

THE EFFECT OF DIGITAL TEXTBOOK ON ACADEMIC ACHIEVEMENT IN KOREA

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ABSTRACT

There is considerable controversy over learning effect of digital textbook since digital textbook has been introduced for the purpose of supporting effective learning in 2006. Therefore it was analyzed the learning effect of digital textbook on academic achievement and suggested improvements of digital textbook. For this research all academic achievement results of pilot schools adapting digital textbook from 2008 to 2012 were collected and meta-analysis was conducted to verify systematically. The result of this research showed that digital textbook was effective in improving academic achievement. In order for digital textbook to be more effective in learning it is necessary to clarify the characteristics of each subject and to fully reflect them on digital textbook.

Keywords: *Digital Textbook, Academic Achievement, Pedagogical Issues, Human-Computer Interface, Classroom Teaching Improvement*

1. INTRODUCTION

The development of computing device and networks has contributed to many changes in education. Knowledge transmission was the main role of education in the past that was difficult to acquire knowledge. Since the advent of computing device and networks people have easily produced, shared and consumed knowledge. The role of school education evolved and began to focus not only on delivering increasing knowledge but also on cultivating the ability to find knowledge and to solve problems.

For this lessons with printed textbook (PT) consisted of text and a few images have been changed to lessons with video, simulation, as well as discussion over time and space. The education based on the average level of learners gradually turn toward individualized education.

The introduction of DT can help teachers as well as students. It was entirely dependent on the teachers' ability to explore and produce various teaching and learning materials. Because DT is distributed with several teaching and learning materials, it is possible to reduce some variation in classes that may occur in the absence of materials.

To maximize learning effect by using computing device and networks, researches at national level were conducted to introduce DT in schoolwide. DT has been developed to help to

increase interest in learning and to cultivate students with 21st learning skills like problem solving skill and self-directed learning skill [1]. DT pilot schools have been operated and are gradually increased.

PT is the most fundamental learning materials but have limits to contain learning materials on a restricted amount of paper. On the other hand DT can support learning by including rich multimedia materials in the contents of existing textbook. It is possible to record various kinds of learning materials to help understanding the contents presented in the curriculum without limitation of quantity. Also storing all the contents in one digital device enhances portability and enables learners to carry lightly instead of heavy bags and to make learning convenient anytime and anywhere. In addition, experiments that learners are dangerous to do or it takes a long time in physical environment can be provided on DT in the type of simulation. Interactive function of DT using networks also may enhance learning by facilitating interactions among learners or between teachers and learners [2, 3]. Learners with DT can study at anywhere and anytime with own learning rate and go to school without heavy textbooks.

DT also help teachers as well as effective learning of students. Teachers had to spend a lot of times and effort in exploring and creating the teaching materials to help the learners understand.

However, the abundance of learning materials provided in DT can save this effort.

The Ministry of Education has started basic research for DT introduction since 1997 [4]. DT pilot schools have been operated since 2008, they were gradually expanded. Pilot schools has been measuring learners' academic achievement, self-directed learning ability, problem solving skill, attitude toward the subject, visual acuity and addictive use of digital devices to verify the effect of DT [5, 6].

In particular, academic achievement is the most essential goal of education and is basic indicator of how well learners have learned. Academic achievement provides a rationale for the effectiveness of using DT as a means to cultivate learners' competency and for suitability of introducing at schoolwide or not. Because the learners' ability is based on knowledge.

But controversy over the effect of DT on the academic achievement is constantly being raised. Though using the same DT, there is a difference – effective or not effective – in the learning effect between schools or subjects. Although there is a statistically significant improvement, there are cases which the effect is not sufficient to be actually effective on learning.

Therefore it is necessary to end the controversy over the DT and to make efforts for stable introduction at the school site. In this study, the characteristics of DT were analyzed, academic achievement report of DT pilot schools were collected, and meta-analysis on the DT effect on academic achievement was conducted. And then the effect of DT was verified and improvements of introduction of DT were suggested based on the results.

