

Learners' Perceptions and Experiences of Using e-Textbooks in Online Learning Environment

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This study explored middle and high school students' learning experiences using e-textbooks in online learning courses. Data were collected from in-depth interviews. The interviewees for this study were 19 students who enrolled voluntarily in an online mathematics and science inquiry program, actively participated in the online learning. The students generally have high academic achievement and motivation for learning in science and mathematics. Data were analyzed based on a grounded theory approach. As a result, the characteristics of the online learning environment using e-textbooks were conceptualized via three different categories including temporal, spatial, and technical. Such characteristics of the learning environment were able to provoke self-directed learning, extended learning, interactive learning, in-depth learning, improved ICT literacy, and formation of positive emotions and learning habits. Most of the learners showed positive feedback towards the use of e-textbooks, while some mentioned the technical limitations compared to conventional paper-based learning. This study suggested that e-textbooks are likely to induce positive experiences for learners in the context of online learning, so it is necessary to design contents that utilize various functions and advantages of electronic teaching materials in order to use e-textbooks effectively.

Keywords : E-textbook, Online learning, Students' experience, Learners' perceptions, Grounded theory

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Introduction

With the proliferation of mobile devices, e-books are rapidly becoming popular and electronic textbooks are currently being utilized in various fields within several educational contexts. E-books are defined as “texts that are digital and accessed via electronic screens” (Rockinson-Szapkiw, Courduff, Carter, & Bennett, 2013, p. 260). E-books range from PDF copies of printed books to interactive books that include interactive and dynamic features such as search and cross reference functions, hypertext links, bookmarks, annotations, highlights, and multimedia objects and interactive tools (Vassiliou & Rowley, 2008; Walling, 2014).

E-textbooks are the combination of an e-book and a textbook and can be seen as a form of e-book that contains learning contents for educational purposes (Gu, Wu, & Xu, 2015; Jung & Lim, 2009; Landoni & Diaz, 2006; Lau, 2008; Rockinson-Szapkiw et al. 2013; Vassiliou & Rowley, 2008). E-textbooks integrate the familiar features of textbooks and provide various learning resources and functions, such as video clips, search functions, and several interactive tools which the traditional textbooks fail to support (Malmi, 2017).

The ability to offer cheaper textbook for students counts as one of the major reasons for introducing e-textbooks into education (Ji, Michaels, & Waterman, 2014; Terpend, Gattiker, & Lowe, 2014), but researchers also believe that e-textbooks could provide students with more engaging and individualized learning because of their interactivity, flexibility, and accessibility (Ashcroft & Watts, 2004; Clark, 2009; Gu et al., 2015; Kang, Wang, & Lin, 2009; Kimball, Ives, & Jackson, 2010; Lau, Lam, Kam, NKjoma, Richardson, & Thomas, 2018; Novak, Daday, & McDaniel, 2018; Reynolds, 2011; Pattuelli & Rabina, 2010). E-textbooks have the potential to enable learners to learn in the ways they prefer (Dobler, 2015), that is, to personalize their own learning (Gu et al., 2015; Jung & Lim, 2009), and to effectively regulate their learning processes via various learning styles (Dobler, 2015; Kim & Jung, 2010; Rockinson-Szapkiw et al. 2013; Van Horne, Henze, Schuh, Colvin, & Russell, 2017; Winters, Greene, & Costich, 2008). In addition, some

researchers have considered e-textbooks to be more appropriate for self-regulated e-learning due to the digital nature of e-textbooks and accessibility in terms of students being able to learn at any time and any place and at their own pace (Dennis, Abaci, Morrone, Morrone, Plaskoff, & McNamara, 2016; Kouis & Konstantinou, 2014; Lau et al., 2018).

Previous studies on e-textbooks sought to explore the students' perceptions and experiences of using e-textbooks in various aspects such as students' preferences and adoption, reading experiences, and the use of the various features of e-textbooks. The interactive features of e-textbooks have been perceived as supportive to learning, and therefore positively influence the adoption of e-textbooks (Hao & Jackson, 2014; Lim & Hew, 2013; Siegenthaler, Bochud, Wurtz, Schmid, & Bergamin, 2012; Smith & Kukulska-Hulme, 2012; Strout, 2010; Weisberg, 2011). The most frequently used features of e-textbooks include annotation, dictionary lookup, bookmarking, highlighting, and search capabilities (McFall, Dershem, H. L., & Davis, 2006; Simon 2001; Van Horne, Russell, and Schuh, 2016).

