figure 10], the teachers' active use was observed, such as importing textbook materials and taking notes with ICanNote.

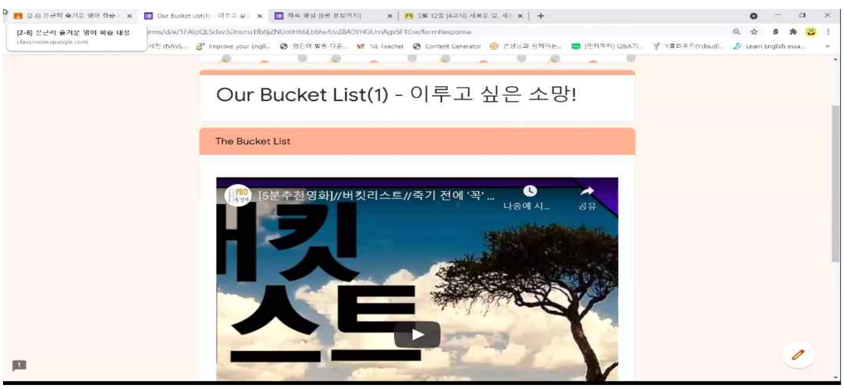
[Figure 10] Online Class Screen of Social Studies

Second, teachers recognized that it was convenient for them to check whether learners are participating in online classes by using Google classroom. As shown in [Figure 11], learning materials were skillfully shared with students by using the document sharing and reservation function.




[Figure 11] Google Classroom Document Sharing and Reservation Function

Third, various functions of Google docs were used actively. For example, it was observed that the real-time correction function was used to give immediate feedback to students' learning activities. In addition, they were actively trying to utilize various media as much as possible in online classes by using the video embedding function of Google forms (see [Figure 12]).




[Figure 12] The Screen of Google Forms

However, the some limitations were observed. First, in the case of

Chromebooks, there was a difficulty in communication between students and teachers because PC KakaoTalk, a meesenger of Korea, which is mainly used by teachers and students as a classroom tool, did not run. This is because Chromebooks use Chrome OS as the operating system, but the system does not support KakaoTalk. Likewise, teachers are not able to use other programs that Chrome OS do not support through Chromebooks.

Second, teachers often used the annotation function in the Zoom program, but this function is not available on Chromebooks. In addition, since only the English version of Zoom can be used on Chromebooks, teachers who are unfamiliar with English had difficulties in using it. In addition, it was often observed that teachers use their own computers instead of Chromebooks due to the difficulty in using Chromebooks and the fact that the camera quality of Chromebook is very poor but it cannot be substituted by a webcam.

**(2) Offline Class Observation and Interview Results**

On May 20, the first offline class observation and interview were carried out for 5 teachers (English, Math, Social studies, Science, Physical education). Among these, one teacher (Science) belongs to a high level of Google Solutions comfort, three teachers (English, Math, Social studies) belong to a medium level, and one teacher (Physical education) belongs to a low level. Since the date was the 3rd day after the network environment was established in J middle School, it was the first or second time in using Chromebooks, so both the students and the teachers were unfamiliar with using them.

Positive aspects of using Google Solutions in offline classroom classes include increased interest and participation in class, improved communication possibilities, use of keyboards and built-in pens of Chromebooks, participation check in real-time learning, easy management of worksheets (compared to paper worksheets), private distribution of level-differentiated worksheets, and cooperative learning with shared document.

> “I am satisfied with the students participating in the class happily. It is much easier to manage online worksheets than paper. I think the level of participation is better because students have individual devices.”

> “I think there are a number of advantages to using Google tools. The best thing is that there is no need to print out worksheets and it is easy to save. And it’s nice to be able to see what students haven’t submitted in real time.”

However, one of the limitations is that students were distracted by Chromebooks unintentionally, which resulted in their low concentration. Also, other limitations include Chromebooks’ limitations to various useful functions, difficulties in using Chromebooks due to students’ digital literacy gap, and the need to control students’ use of Chromebooks. In particular, the PE teacher who is not proficient in Google Solutions, relied on his PC more frequently instead of using his Chromebook due to administrative constraints, and used the basic tools provided by PC rather than Google Solutions. Also, as students become accustomed to Google Solutions, it became difficult to control. They expressed their concerns that it would interfere with learning.

> “I was trying to give volleyball online classes with Chromebooks, so I could only use Zoom to show hand signals and explain certain situations with Microsoft Paint. I tried using Jamboard, but it didn’t work well because some students tend to act wantonly changing the table and images in Jamboard.”

> “In online classes, students were reluctant to use Chromebooks because of compatibility issues with Zoom. Also, there was a need to control because I observed students using Chromebooks for non-study purposes.”

