

UC Irvine

UC Irvine Previously Published Works

Title

Health Effects of Digital Textbooks on School-Age Children

Permalink

<https://escholarship.org/uc/item/3k84j96k>

Journal

Western Journal of Nursing Research, 35(9)

ISSN

0193-9459

Authors

Seomun, GyeongAe
Lee, Jung-Ah
Kim, Eun-Young
[et al.](#)

Publication Date

2013-10-01

DOI

10.1177/0193945913491838

Copyright Information

This work is made available under the terms of a Creative Commons Attribution License, available at <https://creativecommons.org/licenses/by/4.0/>

Peer reviewed

Health Effects of Digital Textbooks on School-Age Children: A Grounded Theory Approach

Western Journal of Nursing Research
35(9) 1184–1204
© The Author(s) 2013
Reprints and permissions:
sagepub.com/journalsPermissions.nav
DOI: 10.1177/0193945913491838
wjn.sagepub.com



GyeongAe Seomun¹, Jung-Ah Lee²,
Eun-Young Kim³, MeeYoung Im⁴, Miran Kim⁵,
Sun-A Park⁶, and Youngjin Lee¹

Abstract

This qualitative study used the grounded theory approach to analyze digital textbook-related health experiences of school-age children. In-depth interviews were held with 40 elementary school students who had used digital textbooks for at least a year. Data analysis revealed a total of 56 concepts, 20 subcategories, and 11 categories related to digital textbook health issues, the central phenomena being “health-related experiences.” Students’ health-related experiences were classified into “physical” and “psychological” symptoms. Adverse health effects related to digital textbook usage were addressed via both “student-led” and “instructor-led” coping strategies. Students’ coping strategies were often inefficient, but instructor-led strategies seemed to prevent health problems. When health issues were well managed, students tended to accept digital textbooks as educational

¹Korea University, Seoul, Korea

²University of California, Irvine, USA

³Dong-A University, Busan, Korea

⁴Seoil University, Seoul, Korea

⁵Konyang University, Daejeon, Korea

⁶National Cancer Center, Goyang, Korea

Corresponding Author:

Youngjin Lee, College of Nursing, Korea University, 145, Anam-ro, Seongbuk-Gu, Seoul 136-705, Korea.

Email: youngj@korea.ac.kr

tools. Our findings suggest that students can form healthy computer habits if digital textbook usage is directed in a positive manner.

Keywords

digital textbooks, health, grounded theory, qualitative study

The 21st century has witnessed numerous changes in information and knowledge absorption due to rapidly evolving information technology. Various educational methods that use the Internet have been developed. The demand for new methods, in which teaching and learning can take place regardless of time or place, has been increasing. To meet this demand, textbooks have been modified. The potential of digital textbooks to offset the functional limitations of conventional paper textbooks has attracted attention (McFall, 2005). In addition to the information found in a standard textbook, a digital textbook may contain multimedia components and hypertext and work seamlessly with search engines, offerings that expand the scope of learning (Shepperd, Grace, & Koch, 2008).

In South Korea, as information technology has rapidly developed, computer usage has become a fundamental aspect of daily life. The number of Internet connections is constantly growing, and each South Korean home has at least one computer terminal. In 1997, the government initiated a nationwide project to develop digital textbooks that would overcome the limitations of conventional paper textbooks. Starting with a selection of 5 pilot schools in 2007, the number of schools involved in the program had increased to 132 by 2010. Digital textbooks are used daily in participating schools (Korea Education and Research Information Service, 2011). In elementary school, digital textbooks are provided for a maximum of six subjects (Korean, Social Studies, Mathematics, Science, Music, and English) in Grades 4, 5, and 6, resulting in an average of 12 hr per week of class time use (Choi, 2011; Ministry of Education, Science and Technology, 2011). According to the Ministry of Education, Science, and Technology, by 2015, the use of digital textbooks will be expanded to include all subjects in elementary, middle, and high schools (Ministry of Education, Science, and Technology, 2011).

Digital textbooks and computer-based learning will fundamentally change teaching methods. These innovations could also affect students' health, however. Because students will use computers not only at home but also during class in the form of digital textbooks, overall computer usage time will increase. Increased computer use has the potential to lead to health problems, such as visual display terminal (VDT) syndrome, one of the most common computer-related health

problems (Hong & Lee, 2007; Huh, 2006; Jang, 2007; Ko & Cho, 2006; Lee, 2006; Moon, Koo, & Park, 2005). VDT syndrome includes visual, musculoskeletal, dermatological, and psycho-neurological symptoms caused by long-term computer use (World Health Organization, 1989).

Given this extensive modification of the educational environment, the frequency and length of computer use sessions among children are expected to increase, and resulting health effects can no longer be considered negligible (Cho, Seomun, Lee, Jeong, & Han, 2008; Seomun & Kim, 2012). Most national and international studies on digital textbooks have investigated application trends and learning efficiency. Health-related studies on computer use in developing children have mainly focused on Internet addiction. Few studies describe potential health problems related to digital textbook usage. It is important to identify physical and psychological symptoms experienced by students who regularly use digital textbooks.