Despite a perception of e-textbook features being advantageous, it was reported that students prefer printed textbooks to e-textbooks, regardless of students' gender, age, and experiences with electronic textbooks (Dillon, 1992; McGowan, Stephens, & West, 2009; Shepperd, Grace, & Koch, 2008; Woody, Daniel, & Baker, 2010). This preference seems to be associated with negative reading or learning experiences with e-textbooks. According to previous studies, students perceived that reading with e-textbooks is less efficient. Students spend more time reading e-textbooks and experience eye fatigue (Kang et al., 2009; Brunet, Bates, Gallo, & Strother, 2011; Daniel & Woody, 2013; Dillon, 1992; Jeong 2012; Landøy, Repanovici, & Gastinger, 2015). Students are more likely to be distracted by other features or activities while reading e-textbooks (Daniel & Woody, 2013; Dobler, 2015; Foehr & Roberts, 2010). The technical problems faced by students in reading e-textbooks also provoked negative experiences (Falc, 2013; Muir & Hawes, 2013). In addition, researchers found that students who read via printed textbooks showed

better performance in reading comprehension and text recall than the students who read via e-textbooks (Dundar & Akcayir, 2012; Kerr & Symons, 2006; Mangen, Walgermo, & Brønneck, 2013; Singer & Alexander, 2017). Several researchers pointed out that the lower reading performance was related to the complex screen navigation, display, and scrolling which requires more mental resources by learners (Dundar & Akcayir, 2012; Mangen et al., 2013).

In addition to reading experiences, prior studies also focused on the effects of e-textbooks on student learning. The majority of research revealed that the use of e-textbooks had little or no effect on student learning (Daniel & Woody 2013; Murray & Perez 2011; Kim, Yoo, Park, Yoo, Byun, Cho, & Ryu, 2010; Shepperd et al., 2008). It has also been reported that students using e-textbooks were not able to use effective learning strategies or metacognitive strategies (Ackerman & Goldsmith, 2011; Daniel & Woody, 2013). For example, Daniel and Woody (2013) compared students' use and performance on printed and electronic textbooks. The research reported that students' scores were similar across format, and also reading time and self-report of multi-tasking were significantly higher in the electronic condition.

Despite the positive perception of e-textbooks by scholars, previous researches have shown that learning using e-textbooks is inefficient, distracting, and low in reading performance. One of the reasons for this results is that e-textbooks were not designed in such a way that leverage the positive aspects of the e-textbook. Another is that the way e-textbooks are used in class do not utilize the strengths of the e-textbook environment. Most e-textbook research studies have been conducted in the context of face-to-face classroom instruction. However, in online learning environment in which students engage in a more active and self-regulated learning through the multiple ways to access and active exploration of information, rather than learning situations such as simple reading and repetition, the role of e-textbooks might have changed (Lau et al., 2018). Many researchers have argued that e-books are suitable for online learning environments, there is little research on the learning experience of learners using e-textbooks in the context of online

learning. Therefore, it is necessary to understand how students interact with e-textbooks in online learning settings and how e-textbooks should be used to facilitate learning.

Therefore, this study aims to explore middle and high school students' learning experiences and their perception in an online learning environment where e-textbooks were used. This study would help to develop an online learning approaches using e-textbooks based on an understanding of learners' e-textbooks based learning.

Method

Participants

Nineteen students were interviewed for this study. The interviewees were selected among students who completed the online mathematics and science inquiry program. Interviewees were carefully screened on the basis of participants who could share meaningful information about their learning experiences. Therefore, the participants of this study were those who volunteered to explain their online learning experiences in detail.

The interviewees consisted of 14 middle school students and 5 high school students out of 150. The number of interviewees who enrolled in mathematics, physics, chemistry, and biology courses were 6 (31.6%), 2 (10.5%), 5 (26.3%), and 6 (31.6%), respectively. Six (31.6%) of the interviewees were female.

Research context: Inquiry-based mathematics and science program

The mathematics and science online learning program was designed to educate students who have an interest and willingness to tackle intellectually challenging tasks. It consists of mathematics or science-based concept learning and inquiry

tasks based on real-world problems. The program is not part of the regular school program, but rather serves as a supplementary learning opportunity open to everyone.