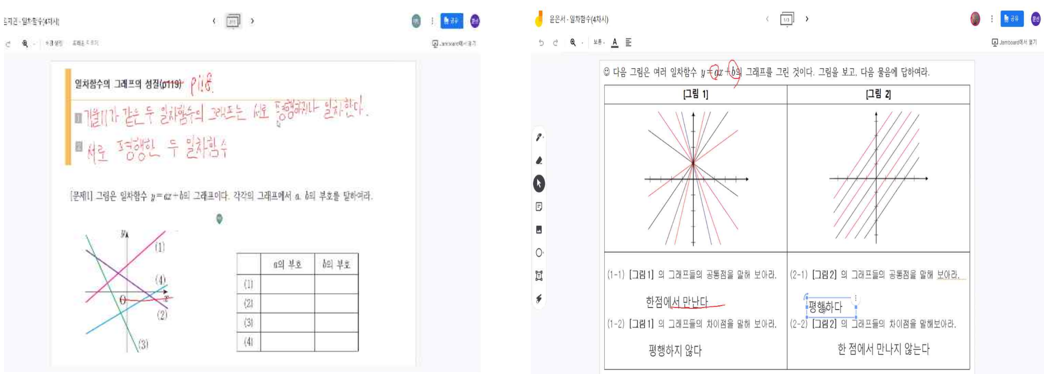
[Figure 13] Online Material Search Using Chromebooks During Offline Class

**(3) Second Online Class Observation and Interview Results**

Due to COVID-19, offline class observation was no longer conducted, and online class observation and interview were conducted with the Math teacher (belonging to the Google Solutions level of comfort 'medium' group). First, positive changes were identified in terms of time efficiency. Compared to the first class observation, it took significantly less time to check student attendance and give behavioral directions. It seems to be due to the fact that students and teachers became quite familiar with online classes using Google Solutions. In the interview, the teacher said that it was easy to capture the level of participation because it was possible to immediately check whether the learners were connected or not and whether the task was being performed.

In addition, it was observed that the teachers actively used Chromebooks. In particular, they provided worksheets for learners using Google Jamboard, and they provided feedback using the built-in pen of Chromebooks. Instead of simply uploading the worksheets to Google Classroom, the students' learning activities were observed in real-time with Jamboard and feedback was given accordingly. In response, teachers expressed their opinions that they were satisfied with the fact that they were able to keep monitoring learners' problem-solving process and that they were able to easily draw graphs in mathematics with Jamboard and built-in pens.

The learners participated in the learning activities at their own pace through the worksheet provided on Jamboard, but some students still showed a non-cooperative or passive attitude in learning.




[Figure 14] Use of Google Jamboard in Online Math Class

### 3) Teachers’ Perceptions After Using Google Solutions

#### (1) Survey Results

In July, a post-survey was conducted to explore changes in the perceptions of 11 teachers. The survey investigated the impact of Google Solutions on teachers' use of work time, the impact of Google Solutions on learning, the impact of Google Solutions on teaching, and satisfaction with Google Solutions and PD Session. The results are as can be seen below.

First, with regard to the impact of Google Solutions on teachers' use of work time, the most common answer was ‘Using Google Solutions saves me time' in the area of teaching, individual planning or preparation of lessons, marking/correcting of student work, general administrative work (communication, paperwork), teamwork and dialogue with colleagues, school management work and other activities. In the case of student counseling, extracurricular activities, and counseling with parents or guardians, the answer 'No effect' was the most common (see <Table 14>).

<Table 14> Questions about Your Schedule and The Effect of Google Solutions on Your Time

| Activity | OECD Average Hours | School Hours | Google Solutions effect on time (Respondent) | | |
|---|---|---|---|---|---|
| | | | Loses me Time | No Effect | Saves me time |
| Teaching | 19 | 18 | 9.1(1) | 18.2(2) | 72.7(8) |
| Individual planning or preparation of lessons | 7 | 6. | 18.2(2) | 18.2(2) | 63.6(7) |
| Marking / correcting of student work | 5 | 5 | 0(0) | 18.2(2) | 81.8(9) |
| General admin work (communication, paperwork) | 3 | 5.9 | 9.1(1) | 18.2(2) | 72.7(8) |
| Teamwork and dialogue with colleagues | 3 | 4.7 | 9.1(1) | 18.2(2) | 72.7(8) |
| Student counselling | 2.1 | 4.2 | 9.1(1) | 54.5(6) | 36.4(4) |
| Extracurricular activities (clubs, sports) | 2.1 | 1.7 | 9.1(1) | 45.5(5) | 45.5(5) |
| Communication and cooperation with parents / guardians | 1.5 | 1.5 | 0 | 72.7(8) | 27.3(3) |
| Participation in school management (e.g. Dept Head) | 1.5 | 3.8 | 0 | 36.4(4) | 63.6(7) |

| | | | | | |
|---|---|---|---|---|---|
| Other (e.g. Break supervision, Mentoring colleagues, PD) | 1.5 | 5.6 | 18.2(2) | 27.3(3) | 54.5(6) |

Overall, 91% of teachers answered positively to whether Google Solutions saves teachers' time in their main work activities. Specifically, the response rate of 'a little time (less than 1 hour per week) is saved' accounted for 27.3%, 'a significant amount of time (less than 1-5 hours per week is saved)' was 45.5%, and 'a lot of time' (more than 5 hours per week) is saved' accounted for 18.2%. In addition, 9.1% of the negative answers 'doesn't save time by making extra work' accounted for 9.1%. Considering the rate, it turned out that 10 teachers excluding one perceived Google Solutions save time for their main work activities.