The first step in expanding digital textbook usage among elementary school students should be establishing healthy habits for using computers. These habits may serve as the foundation for a healthy lifestyle as a child develops and grows. An in-depth understanding of the health problems elementary school students experience as a result of using digital textbooks and how best to cope with these problems is fundamental for establishing healthy habits. Grounded theory considers the nature of human experiences, the active role of humans in a phenomenon, and the changes, processes, conditions, meanings, and relationships between actions resulting from that phenomenon (Strauss & Corbin, 2008). Using grounded theory methodology to analyze empirical data, we delineated the physical and psychological symptoms that elementary school students experienced due to their use of digital textbooks; we also explored their coping strategies. Our study provides information that will be useful for developing appropriate interventions to prevent and reduce physical and psychological symptoms associated with digital textbook use.

Purpose

We analyzed health-related experiences associated with digital textbook use in elementary school students. Specifically, we investigated the adverse health effects of digital textbook usage and explored how students cope with these problems. The research questions are as follows:

Research Question 1: What kind of changes did you notice during or after use of digital textbooks?

Research Question 2: How did you cope with any changes in health?

Method

This qualitative study used the grounded theory approach to analyze digital textbook-related health experiences of school-age children. We started off by conducting a literature review on the health problems that could be caused to the class of computer-based studies (including existing studies on VDT syndrome). And then we methodologically analyzed the interview data using Strauss and Corbin's (2008) grounded theory method, an inductive approach.

Using digital textbooks as educational tools will increase students' overall computer usage time. Increased computer usage time could be related to an increased prevalence of health-related problems such as VDT syndrome. Thus, these types of changes in the classroom environment could potentially influence students' health. Using the grounded theory method, we focused on school-aged children's experiences with these potential health problems when using digital textbooks, attempting to develop a practical paradigm that could be used to explain the health-related experiences of students using digital textbooks.

Participants

The target population was sixth graders who had used digital textbooks for at least 1 year. Participants were drawn from four elementary schools in South Korea. In total, 40 sixth graders participated, 17 boys and 23 girls, most of whom were 12 years old. Prior to conducting interviews, the background and purpose of this study were explained to the principals and teachers at participating schools, and their approval was obtained. Subsequently, the purpose of the study and the interview content were described to participating students and their parents, who signed consent forms. The consent form informed each participant that he or she had the right to withdraw at any time and that data would be kept anonymous and used strictly for the purposes of this study.

Data Collection

First, a questionnaire previously developed for elementary school students by Kim (2005) was administered to each child to assess their risk of VDT syndrome. There were 32 questions, which encompassed whole body (9), musculoskeletal (7), visual (9), and psychological symptoms (7). This questionnaire used a 5-point scale ranging from 0 (*no symptoms at all*) to 4 (*very severe*). Participants were divided into "at-risk" and "comparison" groups, based on the degree of VDT syndrome symptoms reported. Inclusion

criteria for the “at-risk” group are as follows: Children who scored the top score of 12.5% on the VDT questionnaire were classified at-risk, and the other students served as a comparison group (Korea Agency for Digital Opportunity and Promotion, 2003). Of the 40 participants in the study, 5 (12.5%) were classified at risk of VDT syndrome.

Second, from July 13th to July 31st, 2009, we conducted in-depth interviews lasting approximately 30 min with each of the 40 study participants. Thirty-two students were interviewed once, 8 students were interviewed three times, and the average number of interviews per child was 1.4. The purpose of the multiple interviews administered to 8 of the students was to ensure that we understood the information each child was attempting to convey. If a child used ambiguous expressions that were difficult to analyze in his or her first interview, a second interview was conducted to clarify the responses of the subject. A third interview was then used to verify that the researcher’s interpretation of the second interview was accurate. To ensure validity, avoid interruptions, and maintain a quiet and comfortable atmosphere, interviews were conducted in a school counseling room. Interviewers created an atmosphere conducive to conversation, avoided asking leading questions, and constantly confirmed participants’ responses. To avoid the problem of missing data, each interview was recorded with the participant’s consent, and the entire recorded interview was transcribed and proofread. To maintain consistency in interview content, the following questions were asked in each interview: What kind of changes did you notice during or after use of digital textbooks? Were there any health-related symptoms? How did you feel, or what were you thinking? How did you cope with any changes in health? All interview data were labeled with the participant’s class number and a study ID. No names were recorded. After analyzing the data, the audio files were deleted to maintain confidentiality.

Analysis

Data analysis was based on the grounded theory of Strauss and Corbin (2008) and used a constant comparative method. First, the concepts and experiences related by the participants during the interviews were defined and classified. Second, we determined the relationships between the categories and subcategories of these concepts. Third, the main categories of experiences were selected and the relationships between them were delineated. In addition, a logical diagram was created.