1.1 Digital Textbook and Pilot Schools

The introduction of DT began in earnest in 2007 through the government's 'Plan to generalize digital textbooks'. DT is defined as digitalized textbooks for students that are contained abundant learning materials such as terminology dictionary, multimedia, evaluation items, contents for supplementary learning and are emphasized function of support and management for learning [7].

Early versions of DT were electronic forms available only on a unified platform. DT was

developed to run in Windows or Linux environments. However, this made the students' heavy backpack lightly, and it was no different from the existing textbook.

In order to improve the learning effect, the cloud computing system has been improved so that the contents can be used in various terminals. It includes not only existing textbooks but also textbooks, dictionaries, supplementary learning materials, and rich multimedia materials. In addition, it has memo and highlight functions that allow learners to display important content and record additional content.

DT can help students' understanding in that it contains various multimedia and linkage of online materials that cannot be included in PT [1].

Currently used DT contains various multimedia and online materials in the form converted paper type into digital type as it is as shown in Figure 1 and Table 1. DT is based on the cover, table of contents, and images of the PT, and additionally includes bookmarks, memo, various images and video, highlights, search, and animation.

The reference books, evaluation items, and terminology dictionaries enable students to become self-directed learners at anywhere and anytime according to their learning pace and style [1]. The online community linked to DT can facilitate interaction between learners and learners or teachers by sharing opinion with others so that can occur additional learning [8].

The DT of all subjects is composed of the same structure. The characteristics of the subject does not reflected. In addition it is not enough teaching and learning materials being able to improve learning by interacting with learners and DT.

The operation of pilot schools was started from 20 schools in 2008, 103 schools in 2009, 132 schools in 2010, 64 schools in 2011, 13 schools in 2012, 144 schools in 2013, 163 schools in 2014, and 134 schools in 2015 and targeted 4th, 5th, 6th, 7th grades [9]. The applied subject is 6 subjects in Korean language, mathematics, science, social studies, English, and music. Each pilot school can select subjects as much as is desired. Also pilot school has analyzed the effects of DT on academic achievement, self-directed learning skill, problem-solving skill, attitude toward subject, satisfaction, learning immersion, and eyesight.

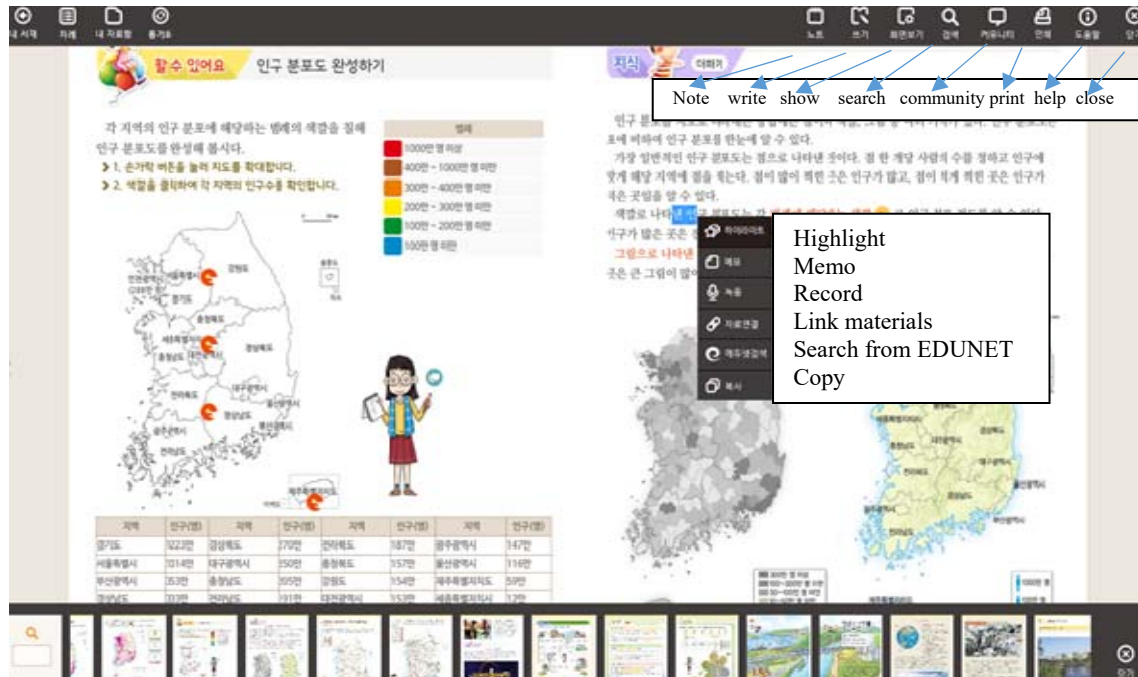


Figure 1: DT interface (Population distribution unit of Social studies)