The average answer to the question about the impact of Google Solutions on learning was 4.21, confirming that teachers' perceptions changed positively. In particular, the items 'The use of Google Solutions enables students' to express their ideas and thoughts better' and 'The use of Google Solutions helps students to find related knowledge and information for learning' were highly rated at 4.56 and 4.67 respectively. In addition, in the responses to 'Google Solutions allow students to be more creative and imaginative in their work' and 'The use of Google Solutions increases students' confidence to participate actively in the class', 3.78 and 3.89 were scored respectively (see <Table 15>).

<Table 15> Questions about the Impact of Google Solutions on Learning (N=11)

| Number | Questions | Average (5 scale) |
|---|---|---|
| 1 | Google Solutions allow students to be more creative and imaginative in their work. | 4.22 |
| 2 | The use of Google Solutions enables students' to express their ideas and thoughts better. | 4.56 |
| 3 | The use of Google Solutions helps students to find related knowledge and information for learning. | 4.67 |

| | | |
|---|---|---|
| 4 | The use of Google Solutions encourages students to collaborate more with their classmates. | 4.22 |
| 5 | The use of Google Solutions encourages students to communicate more with their classmates. | 3.78 |
| 6 | The use of Google Solutions increases students' confidence to participate actively in the class. | 3.89 |
| 7 | I think students learn more effectively with Google Solutions. | 4.33 |
| 8 | I think the use of Google Solutions helps to improve students' ability specifically in reading, writing. | 3.78 |
| 9 | I think the use of Google Solutions helps to improve students' ability specifically in STEM subjects. | 4.44 |
| 10 | The students' are better behaved with the use of Google Solutions. | 4.22 |
| Average | | 4.21 |

The total average of the answers to the questions about the impact of Google Solutions on teaching was 4.07, suggesting that teachers generally have a positive perception. The score for 'improved ability to monitor the whole classroom's work' was the highest at 4.44, followed by 'I can cover the basic teaching content more efficiently' with 4.22. However, the average score of 'improved ability to differentiate for specific students' needs' was 3.78 and that of 'engaging students more deeply in the subject matter', and 'supporting effective communication with stakeholders' was 3.89 respectively, which are lower than the overall average (see <Table 16>).

<Table 16> Questions about the Impact of Google Solutions on Teaching (N=11)

| **Number** | **Questions** | **Average (5 scale)** |
|---|---|---|
| 1 | I have an improved ability to monitor the whole classroom's work. | 4.44 |
| 2 | I have an improved ability to differentiate for specific students' needs. | 3.78 |
| 3 | I can provide more meaningful feedback to students on their work. | 4.11 |
| 4 | I can cover the basic teaching content more efficiently. | 4.22 |

| | | |
|---|---|---|
| 5 | It can engage students more deeply in the subject matter. | 3.89 |
| 6 | Students are more engaged and active in general. | 4.00 |
| 7 | I can communicate more efficiently with non-student stakeholders (parents, other teachers, admin). | 3.89 |
| Average | | 4.07 |

Regarding the general satisfaction with Google Solutions and PD Session, 'recommending to colleagues' is an average of 8.56 points out of 10 (4.28 points converted to a 5-point scale), according to the calculation method of the Net Promoter Score[1] (NPS) (Hamilton et al., 2014). It was found that the satisfaction was relatively high at 27.3 (Reichheld, 2003)[2]. Reasons for recommendation were 'effectively used for teaching-learning', 'effective', 'useful and helpful', and 'capable of a new form of class'. As reasons for not recommending it, there were negative opinions such as 'suitable for online rather than offline' and 'it takes time to learn functions'. In addition, the most common improvement points were 'difficulty in device management' and 'requirement for various methods to utilize'.

To the question asking teachers' perceptions about their students' use of Chromebooks, the average of teachers' responses was 4.18 points out of 5. Considering this, it can be seen that the teachers perceive that Chromebooks effectively support the students' needs. Teachers' positive responses to students' use of Chromebooks included 'convenience', 'usefulness', and 'connection to class materials and data search'. However, there was also a negative opinion saying, "Students use it more for games, watching videos, and others. in their break time

1) The Net Promoter Score is a single metric that quantifies responses to a single direct survey question: "How likely are you to recommend this service?" The three categories of respondents were 'Promoters' who gave a score of 9 or 10 (those who would recommend and use the service again), 'Passives' who gave a score of 7 or 8 (mostly satisfied but not actively promoting the service), and 'Detractors' (those who are actively disappointing) with a score of 0 to 6. The overall score is simply calculated as the ratio of recommenders minus the ratio of detractors (excluding neutrals). Scores range from -100 (not recommended by everyone) to +100 (recommended by everyone). A score of over 50 is considered good performance in the industry.
2) The average NPS of companies was 5~10%, and the NPS of companies above average was 10~50%. Companies with very high customer loyalty have an NPS of over 50%.

rather than learning.”