Data were conceptualized in terms of central phenomena, causal conditions, contextual conditions, intervening conditions, action/interaction strategies, and consequences. Central phenomena (here, “health-related experiences”) are

defined as the central ideas or events being studied. Causal conditions refer to the causes and conditions from which these phenomena arise. Contextual conditions are special conditions or circumstances that affect the central phenomena. Intervening conditions block the appearance of the central phenomena. Action/interaction strategies are the actions participants take to adjust, execute, and cope with the central phenomena, and they result in consequences.

Establishing theoretical sensitivity is particularly important when using the grounded theory methodology. Sensitivity can be increased by conducting a review of the relevant articles, research procedures, and practical experiences reported in the field (Strauss & Corbin, 2008). To enhance theoretical sensitivity, we reviewed national and international articles related to digital textbook usage during the data sorting stage. Reliability was confirmed by comparing our results with those obtained from previous studies of physical (Cho et al., 2008; Choi, 2011; Kim, 2005; Seomun & Kim, 2012) and psychological (Hara & Kling, 2000; Seomun & Kim, 2012; Smith, Conway, & Karsh, 1999) issues related to computer use. In addition, participants were asked to verify whether the results of the analysis matched what they had said during the interview to confirm the accuracy of our analysis. The study process including the data analysis process and results was articulated in detail to enhance auditability.

Results

Quantitative Computer Use Data

For 34 students (80.0%), home was their primary computer usage site. The most common length of computer use was 3 to 5 years (14 students; 35.0%), and 18 students (45.0%) used a computer an average of 2 to 3 days a week. The average daily amount of computer use was 1 hr for 17 students (42.5%) and 1 to 2 hr for 15 students (37.5%); thus, 22 students (80.0%) used a computer for less than 2 hr per day. However, 5 students in the “at-risk” group for VDT syndrome reported using a computer at least 6 days a week and more than 3 hr per day.

Grounded Theory Classification of Data

After categorizing concepts according to their characteristics and integrating similar concepts, we identified a total of 56 concepts, 20 subcategories, and 11 categories (Table 1). We discuss our study’s findings in terms of grounded theory’s central phenomena, causal conditions, contextual conditions, intervening conditions, action/interaction strategies, and consequences (Figure 1).

Central Phenomena

Students experienced a number of adverse health-related experiences while using digital textbooks. Here, we classify participants' health-related experiences as "physical" or "psychological" symptoms.

Students using digital textbooks reported visual, musculoskeletal, dermatological, and general physical symptoms. Visual symptoms included altered vision, eye fatigue, prickly eyes, red eyes, pressure behind the eyes, and blurry vision. Musculoskeletal symptoms involved mild to moderate pain in the neck, shoulders, waist, and wrists. When a digital textbook class generally ran in 2- to 3-hr blocks students reported that the hot air produced by the tablet PC could result in symptoms such as dryness, the sensation of heat, and static electricity upon the mouth, face, and entire body. They also reported experiencing general symptoms such as drowsiness, listlessness, lethargy, fatigue, and dizziness. One child reported, "When I look at the monitor for more than an hour using digital textbooks in class, I get red eyes and blurry vision." Another said,

My waist feels uncomfortable and hurts because I have to sit straight up staring at the monitor to read the digital textbooks for the entire class . . . Also, my wrists start to hurt because I have to hold the tablet personal computer pen all the time while I'm using the digital textbooks.

Yet another complained "My face and the inner sides of my arms feel dry and itchy because of the heat coming out of the computer."

In addition to physical symptoms, students experienced several psychological symptoms while using digital textbooks, primarily increased levels of stress and reduced interpersonal interaction. Stress was caused by technical errors or delays. For example, one student revealed,

I get nervous and anxious when the computer has an error or the monitor stops working all of a sudden . . . I sometimes have this urge to break the computer when it's not working properly . . . I put my face down on the desk when I can't concentrate and don't want to study anymore.

Being subject to discipline for technical maintenance issues was also a source of stress for students. One said, "Sometimes I feel stressed out because my teacher asks me to handle the tablet carefully." Symptoms of increased stress included nervousness, anxiety, and distractions. Student participation in class and conversation between instructors and students also decreased. Participants reported that while the instructor was teaching in front of the board, sometimes students were secretly engaging in other activities, such as surfing the Internet or electronic chatting with friends.

Table 1. Categories Related to Digital Textbook Usage Identified Using the Grounded Theory Approach.

Concepts	Subcategory	Category	Paradigm
<ul style="list-style-type: none"> • Too much time spent retrieving the tablet PC, booting it up, and installing digital textbook software • Difficulty in preparing for class during short breaks • Minimized movement of tablet PC for digital textbook classes because tablet PCs require caution in operation 	Lengthy or consecutive digital textbook classes	Consecutive digital textbook classes	Causal conditions
<ul style="list-style-type: none"> • Computer use for more than 3 hr per day, 6 days a week • Greater number or frequency of health problems in children with higher VDT syndrome scores 	Long-term or excessive computer use	Indiscriminate computer use habits	
<ul style="list-style-type: none"> • Discomfort in the eyes (fatigue, pressure, dryness, redness, and a prickly feeling) • Blurry vision • Reduced visual acuity • Neck pain because monitor is below eye level • Discomfort or stiffness in the shoulders due to poor posture • Pain in the waist due to sitting straight up and staring at the monitor • Wrist pain due to holding the tablet PC pen 	Visual symptoms Musculoskeletal symptoms	Health-related experiences: Physical symptoms	Central phenomenon

