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REVIEW ARTICLE

Verification of the effectiveness of digital therapeutics principle textbooks for elementary and secondary school teachers

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ABSTRACT

As the digital transformation of medical systems accelerates, digital therapeutics based on digital technology is attracting attention. Research on digital therapeutics has just begun, and the digital therapeutic market is growing internationally. For students to prepare for an intelligent information society, teachers must be prepared to lead and teach the principles of promising convergence technologies in the future. In this paper, we developed textbooks that can teach the principle of digital therapeutics (DTx) to elementary and secondary school teachers. Textbooks for elementary school teachers were designed with the principle of DTx for attention-deficit/hyperactivity disorder (ADHD), and textbooks for middle school teachers were developed with DTx corresponding to digital dramas as the central theme. The textbooks were developed based on the analyze learners, state objectives, select methods, media, and materials, utilize media and materials, require learner participation, evaluate and revise (ASSURE) model and included teaching and learning plans, worksheets, and reading materials for immediate use in the school field. In addition, textbooks can be used in non-face-to-face classes by using customized online teaching tools. In order to confirm the effectiveness of the developed textbooks, we applied the textbooks to 33 Korean teachers. As a result, teachers' teaching and learning competency and information teaching efficacy were improved in preparation for the intelligent information society of elementary and secondary school teachers. It was a statistically significant result.

Keywords: digital therapeutics; computer science textbook; experimental verification; information teaching efficacy; teaching and learning competency

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1. Introduction

Intelligence information technology, combining artificial intelligence with the Internet of Things, big data, cloud, and mobile-based information, has emerged as a critical keyword of the fourth industrial revolution. Therefore, it is becoming essential to cultivate talents who understand it. The world is paying attention to the fact that intelligent information technology will be the driving force of the fourth industrial revolution and has a destructive influence on human society. Overseas advanced countries systematically conduct huge investments and large-scale research to preempt future initiatives. In December 2016, the Korean government also released a policy report containing strategies for measures for an intelligent information society to cope with the fourth industrial[1].

With the development of digital-based information technology, digital transformation occurs across all industries. Among many industries, digital innovation in the medical field has recently been in the spotlight. Digital therapeutics (DTx) were selected as a promising

future technology to pay attention to by world-renowned research institutes such as the world economic forum[2] and Mckinsey & company[3]. Also, in south Korea, the Korea health industry promotion agency focused on DTx as one of the top 10 technology trends in 2021[4].

Therefore, in this study, DTx, a concept relatively unfamiliar to the general public compared to the need to know among a wide range of information technologies, were set as the subject of creative information education textbooks. Through conceptual understanding of future technologies and principles, teachers and students can increase their interest in related information technologies. Suppose teachers improve their understanding of the field and learn the application principles used in various fields. In that case, this teacher's understanding will naturally be linked to career exploration and contribute to fostering talent that fosters the technological capabilities required by future society. This paper shows the results of developing textbooks that can teach students the principles of DTx for elementary and secondary school teachers to foster future talents with an understanding of information technology. The textbooks were designed with the theme of DTx for attention-deficit/hyperactivity disorder (ADHD) for elementary school teachers, and DTx for digital drama, a type of cyber violence that occurs among teenagers, for middle school teachers. In addition, this paper aims to prove the effectiveness of the textbook by confirming how the developed textbooks improved the efficacy and competency of teachers.

2. Related works

2.1. Digital therapeutics (DTx)

In order to define the concept of DTx, it is first necessary to organize the terms of related concepts. Leading markets such as digital health and digital medicine reflect in servitization technological trends. Servitization is a strategy to maximize consumer satisfaction through sustainable and innovative value by converging tangible products and intangible services[5].

First, digital health is a broad concept in which information and communication technology and healthcare are fused to obtain health-related information. Since this is not classified as a medical device, clinical verification is not required[6]. These include mobile health apps, electric health records, electronic medical records, wearable devices, telemedicine, and customized healthcare. There are various stakeholders in this field, including patients, doctors, researchers[7,8], application developers, medical device manufacturers, and distributors.

Second, there is digital medicine as a term often used in confusion with DTx. Digital medicine refers to evidence-based hardware or software for health information measurement and is characterized by various regulatory requirements, although medical grounds are necessary[9]. It is used independently or in combination with medicines or medical devices to aid the treatment of patients. It employs high-quality, safe, and effective data-driven medical interventions facilitated by digital medicine, enabling intelligent access for patients and healthcare providers. In particular, the focus is on generating evidence to support medical technology or digital treatment devices.

Finally, DTx are digital-based treatments supported by precise medical verification when applied to humans. It is the strictest and narrowest concept of these three terms. It refers to evidence-based therapy or therapy that utilizes digital and often internet-based health technologies to facilitate changes in patient behavior. DTx provide evidence-based treatment interventions that use high-quality software to prevent, manage, or treat a wide range of physical, mental, and behavioral condition[10].