Regarding the satisfaction level of teachers' needs of Chromebooks, it was found that the average level of satisfaction was 3.89 out of 5, which is relatively high. Reasons for this were 'convenience of using the built-in pen in Chromebooks', 'providing immediate feedback', 'various support programs', 'effective in creating and sharing worksheets', but 'convenient because laptops are more familiar' There were also negative opinions like 'somewhat lacking' and 'the device is not suitable for teaching'. The average usefulness of the PD Session was 4.33 out of 5, indicating high satisfaction, and the trainer's proficiency was 4.89 out of 5, revealing that teachers were highly satisfied with the PD session and they evaluated the trainer's professionalism very highly (see <Table 17>).

<Table 17> General Satisfaction with Google Solutions, Chromebooks, and the Professional Development training

| Num-ber | Questions | Average (5 scale) |
|---|---|---|
| 1 | How likely are you to recommend Google Solutions to a fellow teacher? | 4.28 |
| 2 | Chromebooks were well suited to students needs. | 4.18 |
| 3 | Chromebooks were well suited to my needs. | 3.89 |
| 4 | I found the Professional Development training useful and it met my needs. | 4.33 |
| 5 | My trainers were knowledgeable and skilled. | 4.89 |

In both the pre- and post-survey before using Google Solutions, questions about utilization of working hours was included. We investigated how much time teachers spend on specific tasks during work hours and how Google Solutions affect their use of work time (see <Table 18>).

<Table 18> The impact of Google Solutions in Teachers' Use of Work Time

| Acitivity | Hours before using Google Solutions | Hours after using Google Solutions |
|---|---|---|
| Teaching | 20 | 16.3 |
| Individual planning or preparation of lessons | 6.2 | 5.3 |
| Marking / correcting of student work | 4.7 | 4.2 |
| General admin work(communication, paperwork) | 6.2 | 5.3 |
| Teamwork and dialogue with colleagues | 3.5 | 4.1 |
| Student counselling | 2.1 | 3.6 |
| Extracurricular activities (clubs, sports) | 0.9 | 1.5 |
| Communication and cooperation with parents / guardians | 1.0 | 1.3 |
| Participation in school management (e.g. Dept Head) | 2.5 | 3.2 |
| Other (e.g. Break supervision, Mentoring colleagues, PD) | 3.1 | 5 |

As shown in <Table 18>, the areas where teachers' work hours have been reduced after introducing Google Solutions include teaching, individual planning or preparation of lessons, marking and correcting of student work, and general administrative work (communication, paperwork). Before using Google Solutions, teachers spent an average of 20 hours on overall teaching activities including actual class hours, lesson planning and preparation, grading and proofreading, but it was observed that the average time was reduced to 16.3 hours with the introduction of Google Solutions. This means that the use of Google Solutions has increased overall time efficiency in class activities. On the other hand, among the areas where work hours increased after using Google Solutions compared to those before using Google Solutions, the areas attributed to the use of Google Solutions include teamwork and dialogue with colleagues and student counseling. After the introduction of Google Solutions, teachers at J Middle School voluntarily formed a professional learning community in school and had time to study and search for ways to optimize Google Solutions in class during the semester. In addition, in the case of student counseling, teachers can immediately check the progress and participation of students in online and offline classes through Google Solutions. It can be seen that the time to do it naturally increased. In summary, it was found that Chromebooks saved time in the stage of planning, implementing and managing teachers' teaching and learning activities, while allowing them to spend more time in communication among students and colleagues

**(2) Interview Results**

In July, 11 teachers in charge of the 2nd grade were interviewed. Questions include overall satisfaction with using technology and Google Solutions, efficiency, classroom command, teaching and learning depth, differentiation, communication, and student engagement. The results of the interview are as follows.

**Technology used**

First, the technology used by teachers during the research was diverse. Especially Jamboard and Google Classroom were used the most frequently, and basic programs such as Google Docs, Google Spreadsheet, Google Presentation, and Google Drive were applied properly according to characteristics of subjects, learning topics and types. Other apps, such as Google Keep and Google Earth, were also selected according to subjects and teachers' preferences.

> "It was a great activity for students to write directly on Jamboard using the Chromebooks pen."
> "Jamboard was a good solution for things that were difficult to implement in class."
> "I've been using Google Classroom since last year, so I'm used to it. Google Docs, Forms, and Presentations linked to Google Classroom were useful."

**Satisfaction**

Satisfaction with Google Solutions was turned out in two aspects: satisfaction and dissatisfaction. As for the reasons for satisfaction, there were opinions that the functions of the programs supported by Google were educationally appropriate, and that it was good for Chromebooks to increase the accessibility of these programs, and there were opinions that it was possible to easily create and share learning materials. Other advantages were that the Google app was most appropriate for students to express their thoughts, and that the learning process was recorded. In addition, along with the answer that Google Solutions is simple and convenient, Chromebooks allow students to participate in classes on a larger screen than traditional cell phone screens, and for students who are unfamiliar with typing, they conveniently participate in classes using the built-in pen of Chromebooks.

> "It saves time and is really convenient to make worksheets and distribute it to students at once."
> "I think the Google apps are the best tool for students to express their thoughts."