Table 1: Main Function of DT

Supporting and facilitating learning	Interaction and link with various information resources	Key learning function	Evaluation tool and learning management
<ul style="list-style-type: none"> Multimedia support - data integration like images, pictures, animations, sound, movies, 3D etc. References - Resources for self-directed learning Hyperlink - various connections needed for self-directed learning Learning dictionary 	<ul style="list-style-type: none"> Linkage with information resources - Edunet - Linkage to the national knowledge database - educational contents owned by political / economic / social / cultural institutions Interaction - interaction with experts via web - interaction with external organizations via web 	<ul style="list-style-type: none"> Printed textbook function - Taking notes - memo - bookmark - Turning pages 	<ul style="list-style-type: none"> Evaluation tool - DT system and internal/external evaluation tool - Provision of supplementary/enrichment learning materials Learning management system - Portfolio management of learners - progress and level diagnosis of learners

1.2 Digital Textbook and Academic Achievement

Academic achievement is essential purpose of education. Therefore academic achievement must be considered in the introduction of DT. Korean Education and Research Information Service, the Ministry of Education-affiliated, has conducted the effect of DT on academic achievement every year. However different results were discussed per each study.

In 2008, studies on the effectiveness were conducted for 5th, 6th grade students at 23 elementary schools – 681 students in experimental group and 673 students in control group. The results showed that academic achievement was significantly different between urban areas and rural areas. In urban areas, DT is effective on Korean language, social studies, and science, but not English, mathematics. On the other hand, DT is effective on all subjects in rural areas [10].

In 2009, there are 72 pilot schools that have 3,658 students in experimental group and 3,012 students in control group. The improvement of academic achievement was occurred on social studies and science. Also there was effective for male students on Korean language, social studies, science, but for female students on science only. From a regional perspective, DT was effective on Korean language, social studies, science, and English in rural areas [11].

DT pilot schools were 131 schools and were expanded to 4th grade in 2010. There were 6,052 students. The effect on academic achievement was totally no significant differences between DT and PT and was only in science from perspectives of subjects [12].

32 schools of 63 schools were randomly sampled for analysis on effectiveness in 2011. There were 5,120 elementary and secondary school students. There was no effect on academic achievement between DT and PT. In terms of subjects DT was more effective only science and social studies than PT [9]. The results of this study proved that the opinions of those advocated about the use of DT were wrong. These supports the learners' portability and does not satisfy the expectation that the provision of abundant learning materials will help learners' learning improvement.

According to 'The analysis of effectiveness on digital textbook pilot schools' in 2014, Research Report from KERIS, overall results on effects of DT were suggested based on reports of pilot schools from 2008 to 2012. The results showed that DT was effective on academic achievement. However, these were not reliable and were not generalized. Because the results were drown by simply counting and comparing the number of schools between effective studies and ineffective studies [13].

1.3 Purpose of the Meta-Analysis

The studies on the effectiveness of DT have shown different results. Some studies showed that DT was effective on only particular subjects and others did not. And even if DT was effective, some results showed a small effect size and others did not.

Different results per each study finally led to a negative perception that full adoption of DT would be ineffective when considering the costs of introducing DT at schoolwide. There were also suggestions that the use of digital devices would rather interfering with learning. These controversies

are time consuming and do not play a productive role in deduction of how to improve DT henceforward.

Therefore, in this study, meta-analysis method was adopted. Meta-analysis is a systematic approach that uses statistical techniques to synthesize individual findings and to draw comprehensive conclusion. Thus valid and generalized conclusion can be drawn about the different outcomes of studies conducted on the similar topic.