(continued)

Table 1. (continued)

Concepts	Subcategory	Category	Paradigm
<ul style="list-style-type: none"> • Dryness in the mouth, underarms, or face • Feelings of heat across the face or the whole body • Static electricity build-up due to the hot air produced by the tablet PC • Feelings of lethargy and fatigue • Feelings of drowsiness and frequent yawning • Slight headache • Dizziness 	<p>Dermatological and general symptoms</p>		
<ul style="list-style-type: none"> • Nervousness or anxiety due to technical errors • Worries about admonishment for mishandling the tablet PCs • Upset, agitation, or annoyance due to difficulty participating in class 	<p>Increased stress</p>	<p>Health-related experiences: Psychological symptoms</p>	
<ul style="list-style-type: none"> • Decreased communication between instructors and students during class • Decreased frequency of participation • Distracted by Internet use or chatting 	<p>Decreased interaction</p>		
<ul style="list-style-type: none"> • Frequent occurrence of computer lag or errors • Internet connectivity problems 	<p>Technical problems with digital textbooks</p>	<p>Environment for digital textbook usage</p>	<p>Contextual conditions</p>

(continued)

Table 1. (continued)

Concepts	Subcategory	Category	Paradigm
<ul style="list-style-type: none"> • Inability to keep up with the class due to a lack of familiarity with computers • Difficulty due to a lack of ability in computer use 	Lack of ability in computer use	User's computer operational skill level	
<ul style="list-style-type: none"> • Digital textbooks promote curiosity and interest in learning • Increased student satisfaction with digital textbook information • Better understanding of learning content • Convenient use • Counseling about health problems • Technical problem solving • Giving breaks • Stretching during teaching, or demonstrating how to do so • Empathy and comforting actions when digital textbook problems arise 	Satisfaction with digital textbooks Support from instructors Support from classmates	Positive attitude toward digital textbooks Support system	Intervening conditions
<ul style="list-style-type: none"> • Opening and closing eyes • Rubbing eyes • Massaging or kneading shoulders and neck • Exercises or stretching • Keeping eyes closed • Lying head on the desk • Taking a deep breath • Getting fresh air outside the classroom 	Coping strategies to relieve discomfort Temporary breaks	Student's coping strategies	Action/interaction strategies

(continued)

Table 1. (continued)

Concepts	Subcategory	Category	Paradigm
<ul style="list-style-type: none"> • Teaching students how to stretch • Stretching before and after class 	Regular stretching	Instructor-led coping strategies	
<ul style="list-style-type: none"> • Regular ventilation in classroom • Use of air purifier in the classroom 	Proper ventilation		
<ul style="list-style-type: none"> • Placing a support under the monitor to raise it to eye level 	Using a support		
<ul style="list-style-type: none"> • Alternating with paper textbooks when feelings of discomfort are expressed 	Alternating with paper textbooks		
<ul style="list-style-type: none"> • Attending class but enduring health problems or letting them go unresolved • Inefficient coping with health problems and participation in class 	Participation in class despite inefficient coping with health problems	Accepting digital textbooks as educational tools	Consequences
<ul style="list-style-type: none"> • Continuous participation in class enabled by instructor-aided coping with health problems • Preventing symptoms through eye exercises or stretching 	Participation in classes through cooperative management of health problems		

Note. VDT = visual display terminal.

Causal Conditions

Causal conditions referred to the causes and conditions in which a phenomenon arises. Our results revealed that “consecutive classes using digital textbooks” and “indiscriminate computer use” were causal conditions for adverse health-related experiences linked to digital textbooks.

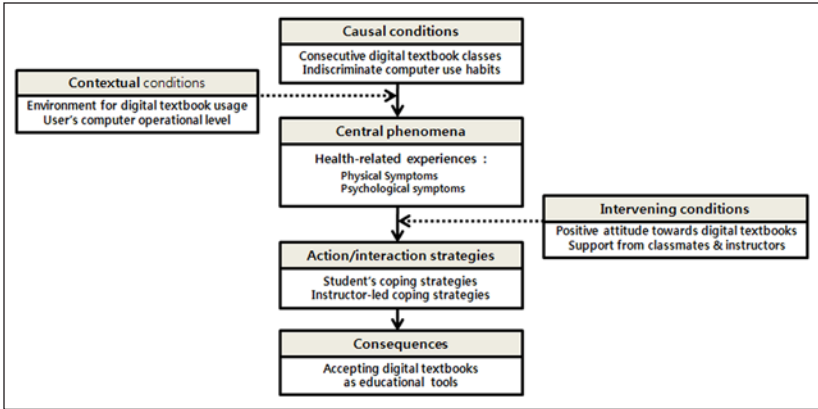


Figure 1. Paradigm model of digital textbook health-related experiences.