One area of improvement mentioned was difficulty in device management and utilization due to the distribution of devices to each student. There were also concerns about the process of gathering agreement forms, the risk of loss or damage, and the exposure to obstacles to learning through computers and networks. In addition, it was pointed out that it was inconvenient because the previously used Hangul documents were not compatible. As for Chromebooks themselves, there are limitations on the program functions required for classes, and teachers have PCs that have higher performance than Chromebooks.

> "It was difficult to manage Chromebooks and guide the children to get used to it."
> "Using Chromebooks, it was difficult to use Zoom or KakaoTalk, which I usually use well."

**Efficiency**

Regarding the time-saving aspect of using Google Solutions, the answer was mostly positive. Except for the fact that it takes some time to learn how to use, the majority of opinions are that the time is reduced in the process of using it.
In terms of the efficiency of Google apps, they support auto-save function, auto-statistics function of Google Survey, importing function from Google Classroom and editing function without the limitations of time and place. Furthermore, the teachers could distribute and manage worksheets share their data easily. In addition, there were opinions that teachers managed classes easily through the real-time whiteboard function using programs such as Jamboard. In addition, most of the opinions about Chromebooks were positive in terms of efficiency. By using the same device, students responded faster to teacher's instructions (e.g. students' answers to Google Forms), students are more prepared to learn, so they have more time for class, and can use the built-in pen. There was also the answer that students can take notes much better, and teachers can easily provide feedback in the pdf form.

> "Before the distribution of Chromebooks, it took a lot of time for children to prepare because they had different devices, but now the children are absolutely ready."
> "Auto-save to Google Drive and editing right away in Google Docs save a lot of time in sharing documents."

However, a lack of document compatibility was also pointed out. There was an opinion that it was inefficient because it took a lot of time to edit the 'Hangeul' file back into Google Docs.

> "There are many cases of downloading and using 'Hangeul' documents, but it takes a lot of time to edit and edit them back into Google Docs."

**Classroom Command**

Most of the perceptions were that Google Solutions was useful in managing overall learning activities such as attendance, assignments, and overall class management. There were many opinions that it was possible to immediately check students' access and participation by using Google Classroom, monitor the learning process in real time and provide feedback, and it was possible to efficiently check whether assignments were submitted or not. In addition, there were opinions that students were able to study in groups easily because Google Solutions support simultaneous work, and it was good for teachers to observe the progress. In addition, there was a perception that fair observation and guidance were possible because there was no difference generated from physical distance between students.

> "I was able to easily check whether each child was working on the Google Classroom screen. Without it, it took a lot of time…"

Some commented that the Google apps were useful, but did not find much benefit in managing class status with Chromebooks.

**Teaching and Learning Depth**

Regarding the depth of teaching-learning using Google Solutions, real-time collaboration tools such as Jamboard and Google Docs facilitate student-centered classes such as discussion and project-based learning. There was a perception that high-quality learning activities were possible by using self-feedback.

> "When I was teaching English writing, there was an automatic recommendation function if there was an error in writing. I think children learn a lot in the process of correcting errors."

However, there were many opinions that it is difficult to say that Google Solutions had a positive effect on the depth of teaching and learning as it differs depending on each student's self-directed learning ability and willingness to participate.

**Differentiation**

The following perceptions were identified regarding how effectively Google Solutions supported learning for students at different levels. Although the level-differentiated class itself is a challenging task, most of the perceptions were positive in that the use of Google apps increase the visibility of each student's learning status, facilitate assignment and enable teachers to provide immediate feedback.

> “I think it is suitable for supporting level-differentiated learning in that Google Classroom can easily identify the level of children's worksheet completion and teachers can provide individual feedback that is appropriate for their level.”

On the other hand, although a separate task was given to students in need of supplementary instruction, there were opinions that it was difficult to see this as an advantage of Google Solutions, and that the instruction by level itself was difficult due to the nature of the class and distance learning with a large number of students. It was also found that the possibility of learning support for each level depends on the teacher's competency, especially the teacher's class design ability, in such a limited environment.

> “Since there are so many features provided by Google, I think the more you know about Google’s features, the higher your teacher’s class design skills will be, the better it will be able to be used by students of different levels.

It’s a pity that I couldn’t do it because I wasn’t proficient with the device and didn’t have enough time.”

**Communication**

When teachers were asked whether Google Solutions effectively supported teacher-student and student-student communication, most of the teachers' responses were positive. In particular, because the speed of accessing Google apps with Chromebooks is fast, communication is efficient, and communication is possible through various channels such as chatting and comments as well as voice conversations. Also, it was revealed that communcation record was useful as a reference material for students’ growth process. In particular, a collaborative tool that allows for co-editing was useful. In some cases, high-level students watched and provided assistance to low-level students, and when students left questions on documents while working individually or in groups, the teacher responded efficiently.

> “As long as I don’t delete the comments, it’s good that there is a record so you can keep watching the growth process”
> “The high-level students were able to understand the activities of the low-level students and immediately helped. There is better feedback and collaboration between students.”

However, in offline classes, there was a concern that the school's original function of cultivating social skills would be reduced due to the lack of face-to-face interaction because students only play with PCs even during breaks if they have individual devices.