1.4 Purpose of Meta-Analysis on Effect of DT

Since 2008, effectivity of DT Every year has raised controversy whether DT is effective or not, whether the effect is great or not, and whether effect on each subject is effective or not etc. In the case of the existing effectiveness analysis study, it is difficult to represent the effectiveness because the result is derived from the group consisting of too few persons or the effect is analyzed from some of the studies conducted from 2008. In addition, all pilot schools have been surveyed but it is not possible to guarantee the transparency and credibility of the effect from the narrative review method.

Therefore the effect of DT on academic achievement was clarified and reliability and transparency of results was ensured through meta-analysis on academic achievement based on the results of the DT pilot schools from 2008 to 2012.

2. MATERIALS AND METHODS

2.1 Criteria for Study Inclusion

All research schools have to submit reports of operation results to the Ministry of Education. Statistical data of study should be included in the report of the research school. The results of pilot schools were selectively analyzed according to academic achievement, self-directed learning ability, problem-solving ability, internet addiction, and visual acuity. Some pilot schools have comparative groups and statistical values are presented as means, standard deviations, and sample numbers, while some research schools have no comparative groups or only averages.

Therefore the data selection criteria for meta-analysis were designed to systematically analyze the effect of DT on academic achievement. The criteria are as follows:

First, research subject for meta-analysis is DT pilot schools. DT pilot schools are under systematic management of the Ministry of

Education so that are appropriate to reduce the differences between schools in terms of methodological quality.

Second, the lesson should be taught using DT and the effect of academic achievement should be measured.

Third, statistical information should be presented that can produce an effect size for meta-analysis like average, standard deviation, sampling number etc.

Fourth, both control groups and experimental groups should be prepared.

2.2 Extraction and Computation of Effect Sizes

The entire reports from DT pilot schools from 2008 to 2012 were analyzed for the effect of DT on students’ academic achievement. DT pilot schools are still operated but the reports on academic achievement only exist until 2012. Because pilot schools operation policy was focused on self-directed learning and problem solving skills since 2013.

715 of 1,544 pilot schools including academic achievement were selected based on the selection criteria. Table 2 shows the details of the analysis subject.

There are 141 science, 159 Korean language, 164 social studies and 69 English in total of 715 data. The number of students in meta-analysis was total 54,723, 21,562 in experimental group and 33,161 in the control group. The effect size was analysis using Hedges’ g. Hedges’ g corrects the weakness of Cohen’s d which is difficult to estimate the standard deviation of an accurate population due to the tendency to overestimate effect size in case the number of cases is small.

Table 2: Research Subject

Object	Effect data on Academic achievement from research reports of DT pilot schools between 2008 and 2012
Type	Quantitative research
data	Total 715 subject - Korean language: 159 - Mathematics: 164 - Social studies: 182 - Science: 141 - English: 69 Total 54,723 students - Experimental group: 21,562 Control group: 33,161

3. RESULTS AND DISCUSSION

Summary effect size is listed in Table 3 to verify the effect of DT on academic achievement. Q value is 720.867(p>.05) and heterogeneity is not statistically significant at the .50 level. It means that each effect size is homogenous.

I² statistic describes the percentage of variation across studies that is due to heterogeneity. If I² of meta – analysis is 0, it means that variability in effect size is from sampling error within studies. On the other hand, If I² of meta – analysis is 50, it means that 50% of the total variability amongst effect size is from heterogeneity between studies. According to Higgins and Thompson [14], percentages of around 25% (I² = 25) means low heterogeneity, percentages of around 50% (I² = 50) means medium heterogeneity, and percentages of around 75% (I² = 75) means high heterogeneity. The I² = 0.953 in this research means that all variability in effect size estimates is by low heterogeneity between studies. Therefore fixed effect model is adapted.