Each subject has 5 levels from level 1 through level 5, for the 7th graders to 11th graders, respectively. Although the content of each level is based on the national curriculum of mathematics and science, the program aims to provide more challenging problems based on real-world context to meet the needs of advanced students, resulting in in-depth learning experiences. Generally, the level of difficulty was adjusted for the top 10 to 15% students in regular school, but in this case, there was no limitation or cut-off process so that any student who wanted could join. Moreover, students could select any level class according to their readiness or achievement level of the subject, although it was recommended to match students based on grade level.

This online program is distinguished from other online programs for secondary school students in the aspect of using e-textbooks. The e-textbooks do not explain basic mathematics and science concepts in detail but provided various questions to let students deliberate on their knowledge and review the related concepts. Students were able to confirm their level of understanding while answering questions within the textbook. When students needed more information, they were encouraged to explore knowledge using other books or the internet, resulting in a self-directed extension of knowledge. In addition, the e-textbooks require students to solve inquiry-based problems using and applying the basic concepts from the e-textbooks. Then students need to fill out and submit the assignment submission forms which include problem-solving processes and results.

The e-textbooks consist of three parts: problem-finding, concept learning, and problem-solving. The first part of the e-textbooks allows learners to know what subjects they will learn and what problems they will solve, arousing learners' interest and understanding the meaning of the learning. Especially, this part includes real-world examples to show how the topic could be related to the learners or our society, resulting in deeper interests and motivation to learn. Second, the

concept-learning part consists of various concepts related to the topic. In this part, learners review the concepts and deliberate their knowledge. Because the online learning program was designed for high achieving learners, the e-textbooks give learners some questions to help them to check their understanding on their own, rather than explaining all related concepts. If needed, they can expand the knowledge by learning provided topic-related information in the e-textbooks and some useful website links that include more detailed explanations. Next, the last part let learners solve problems. This part is consisted of 1 or 2 missions, and each mission include 2~4 small questions. The missions require learners to design original experiments and to report the results, to create new ideas, or to solve real-world problems, applying concepts they learned in the e-textbooks to the mission problems. In this process, learners practice to define problem, design and run experiments, and communicate the results by documenting the research process.

Learners were encouraged to interact to their online classmates and to their tutors. When they needed to ask questions, discuss about some issues, or wanted to share information, they used the LMS class space and communicated actively. Tutors usually provided real-world issues or questions every week, which were related to the learning topics and encouraged students to participate in the online discussion. When students asked questions, tutors answered questions within 24 hours, so learners can keep focus on their learning.

Figure 1 shows an example of an e-textbook uploaded on LMS in this study. Students enter their online classes and click the 'learning' button to open up the e-textbook. The first page of the e-textbook has the lesson topic, and the subsequent page includes a table of contents and recommended guidelines of study, which helps set student expectations for the learning session. The introduction consists of learning objectives and authentic examples that show how mathematics or science concepts can be related to the real world, followed by a concept learning section with important mathematics or science concepts and related questions. Unlike other online education programs, the e-textbooks use various learning

materials for effective learning, such as text, images, video file links, simulation programs, etc. As shown in Figure 1, the menu button on the top, when clicked, provides guides for using the textbooks, such as ‘home’, ‘zoom in/out’, ‘full screen’, ‘select text’, ‘draw’, ‘memo’, ‘bookmark’, ‘timer’, ‘print’, and ‘help’. If needed, students can print out the e-textbooks if they prefer to learn with a printed version. Left and right arrow buttons turn the pages, and typing the exact page number into a box in the upper right corner lets students move to that specific page. The ‘table of contents’ button includes subtitles of the e-textbook in which students can move instantly to that section of the e-textbook. Various questions in the e-textbook make students organize learning concepts. Students can freely fill in the answer form in the e-textbook and compare their responses with the correct answer, provided as a ‘hint’ at the back of the textbook. Students can move back and forth easily to check the hint while they continue referring to the learning page. The e-textbook in this program was developed based on the EPUB (electronic publication) standardized format of IDPF (International Digital Publishing Forum).