**Students Engagement**

Most of the perceptions were that students' participation in activities and progress could be monitored, which made students tense, and that participation increased because it was possible to provide immediate feedback to students with low participation. In addition, there was an opinion that learners could visually check their learning status, enabling self-directed learning and make students' more active.

> "By writing in a shared document, it seems that students have increased their participation because it shows whether the students have accessed in real time."
> "I think the overall participation rate has increased because we can immediately identify students who are not participating and provide immediate feedback."

On the other hand, there were opinions that it is difficult to see that participation increased by Chromebooks themselves, and there were opinions that participation increased temporarily due to the novelty effect. One teacher said that it is more meaningful for students' participation if the teacher prepares attractive contents that can continuously induce students' participation rather than the device itself.

> "I think it's important to provide contents that will keep students interested, rather than simply focusing their attention on a device or technology."
> "I was implementing a mock stock activity using Google Spreadsheet, and the content was so fun, so the children were very active in the online class. I took classes without breaks."

**Others**

When we asked the teachers how they felt while using Google Solutions during the pilot, various responses were found. They were disappointed that they could not learn and test various functions of Google Solutions because of the short preparation period due to the delayed distribution of Chromebooks, they were stressed out because of device management issues such as breaking or losing the device, and had many difficulties in using it before 1:1 coaching of the PD session. In addition, there was an opinion that it was difficult for teachers who are unfamiliar with English because the way to use Google Solutions is mainly in English. It was also pointed out that the unintentional entertainment elements of Chromebooks distracted students and disrupted their learning, which could be handled by CEU with the control and block function.

> "If I had received training during the vacation and had touched the Chromebooks in advance, I think I would have had much more time to use various functions."
> "It was difficult to control the students who played with other things like YouTube or games."

However, most of the opinions were that they received a lot of help as they actively shared teaching methods through learning community activities and workshops. In addition, it was also confirmed that it is important to approach the new technology-based teaching and learning environment with a desire to get rid of fear and enjoy it.

> "Through the workshop, I was able to help solve many problems that may arise when using Chromebooks, and I was able to feel the quality of the class increasing by getting tips and ways to use various teaching tools."

## 2. Teachers' Opinions on Strengths and Improvement Points of Using Google Solutions in Class

### 1) Strengths

The advantages of using Google Solutions in the classroom were identified in the questionnaires and interviews (excluding the pre-class questionnaire and interview contents) during and after the teachers' use of Google Solutions in classes (see <Table 19>). The advantages of classes using Google Solutions were found in the area of efficiency, class management, increased participation, improved interaction, sharing and managing materials, support for cooperative learning, support for student-centered classes, providing feedback, support for various class functions, hardware characteristics of Chromebooks. First, there was the aspect of saving time. Time was saved in planning, preparing, executing, managing the class, and marking and correcting assignments. Students were faster to prepare for class by using the same device, which resulted in time efficiency. Second, there was an opinion that the class management was convenient. When using Google Solutions, visibility of individual students' learning status increased, it was convenient to check whether students are connected or not, and it was recognized that it is useful to record students' learning processes. Third, student participation was enhanced. It has been confirmed that students were more active, it was convenient to check participation, and to monitor student activities and encourage participation. Fourth, interaction in class was enhanced. With Chromebooks, the access of Google apps has become faster, which makes communication more efficient, and communication is possible through various channels such as voice, chat, and comments, which increases interactivity. Fifth, sharing and managing learning materials has become more convenient. There was an opinion that it was convenient to produce and distribute learning materials at once, and in particular, it was possible to distribute the study materials individually and privately, which facilitated level-differentiated learning. Sixth, it effectively supports cooperative learning. In Google apps, shared documents and co-editing are basically possible, so cooperative learning is supported more easily. Seventh, Google Solutions support student-centered class activities. Students can directly search for information, and it is suitable for learners to express their thoughts, and apps such as Jamboard and Google Docs are real-time collaboration tools that support better discussion and project learning. In addition, it was recognized that self-inspection of the learning status was easy and that self-directed learning was effectively supported.

<Table 19> Teachers' Opinions on Strengths of Using Google Solutions in Class

| Domain | Contents |
|---|---|
| Time-Efficiency | • Helps with teaching activities, individual lesson planning and preparation, and grading/correction of student work<br>• Saves time in planning, implementing, and managing classroom activities<br>• Helps students to get ready for class faster than before. |
| Classroom command | • Helps easily track students' learning progress<br>• Makes it possible to check student participation in online classes immediately<br>• Helps to check if students have completed their homework |
| Student Engagement | • Makes students more active in class<br>• Promotes students' participation by monitoring students' learning activity and encouraging students who are low-level in participation<br>• Makes checking class participation convenient |
| Communication | • Makes communication in class efficient thanks to fast access to Google apps with Chromebooks<br>• Communication is possible through various channels like chat, written comments, etc. |
| Sharing and managing learning materials | • Makes it convenient to produce and distribute learning materials<br>• Makes it possible to produce and distribute level-differentiated learning materials individually |
| Support for cooperative | • Provides the document sharing function (Google Docs) so, |