Table 3: Weighted summary effect size of DT utilization on academic achievement (Total)

Model	Effect size and 95% CI					Heterogeneity			
	k	ES (g)	U ₃	95% CI		Q	df	P	I ²
				Lower	Upper				
Fixed	715	0.23	59.10	0.21	0.25	720.867	714	0.421	0.953
Random	715	0.23	59.10	0.21	0.25				

K: Number of effect sizes, ES (g): Effect size (Hedges’ g), U₃: Cumulative distribution of effect size, 95% CI: 95% confidence interval, Q: Dispersion of observed distribution, df: Dispersion based on the effect size of the same population, I²: Ratio of the actual dispersion to the total dispersion

The weighted summary effect size in this study was 0.23 (95% CI 0.21 – 0.25), and positive number on effect size indicate that DT has a positive effect on academic achievement compared to PT. According to Cohen [15], this result means that the use of DT had a small positive effect compared to the PT. Percentile U_3 , the cumulative distribution method of effect sizes, showed a percentile of 59.10. This means that experimental group has a 59.10% achievement rate when the control group has 50% achievement rate. This

result shows that achievement rate at experimental group is 9.10% higher than achievement rate at control group and the instruction using DT is more effective on academic achievement than that using PT [16].

Table 4 shows the effect of DT for each subject. Small summary effect sizes were found in all subjects – science, Korean language, social studies, mathematics, and English.

All effect sizes were statistically

Table 4: Weighted summary effect sizes of DT utilization on academic achievement (Subject)

Subject	Effect size and 95% CI					Heterogeneity			
	k	ES(g)	U_3	95% CI		Q	df	P	I^2
				Lower	Upper				
Science	141	0.26	60.26	0.21	0.31	205.28	140	0.000	31.80
Korean	159	0.23	59.10	0.19	0.27	181.98	158	0.093	13.18
Social studies	182	0.24	59.48	0.21	0.28	178.04	181	0.548	0.00
Math	164	0.21	59.32	0.17	0.25	117.40	163	0.997	0.00
English	69	0.23	59.10	0.17	0.28	36.58	68	0.999	0.00

K: Number of effect sizes, ES (g): Effect size (Hedges' g), U_3 : Cumulative distribution of effect size, 95% CI: 95% confidence interval, Q: Dispersion of observed distribution, df: Dispersion based on the effect size of the same population, I^2 : Ratio of the actual dispersion to the total dispersion

Funnel Plot of Standard Error by Hedges's g

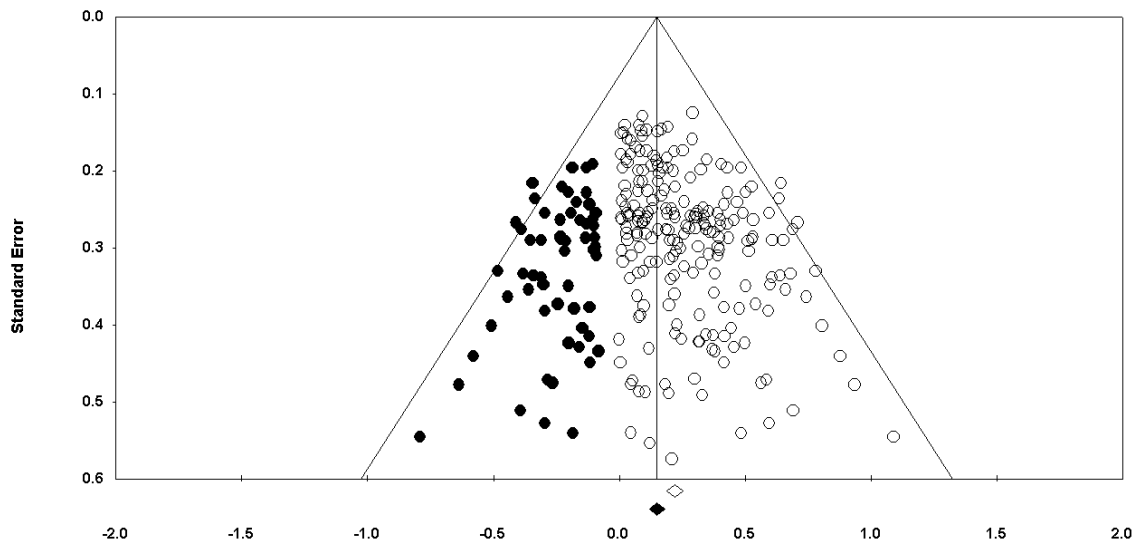


Figure 2: Funnel plot diagram of the 715 effect sizes for academic achievement outcomes

significant because they did not include 0 in the 95% confidence interval level. Percentile U_3 shows that DT is more effective 10.26% for science, 9.10% for Korean language, 9.48% for mathematics, and 9.10% for English.