Digital textbook classes often required some hassle unrelated to the teaching, such as the installation of the software or computers and booting them up. In addition, students needed to pay close attention when running the digital textbook software on the tablet PCs to fully understand how to use them. Therefore, most classes using digital textbooks took place in 2 to 3 consecutive hour blocks, which was a primary cause of the health-related experiences. Furthermore, extended periods of computer usage and indiscriminate computer use habits at home were also related to health-related experiences. The conditions that caused or aggravated the health problems of students during digital textbook usage are discussed in detail below.

At the pilot schools studied, digital textbook classes generally ran in 2- to 3-hr blocks to minimize the time spent preparing and moving tablet PCs between classes. Although we observed some variation, longer classes were related to more physical and psychological symptoms. Symptoms varied, but included dry eyes, fatigue, and shoulder pain. One student said, "Digital textbook classes take more time to prepare for because we have to set up the computers. Because this is so inconvenient, one class lasts for 2-3 hours." Another admitted, "I worried about getting into trouble for dropping the tablet PC when I had to bring it to my desk to boot up . . . Using digital textbooks for 2-3 hours makes my eyes tired and it becomes hard to concentrate."

We considered students at risk of VDT syndrome if they reported using computers more than 3 hr per day, at least 6 days per week. Participants at risk of VDT syndrome were more likely to have computer-related health problems than the comparison group. In addition, even within the comparison group, students who had higher scores on the VDT questionnaire or used

computers for longer amounts of time experienced more health problems. A student at risk of VDT syndrome confessed,

I use the computer every day at home. I spend more than three hours playing games or using the Internet . . . In school, my eyes get tired, and I feel fatigue and lethargic after only 20 minutes of using the digital textbooks. I also have to go out of the classroom to get some water, because my mouth gets pretty dry.

Contextual Conditions

Contextual conditions are defined as special conditions or circumstances that affect the central phenomenon at that particular time and place. We found two contextual conditions that affected adverse computer-related health experiences: “environment for digital textbook usage” and “user’s computer operation skill level.”

Environment, as used here, refers to factors that affect digital textbook operation, such as the frequency of tablet PC malfunction and the overall technical stability of digital textbooks. Because the schools we studied were merely testing digital textbooks, the school environments were not fully digitized. When 30 students accessed their computers simultaneously, computer lag frequently occurred, upsetting students or causing them to experience stress. Furthermore, they often became impatient and stopped participating if the class did not flow smoothly or if computer access was hindered. One student commented,

The monitor for the digital textbook computer lags every now and then during class. It’s very distracting and upsetting to me, because I just want to read the study materials . . . Sometimes it makes me think that I don’t want to take the class.

In addition, participants assessed their own computer operating skills during the interviews. Students who reported being unfamiliar with operating computers had more difficulty participating in class and were more likely to become agitated or experience stress. One shared, “Classes are more difficult for me because I’m not so good at using computers. I can’t follow the material easily or understand it. So I just put my face down on my desk when I’m very stressed out and upset.”

Intervening Conditions

Intervening conditions referred to the conditions that intervene in the appearance of the central phenomena. Intervening conditions identified in the present study were “positive experiences with digital textbooks” and “support from classmates and instructors.”

Satisfying experiences resulting from digital textbook use promoted students' curiosity and interest in learning. Some students appreciated the extra information they could obtain via digital textbooks and lauded their overall convenience. One student remarked, "I like using digital textbooks because it's fun . . . Paper textbooks are only filled with letters, but with digital textbooks, I can see photos and videos. I can get more information and understand more quickly."

Participants also described receiving support from others in the classroom; displays of support included empathy from their classmates or support from their instructors when difficulties arose during a digital textbook class. Students said they often helped each other use the textbooks appropriately. One commented, "I get stressed out when the digital textbooks don't work properly during class. But, I'm comforted when my friends say, 'It's ok. It's ok.'" In addition, instructors provided suggestions to prevent computer-related health problems, such as taking a break or stretching during or after digital textbook use. When a student's computer was not working, instructors often suggested switching to another tablet. One student said,

I do stretching with my teacher before class . . . My teacher taught me how to relieve eyestrain, and how to do eye exercises. I do those with my friends once in a while when my eyes start to ache . . . I ask my teachers if my computer doesn't work very well.

Action/Interaction Strategies

Action/interaction strategies are the actions participants take to adjust, execute, and cope with the central phenomena in given contexts. We found two action/interaction strategies designed to ameliorate computer-related health problems: "students' coping strategies" and "instructor-led coping strategies."

Students experiencing health problems often adopted individual coping strategies, such as closing and opening, blinking, or rubbing their eyes; doing neck exercises; or stretching to relieve discomfort. They also reported keeping their eyes closed or laying their heads down on their desks. Sometimes, they would take deep breaths or step out of class for a moment to take a quick break and get some fresh air. One student reported:

My eyes get very dry and stiff. Whenever I feel that way, I try to make my eyes teary by rubbing them . . . If it keeps bothering me, I close my eyes and lay my head down on the desk for a while . . . About two hours after the class begins,

my neck and back start to hurt. When I get tired and sleepy from staring at the computer, I stretch or talk to my friends.