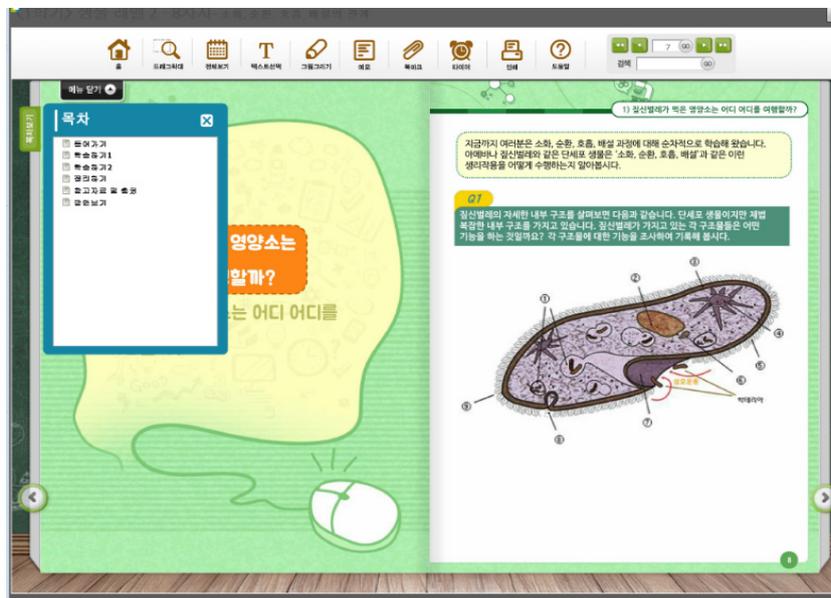


Figure 1. E-textbook example

Data collection

To investigate students' perceptions and experiences using e-textbooks in their online learning, data were collected from four separate interviews, which have advantages on obtaining one's own perspectives in detail, compared to quantitative research methods. In a semi-structured focus group of four to five interviewees, participants answered freely at length to the prepared questions, as well as talked about any related experiences or topics.

Interviewers emphasized that there was no right answer to the questions and all information from the interviews would be used only for research purposes. This was to help open students up to expressing their experiences or emotions honestly. The main questions were as follows: "How did you use the e-textbook in the learning session, and how did you learn in the online program?"; "What were the advantages and disadvantages of the e-textbook?"; and "What did you experience in the online learning program in regards to cognitive and emotional aspects?" Interviews were carried out at the end of the first semester of the program, during summer vacation. One interview typically lasted about 45 minutes to 75 minutes. All the conversations were audio-recorded and transcribed.

Data analysis

Data were analyzed based on grounded theory (Strauss & Corbin, 1988). At the stage of open coding, the researchers conceptualized and categorized the transcripts line by line, analyzing the latent meaning of the data and generating initial concepts from the data. Then, the concepts were linked or merged into new concepts through axial coding, by making connections among categories. Finally, selective coding was done to find core variables and formalize relationships into theoretical frameworks (Sung, Choi, & Han, 2009). The open coding, axial coding and selective coding were not done in order; when needed, the researchers moved from

axial coding to open coding, or selective coding to axial coding.

Three researchers participated in the coding process in separate, and the reliability was about .85. Next, all three researchers met and worked to reach a mutual consensus, resulting in 100% consensus. To confirm the analysis results, one Ph.D. and one doctoral student, both in the field of education, also reviewed the analyzed results. The researchers reviewed the comments, and when it needed, the researchers re-analyze or re-code.

Results

Categorization of students' perception on e-textbooks and learning experience

The interview data of students' perceptions on e-textbooks were classified into 3 categories and 12 sub-categories, and the data of students' perceptions on learning experiences with e-textbooks in online learning were divided into 6 categories. Each category was generated by open coding and axial coding of the interviews data. The categories of open coding of interviews are presented in Table 1.

The categories of students' perceptions of e-textbooks are divided into temporal, spatial, and technical attributes. First, in the category of temporal attributes, e-textbooks in online learning were recognized as an environment of unlimited access, learning time management, time-saving. Second, in the category of spatial attributes, e-textbooks in online learning were recognized as a space of well-organized learning materials, search and navigation, learning and problem solving, and information processing. Third, in category of technical attributes, there are subcategories of nonlinear accessibility, stability, multi-tasking, convenience of information utilization, and functional limitations.