The achievement rate of all subjects is similar despite having different characteristics. This study did not reveal the cause of these results. So it needs to be clarified through subsequent studies and to be checked whether there is an initial curiosity about using DT or other reasons.

Publication bias can occur if considerable studies were missed or not included in a meta-analysis. These missed or not included studies can lead to wrong result unlike when analyzing entire studies [17, 18]. In order to identify missed studies or sampling bias, the existence of a publication bias was examined by mean of Egger's regression intercept, Classic fail-safe N, and Funnel Plot [19].

The analysis of the funnel plot indicated that data tended to not be symmetrical with respect to the summary effect size as shown in Figure 2.

Egger's regression test was conducted to test statistical significance of publication bias. Egger's regression test showed that the p value of intercept was statistically significant ($p < .05$), which means that publication bias exists. The effect size was corrected using the Duval and Tweedie's Trim and Fill method. The summary effect size of adjusted value decreased to 0.17 (95% CI 0.15 – 0.19) compared at initial effect size of 0.23, but it was confirmed that DT is still more effective than PT.

The results of the meta - analysis that DT is more effective eliminate the controversy about the effectiveness of DT, the diversity of effect sizes, and the diversity of effects by subjects.

4. CONCLUSIONS

In order to verify the effect of DT on academic achievement, meta-analysis was conducted. There has been much controversy as to whether DT could be fully introduced into the schools. This is because many studies on DT suggest different results on whether or not DT is effective. As a result of all survey on the academic achievement of DT pilot schools, which have been in operation since 2008, it was confirmed that DT has a small summary effect size on academic achievement improvement compared to PT. It was

indicated that DT is more effective on academic achievement than PT.

Though DT is effective on academic achievement, to make learning more effective reflecting characteristics of DT, the following suggestions were proposed:

First, DT needs to be composed to fully reflect the characteristics of each subject. The current DT has a form moved PT to a digital device and added multimedia materials. This configuration is the same for all subjects. However, each subject has different characteristics. For example, it is appropriate that the reading of the Korean language is mainly composed of text. On the other hand, for the social studies, it can be more effective to be composed of images of video that can understand the context of historical events rather than text. In social studies, it may be appropriate to use some of the text to represent the core concept. Since science is the subject that explores scientific phenomena, it is necessary to focus on the simulation materials that can be experimented and identified the process of scientific phenomenon.

Second, there is a need to support learning by including interactive materials with learners. One of many advantages is that DT can include a variety of multimedia. This feature enables learners to experience too dangerous to experiment or too long time taken to observe through interactive simulation. For example, the motion of the planets in the solar system cannot be experienced during lessons because it takes a lot of time to actually observe. However, by interacting with relevant simulation in DT, students can easily observe what a planet's movement looks like and why.

Third, it is necessary to provide an opportunity to extend the learners' thinking by connecting the contents presented in DT to the other subjects. The talents required by the 21st century society are not those who have a lot of knowledge, but who can use various related knowledge to think broadly and solve problems. Therefore, it is necessary to link the various related knowledge throughout subjects and to enable the learners to view the knowledge from various viewpoints and extend the range of thinking.

The research result presented in this study, DT is more effective on improving students' academic achievement than PT, can be dissolved much controversy about DT introduction. Despite the meta-analysis targeted to all pilot schools was conducted,

As a result of the analysis of effectiveness by subject, it was more effective to introduce DT. However, the size of the effect was very similar for each subject, but the cause could not be revealed.

Also, the statistical figures from the study school are the result of applying for about 2 months. Because each subject is between 2 and 4 weeks in a week, the results are the result of application from a minimum of 18 hours to a maximum of 32 hours.

The learning effect of DT is needed to be analyzed more deeply by combining qualitative research and longitudinal analysis to clarify whether the learning effect from curiosity the introduction of new devices or difference of teaching and learning method or real effect from introduction of DT because this is not a result of long-term observation.

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