As mentioned before, instructors often taught their students coping strategies as well. One student recalled, "I did exercise every morning with my teacher. I also feel more relaxed after stretching with my teacher at the end of a digital textbook class . . . All students did this together every morning during the broadcast." Some teachers also ventilated the classrooms or used air purifiers during digital textbook classes. A participant commented, "If we start to yawn often, my teacher opens the window to increase the ventilation and also turns on the air purifier." Furthermore, teachers used supports to place the monitors at eye level, thus minimizing physical discomfort. One student remembered, "I often got neck pain because the monitor is below my eye level. So my teacher puts a support under the monitor and this makes me feel more comfortable during class." Finally, instructors replaced or alternated digital textbooks with paper textbooks when students experienced discomfort. One child said, "My teacher suggested using a paper textbook until my eyes no longer felt so tired and afterwards I switched back to using the digital textbook . . . We also use paper textbooks when we start to get frustrated because of computer lag." Through these diverse coping strategies, teachers enabled their students to participate consistently in the class.

Consequences

As discussed, students and instructors used action/interaction strategies to reduce discomfort, and successful strategies were associated with a higher likelihood of student "accepting digital textbooks as educational tools." We found students tended to view digital textbook-associated health issues as personal problems, and as a result, they often used inefficient strategies to attempt to manage them. For example, one student mentioned,

Using digital textbooks for more than 2 hours makes my eyes tired, and it becomes hard to concentrate. Whenever I feel that way, I just rub my eyes and blink . . . I try to tolerate the discomfort during class but, if I can't, I close my eyes for a minute.

Such strategies often led to negative consequences such as diminished class participation and concentration. However, when instructors proactively dealt with the health problems of the entire class, such problems were often prevented. A participant stated,

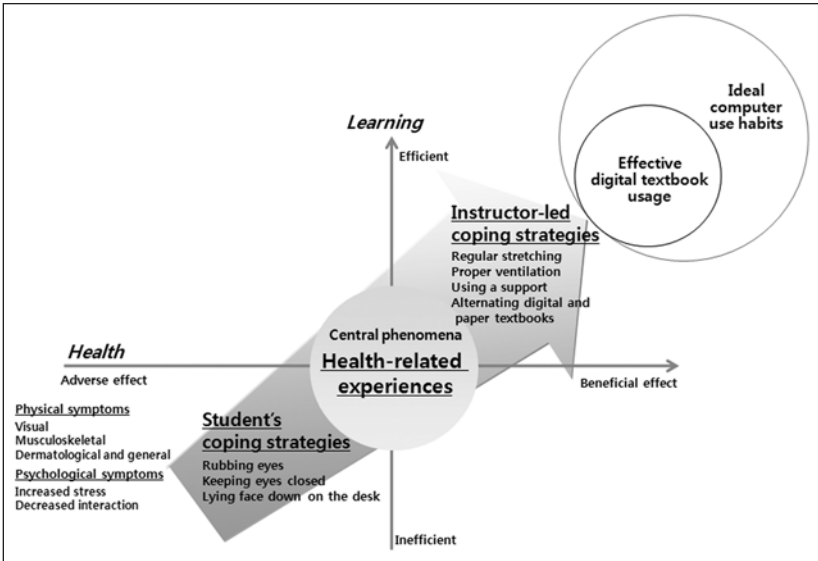


Figure 2. A model for ideal computer habits informed by digital textbook use.

I massage my shoulders or stretch if I start to get shoulder pain while using digital textbooks. Other students stretch when their waists begin to hurt. But this is distracting and causes a lot of agitation during class. But it's good when we stretch with our teacher before and after class. This helps us concentrate and improves the atmosphere.

Discussion

Our goal was to analyze the health-related experiences of elementary school students participating in a digital textbook pilot program and, in particular, to obtain an in-depth understanding of the adverse health effects resulting from digital textbook usage. Data analysis revealed a total of 56 concepts, 11 categories, and 20 subcategories related to digital textbook health issues, the central phenomena being “health-related experiences” (Figure 1). Students’ health-related experiences were classified into “physical” and “psychological” symptoms. Three major subcategories of physical symptoms were reported, including “visual,” “musculoskeletal,” and “dermatological and general” symptoms. Psychological symptoms were classified into two subcategories: “increased stress” and “reduced interaction.” Adverse health effects related to digital textbook usage were addressed via

both “student-led” and “instructor-led” coping strategies. Students’ coping strategies were often inefficient, but instructor-led strategies seemed to prevent health problems. When health issues were well managed, students tended to accept digital textbooks as educational tools. Our findings suggest that when digital textbook usage is thoughtfully directed, students develop better computer habits (Figure 2).

The physical symptoms reported by students were related to fatigue and pressure of the eyes; eye redness; discomfort or pain in the neck, waist, or wrist; drowsiness; and skin dryness. Previous studies on children’s digital textbook experiences (Kim, 2005; Seomun & Kim, 2012) have also found that the physical symptoms of VDT syndrome involve the eyes, musculoskeletal system, and body in general. Similarly, Kim and Lee (1999) report that VDT syndrome includes visual symptoms such as decreased visual acuity, dry eyes, and musculoskeletal symptoms, including back pain. Thus, our findings are consistent with previous research on this subject.