In summary, digital health is a field developed for consumers to obtain health or well-being-related data, which is not classified as a medical device. Digital medicine refers to evidence-based software or hardware that measures health, and the degree of regulation varies, so medical evidence is not necessarily required. DTx

refer to medical devices that require medical verification and are intended to prevent, manage, and treat diseases. Therefore, digital health includes digital medicine and DTx, and digital medicine includes DTx. Researches related to DTx have been exploding since 2018, and the amount of investment is expected to increase gradually, and the related market is expected to expand further in the future[11]. As such, it can be seen that DTx are future technologies based on intelligent information technology with very high future growth potential.

2.2. Information education textbook for teachers

Research on the development of information education programs for teachers and information education programs for students is being conducted by several researchers, but only a small number of research on the development of information education textbooks for teachers. In addition, it isn't easy to find information textbooks for students or textbooks for teachers with the theme of DTx.

Park et al. predicted that teachers' informatization and creative problem-solving skills would become important when computer education has just begun in Korea. Accordingly, they conducted a study on developing computer education textbooks for prospective elementary school teachers at teacher training schools[12]. They dealt with the contents of various information education in the textbook and showed the composition of the textbook as a learning goal and a simple composition as a learning content.

In the early 2000s, when personal computers began to spread to public institutions and homes, the united states began to study how to use computer technology in school classes[13]. They argued that computer technology could be used to design a student-centered learning environment. They developed teaching materials for teachers and provided several examples and guidelines for teachers to plan practical classes using computers effectively. In this textbook, computers were used as a means of subject education rather than a subject of education.

As computer science education began in earnest in k-12 worldwide, a computer science education guide for teachers was developed[14]. They used activity-based approaches to present conceptual frameworks and implementation guidelines for computer science education and structured them to be applicable to various educational levels and organizations. The textbook presented over 150 activities and ways to improve students' computing thinking, data science, and soft skills.

Meanwhile, the Jeju national university creative education center in Korea has been developing textbooks on specific ways to educate students on new advanced information technology through various teaching methods to strengthen the creative information teaching capabilities of teachers in the intelligent information era since 2017[15,16]. The center's researchers developed textbooks to train teachers who can teach students the core technology principles of advanced information and communication technology. Textbooks are divided into an overview of the subject, the necessity of the subject, core principles, core knowledge, sub-themes by each lesson, 21st-century skill maps, learning strategies, teaching and learning activities, and class materials. Four textbooks cover topics such as hyper-connected communication, advanced virtual reality, artificial intelligence and ethics, and cloud system and security. These textbooks provided instructional materials that teachers can use immediately in class and guidelines for computer classes concerning various subjects to facilitate teachers' convenience.

3. Digital therapeutics textbooks for elementary and secondary school teachers

3.1. Textbook development procedure based on ASSURE model

The textbook proposed in this study was developed based on the ASSURE model of Molenda presented

by Kim et al. as a model that can be referenced when developing textbooks for information education[17,18]. The ASSURE model is named after the initials of analyze learners, state objectives, select methods, media, and materials, utilize media and materials, require learner participation, evaluate and revise, the stages of textbook design. This model refers to a teaching model that embodies how to appropriately use various media used by instructors in the lecture process according to the situation. In particular, in this model, learning media, teaching tools, and teaching materials are regarded as essential items that determine the level and quality of learning content[19]. In this study, the ASSURE model initially developed for a class design using digital tools was based on a study by Gagne that focused on designing information education textbooks[19]. Various researchers are conducting research on the development of textbooks using the ASSURE model. Choi and Baek developed a visual simulation textbook that can be shared in game mathematics and programming subjects based on the ASSURE model. They applied the developed textbooks to students and showed that students acquired the concepts of game mathematics and programming more efficiently[20]. Yeom et al. developed an electrocardiogram (EKG) assistance textbook for nursing students by adopting the design method of the ASSURE model and analyzed its effectiveness. The EKG knowledge and confidence of the experimental group who took the class with the corresponding textbook were significantly improved compared to the control group[21]. Moreover, the ASSURE model emphasizes increasing learners' concentration by using learning media using digital technology in education. Therefore, as the classroom environment changes after the COVID-19 pandemic, this model is suitable for developing textbooks related to classes using online tools for contextualized education in online and offline classrooms. **Table 1** shows the textbook development process proposed in this paper according to the six stages of the ASSURE model.

Table 1. Textbook development process according to the ASSURE model.