| | |
|---|---|
| learning | cooperative learning is possible<br>• Helps students to collaborate efficiently with the document sharing function |
| Support for Student-Centered Class | • Makes it easier for students to search for le knowledge and information<br>• Google Apps are suitable for learners to express their thoughts<br>• Provide real-time collaboration tools such as Jamboard, Google docs which makes student discussion and project learning possible<br>• Helps students to reflect their learning progress by themselves, which ultimately leads to self-directed learning |
| Giving Feedback | • Makes it possible to provide immediate feedback by observing the problem-solving process of learners, especially for students in low-level learners' participation |
| Various functions for classroom activity | • Increases the delivery of lessons with various Google Apps<br>• Chromebook increases accessibility to Google apps<br>• Provides the automatic survey statistics function.<br>• Provides real-time whiteboard function of the Jamboard |
| Functions of Chromebook | • Provides built-in pen, which is convenient for taking notes, handwritten feedback, etc.<br>• Makes it available to use keyboard and pen at the same time<br>• Offers a larger screen than a mobile phone |

### 2) Improvement Points

In the questionnaires and interviews after the teachers' use of Google Solutions in classes (excluding the pre-class questionnaires and interviews), the areas that call for some improvements when using Google Solutions in classes were identified as follows (see <Table 20>). First, the programs and functions required for the class are not supported. Programs and functions like Zoom annotation and KakaoTalk, are not supported by Chromebooks (problems with Chrome OS, etc.), which interfered some teachers with smooth class management. Second, there was a problem that external programs and functions were not compatible well. We identified the opinion that there was inconvenience because the ‘Hangeul’ document, which are commonly used by Korean teachers, are not compatible with Google docs. Third, the problem of device management was identified. There were many opinions that the procedure for obtaining agreement and the risk of loss or damage should be considered due to the distribution of one device to each student, which ultimately results in too much work for teachers. Fourth, student distraction was pointed out. There were many opinions that the device and network environment make it easier for students to be exposed to entertainment elements that make it difficult for them to concentrate in class. Fifth, there was an opinion that it takes time to become proficient in using it. We identified the opinion that not only the technology itself but also the time to prepare for how to use technology in class was insufficient, so that it was not used sufficiently in the class. In addition, we identified limitations in that it was difficult because the method of using Google Solutions is mainly in English, and that there is a limit to the use of various methods of use and practical skills-oriented subjects like PE.

<Table 20> Teachers’ Opinions on Improvement Points of Using Google Solutions in Class

| Domain | Contents |
|---|---|
| No support for programs and functions necessary for | • KakaoTalk is not supported<br>• It is difficult to use Zoom annotation function |
| Poor compatibility with external programs | • The Korean commonly-used document program(‘Hangeul’) is not compatible<br>• It is Difficult to use websites and programs necessary for administrative work (e.g., NEIS) |
| Device management issues | • It is Difficult to manage damage of Chromebook, etc. due to distribution of one device per person<br>• Device management becomes overloaded for teachers |
| Student Distractions | • Chromebooks and networked entertainment elements distract students and disrupt learning<br>• It is necessary to install a CEU that can control/block |
| Short Time for Training | • It takes a lot of time to learn the various functions of Google Solutions |

| | |
|---|---|
| | • The preparation and utilization period were short, so it was impossible to learn and try various functions of Google Solutions in class |
| Others | • It is difficult to use Google solution because manuals are mainly provided in English<br>• Various usage methods are required<br>• There is a limit to its use in practical skills-oriented subjects such as Physical education. |

## V. Discussion and Conclusion

In this research, in order to investigate the effectiveness of classes using Google Solutions, the teachers' responses to using Google Solutions were continuously explored and changes in their perception were investigated. In addition, it was attempted to check teachers' opinions on the advantages and improvement points of classes with Google Solutions, and to understand the effects of Google Solutions on teaching-learning, class observations, surveys, and interviews were conducted with 11 teachers for $8^{th}$ students of J middle school, and several implications were derived as follows.

In terms of teachers' perceptions about classes using Google Solutions, there are some changes due to the experiences with Google Solutions. First, the teachers recognized that the use of Google Solutions helped them to use their work time efficiently. According to the result of the survey, teachers' time devoted to working and teaching activities was significantly reduced compared to when it is not used. Especially, Chromebooks have the effect of saving time in the planning, implementing, and managing each phase of teaching-learning. In the survey, more than 60% of teachers answered that the Google Solutions supports auto-save and link-sharing functions, and those functions are quite efficient in managing and distributing worksheets, which helps to save time in activities such as teaching activities, individual lesson planning and preparation.

Second, the teacher perceived that the use of Google Solutions had a positive effect on students' learning. In the questionnaire on the effect of Google Solutions in teaching-learning, the total average of responses was 4.21 (5-point scale), which means the teachers' positive attitude toward them. Especially, very positive responses were observed in the items such as 'students were able to express their ideas and thoughts better' and 'it helped students to search for learning-related knowledge and information'. In addition, the average level of student satisfaction (4.18, 5-point scale) was higher than the average (3.89, 5-point scale) of teacher satisfaction for Chromebooks. The high satisfaction is because of convenience and usability improved by providing students with a Chromebook as a device, and it is easier to check and use materials.