Table 1. Students' perceptions on e-textbooks and learning experience

Perceptions of e-textbooks		
Category	Sub-category	Description
Temporal attributes	Unlimited access	Able to access to the learning materials any time, repeatedly as much as the students want.
	Learning time management	Able to adjust the learning pace according to their own schedule. Able to adjust the learning time according to their level of understanding.
	Time-saving	Able to save time when accessing learning.
Spatial attributes	Space of well-organized learning materials	Able to present well-organized learning materials in an online environment.
	S. of search and navigation	Able to search for additional data via internet or navigate to related learning materials.
	S. of learning and problem solving	Able to learn and problem solve through reading, thinking, asking for help, making ideas, and performing tasks.
Technical attributes	S. of information processing	Able to produce and process information through documentation and modification.
	Nonlinear accessibility	Able to access and open page easily what they seek.
	Stability	No risk of loss or damage.
	Multi-tasking	Able to do tasks simultaneously.
	Convenience of information utilization	Able to provide convenience in documenting, saving, and sharing.
	Functional limitations	Functional limitations in making formulas, drawing graphs, and solving mathematical problems.
Characteristics of learning experiences		
Category	Description	
Self-directed learning	Able to learn, based on student's learning paces.	
Extended learning	Able to learn, exploring related learning materials via internet.	
Interactive learning	Able to ask for help and compare ideas among colleagues and tutors.	
In-depth learning	Able to learn profoundly and abundantly about learning topics.	
Improved ICT literacy	Able to improve ICT skills in documentation, internet search, and information sharing.	
Formation of positive emotions and learning habits	Able to develop self-confidence and self-directed learning habits.	

And characteristics of learning experience with e-textbooks in online learning environment has 6 categories like self-directed learning, extended learning, in-depth learning, interactive learning, improved ICT literacy, and formation of positive emotions and learning habits.

Students' perceptions of e-textbooks in online learning

In the aspect of online learning with e-textbooks, students' perceptions of e-textbooks can be categorized into temporal, spatial, and technical attributes. Moreover, the aforementioned attributes interact with each other to have an influence on the learning process. The details of students' perceptions on online e-textbook learning environment are as follows.

Temporal attributes

Among the student-perceived characteristics of online e-textbook learning environment, unlimited access, learning time management, and time-saving were categorized as temporal attributes. And students' general perceptions about these attributes turned out to be positive. First, students responded positively to the unlimited access. Examples of the responses were, "It was good to have access to the learning materials at any time, any place," and "Unlimited access made it easy for me to study." Accessibility for repeated learning is one key factor in students' perceptions on temporal attributes. Second, students were able to adjust their learning pace and time effectively according to their schedule, difficulty level, and level of understanding. For example, students answered, "I was able to study according to my own pace," and "Some concepts were difficult to understand while others were easy. In case of difficult concept, I reviewed that subject several times to understand it better." Third, students replied that easy access to online class was helping with saving time. They responded, "Computer-based learning made it easy for me to save time since I don't have to go to class and take time for class prep," and "Quick page search functions were helpful for time saving, too."

Spatial attributes

The Students perceived online learning environment as a spatial place for all activities related to learning and problem solving. It means online learning environment is recognized as a place for well-organized learning materials, search and navigation, learning and problem solving, and information processing. Similar to the temporal attributes, students responded positively to spatial attributes. First, students mentioned that well-organized learning materials in an e-textbook made it easy for them to get access to the learning materials they needed, compared to a paper-based textbook. Second, students perceived the online space as a place for free search and navigation when they have questions. They responded, "The links given in the e-textbooks were easily accessible for further knowledge." Third, students perceived the online space as the place for learning and problem solving. They responded that they performed a series of tasks in this place, such as reading, thinking, applying, creating ideas, seeking help, and writing reports in the process of learning and problem solving. Lastly, the online learning environment was perceived as a place for information processing, such as documentation and modification. One example of information processing was seen in the mention of a student, like "I was able to handle the information more easily than in printed papers, with the functions of copy and paste"