The causal conditions related to VDT syndrome and other computer-related health problems included “consecutive classes using digital textbooks” and “indiscriminate computer use.” These findings are also supported by a number of previous studies. For example, Kang and Choi (2001) compared people’s visual symptoms and eye function both before a session of VDT work and 2 hr after it. They found that eye fatigue and compromised visual function, particularly decreased visual acuity, occurred after working on a VDT. In addition, it has been shown that the degree of physical symptoms associated with VDT work increases with years of computer use, overnight use (Im, Gham, Han, Kang, & Cha, 2002), long sessions of computer use, Internet addiction (Jeong, 2005; Kim, 2005; Kim & Cho, 2005), and shorter breaks (Jeong, 2002; Kim, 2005). In particular, indiscriminate computer use, including Internet addiction, negatively affects students’ physical strength and lifestyles (Lee, 2006). These findings indicate that providing a healthy environment for computer use and properly allocating break time are both important components in preventing health problems caused by digital textbook use.

As for the psychological symptoms, students reported nervousness or anxiety due to technical errors and decreased communication between instructors and students during class. One of the main sources of stress was being admonished by the instructor for carelessness when carrying around a tablet PC. Functional errors or system lags during digital textbook use were also considered a major source of stress. In Smith and colleagues’ (1999) review on human–computer interaction, they reported that technical lag and functional errors increased biomarkers of the physical stress response, including heart rate, blood pressure, catecholamine levels, and electroencephalographic activity changes. It should be noted that a decreased ability to concentrate—manifesting as

nervousness, anxiety, irritation, or annoyance—can mimic the psychological symptoms associated with stress. We suspect that impaired concentration during digital textbook use is more severe for students who already have attention and concentration weaknesses. It should be noted that the South Korean digital textbook pilot project is still in its early stages; because the “increased stress” due to digital textbooks was mainly related to technical issues associated with their operation, psychological problems may decrease over time as technical problems are addressed. In addition, MacFadden, Herie, Maiter, and Dumbrell (2005) report that web-based instruction can be associated with positive emotional experiences as well as frustration with technical problems.

Some of the factors that triggered health problems in our study included “digital textbook usage environment” and “user’s computer operation ability.” According to a preliminary study by Cho et al. (2008) on digital textbook usage, students exhibit negative emotional responses such as agitation, drowsiness, fatigue, annoyance, and lack of interest when their digital textbooks do not work properly. MacFadden et al. (2005) also reported on students’ frustration with technology, and Smith et al. (1999) described negative emotional responses such as disillusionment, complaints, anxiety, fear, and anger resulting from computer errors. The fact that less competent computer users tend to experience more stress than competent ones (Smith et al., 1999) supports our finding that computer operation ability by self-report is related to the health problems a student experiences.

Both students and instructors implemented coping strategies to manage computer-related health issues. For example, students often rubbed or blinked their eyes to relieve discomfort during class. They also did stretches while sitting to relieve neck pain, and some closed their eyes for several minutes and put their heads down on their desks to relieve general discomfort. Unfortunately, such efforts often increased discomfort or resulted in distractions during class. Instructor-led coping strategies tended to be more effective. Students positively viewed instructor-led stretching before and after class. Other instructor-led suggestions also resolved health problems and ensured that classes went smoothly, including using accessories such as supports for students’ chairs. One study has shown that students taking web-based distance education courses in the United States feel distressed and experience helplessness when technical difficulties arise, as they often have no one to support them (Hara & Kling, 2000). Our results demonstrate that a support system created by caring instructors serves as an intervening condition that promotes effective coping strategies on the part of the student. Developing and implementing successful instructor-led interventions will help establish an environment conducive to learning from digital textbooks.

Because the school years are a period of active growth, the physical and psychological health of elementary school children is very important. If students cope with potential or actual health problems on their own during digital textbook classes, it can hinder their learning. For example, students rubbed their bloodshot eyes to relieve discomfort, but that is considered unhealthy. In addition, learning could be temporarily disrupted when students closed their eyes during the class or lay their heads down on their desks. In addition, stretching distracted the overall classroom atmosphere. However, if students deal with the health problems alongside their instructors appropriately, digital textbooks can be used to increase the learning efficacy in class.

Health problems experienced by elementary school students may have future ramifications. In the present study, the physical and psychological symptoms related to digital textbook use that students described were mild. Nevertheless, appropriate plans to prevent health problems should be developed prior to the expansion of digital textbook use. Guidelines for instructors based on the results of this study should be established. A thorough understanding of the health problems stemming from digital textbooks is necessary to prevent adverse effects and promote the formation of good computer usage habits in elementary school students.

Declaration of Conflicting Interests

The author(s) declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

Funding

The author(s) disclosed receipt of the following financial support for the research, authorship, and/or publication of this article: This study was financially supported by The Korean Education and Research Information Service at the Ministry of Education, Science and Technology in South Korea (No. CR2009-14).