Third, teachers recognized that using Google Solutions to manage class was very helpful, which is consistent with what teachers expected in the pre-survey. Most of the teachers thought that Google Solutions was useful in managing overall learning activities such as attendance, assignments, and teaching in the management of class. To be specific, there were many opinions that it was possible to immediately check students' attendance and participation by using Google Classroom, to check and provide feedback on the learning activity process in real-time, and to efficiently check whether or not assignments were submitted. In addition, it was possible to provide a fair instruction because teacher can check students' learning process without the limitation of physical distance. Also, it was found that it was much easier for students to prepare classes and participate in learning activities than before as all of them had the same device, Chromebook. In fact, Google Classroom can save all of the student's work in the program, so the teacher can organize the student's learning activities, which help the teacher quickly identify students who are struggling with their assignments (Iftakhar, 2016).

Finally, the teachers perceived that Google Solutions facilitated communication and students' engagement. Specially, 'Easy to provide feedback', 'increased learner engagement' and 'better collaboration' are consistent with teacher perceptions in the pre-survey. Teachers perceived that using Google Solutions helped them to provide more meaningful feedback to students (average 4.11, 5-point scale), made students express their opinions more (average 4.56, 5-point scale), and facilitates cooperative learning (average 4.22, 5-point scale). In addition to this, the teachers thought that the various communication methods (chat, comments, etc) provided in Google Solutions improved communication with students. Also, Google Classroom improved teachers' visibility into students' learning progress, so low-level students were able to receive immediate and meaningful feedback from the teachers, which leads to better participation in learning activities. Regarding this, Kwon (2017) stated that technology has the characteristic of enabling active participation and exchanges of opinions of learners because it generally secures interactivity.

In terms of using Google Solutions in class, there are several advantages. First, Google Solutions enhances efficiency and makes it easy to manage the entire class, including class status and learning materials. Specifically, in the survey, it was confirmed that the planning, preparation, implementation, management steps of classes using Google Solutions and the grading/correction of assignments are time-saving than before. The time for preparing a class has been reduced as all the students had Chromebooks. It was also found that the time devoted to work and teaching activities was significantly reduced compared to before using, and the results support the opinion that Google Classroom helps teachers save time and organize classes (Iftakhar, 2016).

Second, the use of Google Solutions increases student participation and promotes various interactions in the classroom. Because the teacher can check the learning results immediately by using Google Solutions, it was possible to check students' performances and provide feedback effectively, which increased the students' active engagement. In addition, it was confirmed that it became more convenient for teachers to monitor students' activities and encourage participation as it is convenient to check students' attendance or parcitipation. Also, efficient communication through various channels became possible due to Chromebooks.

Third, Google Solutions support learner-centered activities and help real-time collaboration activities using various collaboration tools. For instance, Jamboard and Google Docs are real-time collaboration tools that seamlessly supported students' discussion activities and project learning. Furthermore, sharing documents and co-editing are basically possible in Google apps, so effective cooperative learning could be possible, which leads to students create something as learning results and express their thoughts. To sum up, the class with Google solution corresponds to cloud computing-based education, and it can help learners to have a variety of positive interactions and can produce effective and creative results (Park, 2015).

Despite the many advantages of Google Solutions, a few limitations were identified, and teachers' opinions on improvement are summarized as follows. First, there was a problem that programs frequently used in class were not supported by Chromebooks. For example, annotation function of ZOOM and KakaoTalk were not supported by Chormebooks, which caused several difficulties for teachers to give online classes. Other programs could address this compatibility problem, but these are quite new to teachers and students, so using them created additional difficulties.

Second, there were difficulties in managing students' Chromebooks. For example, there was a risk of loss or damage when using a Chromebook, and there were many opinions from teachers that it is rather too much work to obtain a consent form from students and manage their devices as a whole.

In this research, teachers' responses to classes using Google Solutions were observed, and various opinions were reviewed to derive the advantages and points of improvement of classes using Google Solutions. However, since it was conducted for a relatively short period of time, it was insufficient to examine the changes in teachers' perceptions in depth, and there is a limitation in that the number of samples is small as the subject of the study is 11 teachers. In addition, there were practical problems such as changes in school schedules due to COVID-19, delay in supply for Chromebooks, and CEU installation that was not proceeded well.

Despite these limitations, however, the research demonstrates teachers' perceptions and changes in classroom technology utilization in various aspects through the process of designing, implementing and reflecting classes with Google Solutions. In conclusion, regardless of the teachers' differences in their subject, experience, digital literacy, etc., continuous learning community and expert coaching enabled them to gradually become more proficient in using technology in teaching-learning, which is effective for both teachers and students. This resulted in very positive perceptions for both teachers and students in terms of efficiency and effectiveness. In the future, systematic research and continuous practice are needed to ensure that learning and teaching through Google Solutions is well-established in school to increase educational effects and bring about positive changes in classrooms.

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