Technical Attributes

Students perceived the characteristics of nonlinear accessibility, stability, multi-tasking, convenience of information utilization, and functional limitations in online learning environment, which were categorized as technical attributes. First, students perceived nonlinear accessibility as the aspect most different from the paper textbook, which means that one can easily look for any page they want. Students responded, "Easy and quick access to the information makes it convenient to use that when performing experiments for problem solving" and "I was able to go to any page that I did not fully understand." Second, an e-textbook cannot be

lost or damaged, and therefore has stability that “cannot be damaged even if the computer is broken.” Third, multitasking allowed students to open several online pages related to the task, by allowing students to get access to information while solving the task. Students responded, “Simultaneous access to a learning information page and an inquiry task page made it easy for me to solve the problem.” Fourth, the convenience of information utilization, which is related to the information processing in spatial attributes, makes it easy for students to document ideas and use functions such as zooming in, shortcuts, and focusing. Students responded, “It was convenient to get access to only necessary information via zooming and focusing.” Lastly, despite the advantages of e-textbooks, students pointed out the functional limitations of the current e-textbooks, such as difficulties of input when making formulas, drawing graphs, and solving mathematical problems. In addition, disappearing memos, low resolution of some texts in the images, and complex graphic interfaces were perceived as functional limitations.

Students’ learning experiences with e-textbooks in online learning

Students’ perceptions of learning experiences with e-textbook-based online learning, they were categorized into 6 characteristics; self-directed learning, extended learning, interactive learning, in-depth learning, improved ICT literacy and formation of positive emotions and learning habits. And these 6 characteristics of learning experiences has different properties in the two terms like domains of learning outcomes and phases of learning timeline. The descriptions of six characteristics of learning experiences and the elements of each characteristics are as follows.

First, self-directed learning indicates whether students are able to control their learning pace according to the learning schedule and speed, then they can have time to look for the solutions by themselves. Students’ perceptions on self-directed learning were as follows. The first aspect of self-directed learning is that “I was able

to control my own learning speed.” or “Here I studied according to my own schedule rather than comparing myself with others.” The other aspect of self-directed learning is that “I had to look for how to solve problems by myself, compared to school curriculum where there is a fixed answer given by teachers.”, or “I was able to do tasks on my own without any help from the teacher.”

Second, extended learning means that students further extend their knowledge through online search to complete the task. For example, students said “I searched for any research sites, related university majors, and educational sites.” or “I’ve looked at videos that I found on the internet.” and ‘some students responded that such extended learning helped them in choosing their future careers.’

Third, in-depth learning means that students had more time to study not only the textbook but also related information and therefore they could get deeper learning. Students responded, “Since there is no teacher, I took time to read through the textbook several times to understand.”, “Deeper learning was possible since I looked for more information and studied it when I couldn’t understand something from the textbook, and I thought several times before I finally submitted the assignment.”

Forth, interactive learning represents students’ interactions among classmates and tutors when they have difficulties in solving the tasks, referring to others’ idea or feedback. Students were “able to compare their ideas with other students’.” Students showed positive feedback to interactive learning in an online learning environment. However, they also pointed out that since the learning environment is asynchronous and the access hours are all different, instantaneous responses were unlikely to occur during the semester.

Improved ICT literacy counts as the fifth characteristic in online learning experiences. As the class requires many computer-related tasks, students perceived that their ICT proficiencies were improved through information acquisition and processing. For example, students responded, “I was able to improve my internet search skills by using a computer.”

Lastly, positive emotions and learning habits were formed throughout the self-directed learning. Students answered, “I could develop self-esteem since I completed all the work by myself,” and “Despite the level of difficulty, I felt proud when I finished the task.” Emotional experiences such as fun, a sense of self-achievement, satisfaction, and tolerance were also achieved. Students also mentioned time management and learning habits as part of the advantages of having e-textbook based online learning.

Above, we reviewed six categories of students’ perceived learning experiences with e-textbook in online learning. And then the result of axial coding about 6 categories has shown that there are two axes in the learning experiences. One is the axis of process-result dimension in terms of time process, the other is axis of domain of learning experience like behavioral, cognitive and emotional dimension. Therefore, it could be inferred that there are some interactions between environmental attributes of e-textbooks and students’ learning activities and they generate different learning outcomes. The details of structure and process will be explained in the next session.