References

- Cho, D. Y., Seomun, G. A., Lee, H. J., Jeong, Y. S., & Han, C. H. (2008). *Operating plan of pilot school for field application of digital textbooks*. Seoul, Korea: Ministry of Education, Science and Technology, Seoul Metropolitan Office of Education.
- Choi, M. A. (2011). *An analysis of factors for continuous use of digital textbooks: Survey of teacher and student perceptions of pilot school* (Unpublished doctoral dissertation). Sungkyunkwan University, Seoul, Korea.
- Hara, N., & Kling, R. (2000). Students distress in a web-based distance education course. *Information, Communication & Society*, 3, 557-579.
- Hong, S. P., & Lee, H. J. (2007). Research on asocial behavior by types of internet addiction in elementary school students. *Journal of Korean Association of Child Studies*, 28, 205-216.

- Huh, N. S. (2006). *Relationship between internet addiction, the parents' & teachers' attitude and mental health in elementary school children* (Unpublished master's thesis). Seoul National University of Education, Seoul, Korea.
- Im, G. J., Gham, S., Han, C. H., Kang, Y. S., & Cha, B. J. (2002). State of computer use and VDT related symptoms in adolescents. *Journal of Maternal and Child Health, 6*, 53-69.
- Jang, Y. J. (2007). *Relationship between internet addiction and mental health in elementary schools* (Unpublished master's thesis). Chungnam National University, Daejeon, Korea.
- Jeong, I. S. (2005). *The effects of adolescents' level of Internet addiction on their health status: Focused on a group of middle and high school students in Seoul* (Unpublished master's thesis). Ewha Woman's University, Seoul, Korea.
- Jeong, Y. H. (2002). *Use of computers by teenagers and the effect on subjective symptoms of VDT syndrome* (Unpublished master's thesis). Seoul National University, Seoul, Korea.
- Kang, M. J., & Choi, O. M. (2001). The investigation of the changes visual problems in VDT workers. *Korean Journal of Vision Science, 3*, 219-228.
- Kim, J. Y., & Cho, K. J. (2005). A Study on the comparison of video display terminal (VDT) subjective symptoms for computer-addicted and non-addicted adolescents. *Korean Journal of Child Health Nursing, 11*, 159-166.
- Kim, S. W. (2005). VDT syndrome according to the types of computer use among elementary students. *Journal of the Korean Academy of Public Health Nursing, 19*, 359-370.
- Kim, Y. J., & Lee, S. Y. (1999). Factors related symptoms of video display terminal users. *Journal of the Korean Academy of Family Medicine, 20*, 1091-1098.
- Ko, M. H., & Cho, B. H. (2006). Relationship of internet addiction and stress coping behaviors among the 5th & 6th graders at a local city. *Journal of the Korean Society of School Health, 19*, 45-54.
- Korea Agency for Digital Opportunity and Promotion. (2003). *Internet addiction self-diagnostic test (K-Scale) and prevention education programs*. Seoul, Korea: Korea Agency for Digital Opportunity and Promotion, Ministry of Information and Communication.
- Korea Education and Research Information Service. (2011). *Digital textbook development progress*. Available from <http://www.dtbook.kr>
- Lee, J. A. (2006). *The effects of internet addiction on fitness and health-related behaviors of middle school students* (Unpublished master's thesis). Korea Maritime University, Seoul, Korea.
- MacFadden, R. J., Herie, M. A., Maiter, S., & Dumbrell, G. (2005). Achieving high touch in high tech: A constructivist, emotionally-oriented model of web-based instruction. *Journal of Teaching in Social Work, 25*, 21-44.
- McFall, R. (2005). Electronic textbooks that transform how textbooks are used. *Electronic Library, 10*, 72-81.
- Ministry of Education, Science and Technology. (2011). *Smart education promotion plan execution strategy*. Seoul, Korea: Author.

- Moon, Y. I., Koo, H. Y., & Park, H. R. (2005). Scope of internet addiction and predictors of addiction in Korean children in early elementary school. *Korean Journal of Child Health Nursing, 11*, 263-272.
- Seomun, G. A., & Kim, E. Y. (2012). Factors of video display terminal syndrome in elementary school students who use digital textbooks. *Journal of Korean Academic Society of Nursing Education, 18*, 140-147.
- Shepperd, J., Grace, J. L., & Koch, E. J. (2008). Evaluating the electronic textbook: Is it time to dispense with the paper text? *Teaching of Psychology, 35*, 2-5.
- Smith, M. J., Conway, F. T., & Karsh, B. T. (1999). Occupational stress in human computer interaction. *Industrial Health, 37*, 157-173.
- Strauss, A. C., & Corbin, J. M. (2008). *Basics of qualitative research: Grounded theory procedures and techniques* (3rd ed.). Thousand Oaks, CA: Sage.
- World Health Organization. (1989). Work with visual display terminals: Psychosocial aspects and health (Report on a World Health Organization meeting). *Journal of Occupational Medicine, 31*, 957-968.