Learning-Experience-Model in online learning using e-textbook

Students’ perception of e-textbooks arises from performing learning activities. It means that students’ perception of learning experiences and perceptions of e-textbooks happen simultaneously. So, we made model that showed the relation among the 3 physical attributes of e-textbooks in online learning environment, process-result dimension of learning experience and 3 domain of learning outcomes. So the diagram of the relationships between all the categories of 3 dimensions has been shown in the model of Figure 2. The details of these relationships are described as follows.

First, three attributes of students’ perceptions of the online e-textbook learning environment including temporal, spatial, and technical attributes were related to

each other, and the perception happened simultaneously or separately.

Second, these three environmental attributes, along with the instructional design principles of e-textbooks have a significant impact on students' learning activities and their perceptions. Such an impact appears in six categories of learning experiences, such as self-directed learning, extended learning, interactive learning, in-depth learning, improved ICT literacy, and formation of positive emotions and learning habits. For example, spatial attributes of search and navigation help extended learning and in-depth learning, and temporal attributes of unlimited access and time management can help self-directed learning and formation of positive learning habits.

Third, each category of learning experiences turned out to have two aspects of process and outcomes longitudinally. That means, the first 3 categories of learning experiences like self-directed learning, extended learning, and interactive learning strongly have process aspect of learning and weakly have result aspect; the latter 3 categories of learning experiences like in-depth learning, improved ICT literacy and formation of positive emotions and learning habits, strongly have a result aspect of learning but weakly have process aspect.

Fourth, each category of learning experiences turned out to have horizontal aspects of cognition, emotion, and behavior as well. So, self-directed learning, extended learning, interactive learning, and improved ICT literacy strongly have behavioral/skills aspects; deep learning has strongly cognitive aspects; and formation of positive emotions and learning habits for learning has cognitive, emotional and behavioral aspects.

Therefore, the results of students' perception of e-textbooks and learning experience in online environment were summarized in the model of Fig 2: Side-view shows the relationships between learning environment and learning experience in terms of longitudinal time process and top-view illustrates the horizontal relationship between 3 attributes of learning environment and 3 domains of learning experiences.

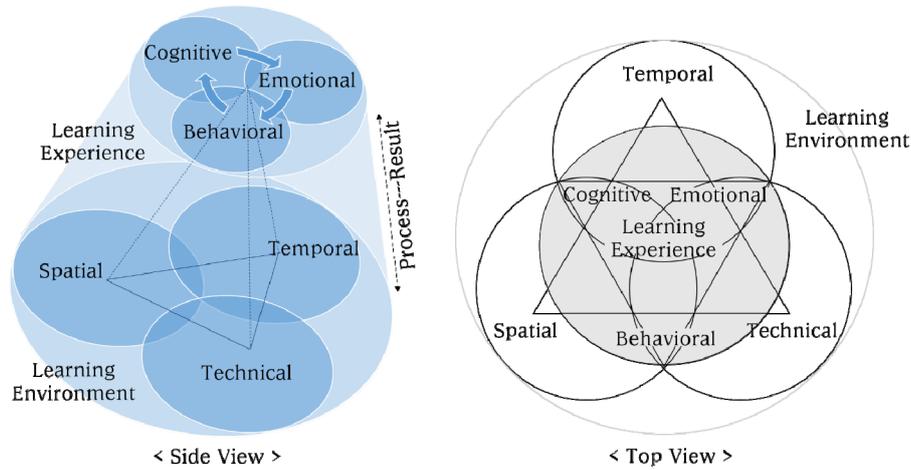


Figure 2. Model of relationships among categories of students' perception on learning experiences using e-textbook in online learning environment

Discussion and Conclusions

Most studies on e-textbooks have focused on the preference of e-textbooks and the effects of e-textbooks on reading and learning. However, there is little research on the in-depth learning processes students experience while using e-textbooks. In particular, previous studies have reported that learners were aware that various functionalities of e-textbooks are helpful for learning, but there was no in-depth analysis of how these functions are used in learning process and how they affect learning. Therefore, in this study, we tried to examine the middle and high school students' learning experiences in online courses using e-textbooks through a grounded theoretical approach.

As a result, the characteristics of an online learning environment using e-textbooks were conceptualized in three different attributes including temporal, spatial, and technical. Such characteristics were able to provoke self-directed learning, extended learning, interactive learning, in-depth learning, improved ICT literacy, and formation of positive emotions and learning habits. Most of the learners showed positive feedback towards the e-textbooks, while some mentioned

the technical limitations on equations, graphs, and problem solving compared to conventional paper-based learning.

Throughout the research, it was shown that self-directed learning was most affected by e-textbook based learning. Its unlimited access, easy search functions and access to learning resources, and the variety of ways learners used metacognitive strategies such as establishment of learning strategies, monitoring of the learning process, and repetition of learning, allowed students to experience self-directed learning. The aspect of promoting self-directed learning with e-textbooks has already been reported in previous studies. Compared to a printed textbook system where information is given linearly, e-textbooks offer nonlinear access to information, allowing students to take control of the information search and access (Hsu et al., 2009; Kim & Jung, 2010), not to mention the various functions of e-textbooks motivate self-directed learning strategies such as planning and goal setup, monitoring, control, and reflection (Dobler, 2015; Van Horne et al., 2017). Several studies attempted to prove such theories; however, they were not able to reach a consistent conclusion. Some suggested that learners with e-textbooks did not use effective learning strategies or metacognitive strategies (Ackerman & Goldsmith, 2011; Daniel & Woody, 2013), while Rockinson-Szapkiw et al. (2013b) purported that learners with e-textbooks showed better utilization of cognitive strategies and self-regulated strategies than learners with printed textbooks. In this research, it was shown that a self-directed learning experience is the core advantage of utilizing e-textbooks. This could be due to the fact that the subjects of this study were students who participated in an online learning program with a higher level of motivation and completed the program with excellent achievement, so that they were likely to participate more actively and self-directly in the learning program, compared to the general student population. Such assumptions should be kept in mind when interpreting and applying the results of this study.

Another result of this research is that students' experiences extended into

in-depth learning. Previous research studies showed consistent results that the use of e-textbooks is less effective in learning than the use of printed textbooks (Daniel & Woody 2013; Dundar & Akcayir, 2012; Kerr & Symons, 2006; Mangen, Walgermo, & Brønnick, 2013; Murray & Perez 2011; Kim et al., 2010; Shepperd et al., 2008; Singer & Alexander, 2017). Especially in case of e-textbooks, studies that focused on reading experiences showed that learners with e-textbooks had lower achievement in reading comprehension and text recall than learners with printed textbooks. This was due to students' habit of F pattern reading that is skimming for key words, compared to the line-by-line typically reading done with printed textbooks (Nielsen, 2006). The findings that electronic textbooks are less effective in reading mean that it may not be appropriate to use electronic textbooks for text-based reading or learning materials. In other words, rather than adding multimedia elements to the printed textbook format, e-textbooks need to further develop differentiated learning content by effectively utilizing the various capabilities of e-textbooks. The e-textbooks used in this study were sophisticatedly designed to give questions to students to actively engage them in exploring, organizing and elaborating information, rather than giving text-based learning materials. In addition, tasks were given to apply the learned concepts to real-world problems. Such a design approach induced extended learning and in-depth learning among students, contrary to the previous studies. That is, e-textbooks require thorough research on designing e-textbooks for in-depth and self-directed learning, owing to the fact that e-textbooks do not have the same structural restrictions.

Lastly, the experience of using various learning strategies and solving problems by themselves in an e-textbook based learning environment can lead to self-confidence and other positive attitudes towards learning, and therefore appropriate instructional design strategies are required to maximize these students' personal initiatives. For example, tasks that require integrating what students learned into real-world problem solving, as used in the current study, turned out to be a very effective e-textbook design strategy for students with a certain level of

self-motivation and achievement.

Many researchers have suggested that e-textbooks are more suitable for online learning (Dennis et al., 2016; Lau et al., 2018; Yair, 2014), and this study has its significance in deeply exploring learning experiences in an e-textbook based online learning environment. However, as this study also showed somewhat contrary results to previous studies due to the nature of subject group and its context, further replication studies should be conducted to make comparisons with various learning groups in online learning environments. Students in this study participated in online mathematics and science programs offered by K University and completed the online courses for one semester with excellent grades. These students generally have high academic achievement and motivation for learning in science and mathematics, and have the characteristics of actively participating by voluntarily participating in online learning. Therefore, it may be somewhat heterogeneous with the general group of learners, so it is necessary to pay attention to the interpretation and application of this study. And, we need another research using different data gathering methods like observation, questionnaire or log data also, in the future.

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