Stage	Main question	Textbook development
Analyze learner characteristics	Who is the subject of the textbook?	• Teachers' interest and familiarity with intelligent information technology. • Awareness and prospects of changes in school education in the intelligent information society. • Awareness of teachers' necessary competencies in the intelligent information society.
State objectives	What should students learn?	• Audience: elementary and secondary school teachers. • Behavior: strengthening teachers' capacity to prepare for an intelligent information society and the information teaching efficacy for teachers. • Condition: after applying classes based on textbooks to students. • Degree: significant improvement in pre-and post-test results.
Select methods, media, and materials	What methods, media, and materials should instructors use in class through textbooks?	Analyzing information education methods according to teaching and learning situations and matters to be considered when using media in information classes.
Utilize materials	How will teachers use media and materials?	Developing and utilizing mobile courses using a micro-learning development platform (EdApp), unplugged worksheets (Miri Canvas), and materials using artificial intelligence.
Require learner participation	What method should students take to participate in the class actively?	Research and application of learner participation induction methods from behaviorist, cognitive, and constructivist perspectives.
Evaluate and revise	How can textbooks be supplemented?	Reflecting on the results of the effectiveness analysis after applying the textbook to future textbook production.

First of all, in the first stage of the ASSURE model, the learner characteristic analysis stage, the characteristics of teachers were identified because the readers of the textbooks proposed in this paper were elementary and secondary school teachers. Then, the Korea institute of curriculum and evaluation conducted a study to understand the capabilities of teachers in the intelligent information society, analyzed teachers' interest and familiarity with intelligent information technology, perceptions and prospects of changes in the

intelligent information society[22]. As a result of the survey, when looking at teachers' interest in intelligent information technology, 58.3% of the respondents said that their interest was "high", and 27.7% said that it was "very high". In addition, due to the familiarity survey on intelligent information technology, 48.3% of the respondents said they use ICT materials in class "often", and 25.8% said they use them "very often". Second, 82.5% of teachers answered positively whether they expected teachers' teaching methods to change if intelligent information technology was introduced into school education. Third, when asked whether incumbent teachers need to prepare for changes in school education caused by the introduction of intelligent information technology, no teacher said that teachers' preparation for educational changes was not significant. In conclusion, teachers agreed that they would need their countermeasures for intelligent information technology and were highly willing to explore related materials for this purpose. **Table 2** shows the results of the detailed teacher characteristics analysis.

Table 2. Results of teacher characteristics analysis.

Variable		**Response (%)**				
Interest and familiarity in intelligent information technology	Interest in change due to intelligent information technology	Very low	Low	Moderate	High	Very high
		0.8	0.0	13.3	58.3	26.7
	ICT data utilization during class	Very raley	Raley	Sometimes	Frequently	Very frequently
		2.5	1.7	20.8	48.3	25.8
Awareness and prospects of school education changes in intelligent information society	Change in teaching methods of teachers	Strongly disagree	Disagree	Undecided	Agree	Strongly agree
		0.0	0.8	7.5	51.7	30.8
Awareness of teachers' necessary competencies in the intelligent information society	Teachers' readiness for educational change	Not important	Slightly important	Moderately important	Important	Very important
		0.0	0.0	6.7	49.2	35.0

The second procedure is stating objectives. The primary goal of the textbooks was to enhance teachers' capabilities in teaching information classes in the future, with the ultimate aim of nurturing students to become the talents required by the future society. In order to specifically state the objectives of the textbook proposed in this study, Mager's study target was presented, and audience-behavior-condition-degree (A-B-C-D principle), a principle that states the learning goal by presenting the expected behavior, conditions, and certain criteria that the learner's achievement behavior may occur[23]. First, the audience of the textbook was aimed at elementary and secondary school teachers who taught students in schools. Second, the behavior expected through textbooks is to improve teachers' competence in preparation for an intelligent information society and information teaching efficacy. Third, the condition for the second actions to come out was based on the application of the class to students. Fourth, the degree of behavior that can be achieved through the textbook is to determine that the second behavior has been achieved if there is a significant improvement in the pre-posttest.

The third procedure is the selection of teaching methods, media, and materials. In the textbooks, we selected EdApp, an online customized learning tool, and adopted gamification that can increase interest or unplugged education techniques for various educational environments. In this study, the media was selected by referring to the research presented on the matters to be considered when using the media in information classes. Additionally, we designed the textbook to incorporate the media selected in the proposed class, enabling classes to be conducted in diverse situations. The study argued that appropriateness, reliability, interest, organization and balance, technical status, and cost should be considered. We tried to use vocabulary that the general public or students could understand rather than complex technical vocabulary when suggesting class materials. It also suggested using an online platform or virtual reality machine that allows users to

experience information technology in person to increase interest in teaching materials. In addition, we have developed unplugged materials that are fine for conducting education in various educational environments considering cost problems.

The fourth procedure is utilizing media and materials. **Figure 1** shows part of the first screen of the ADHD DTx class using EdApp, one of the media selected in the third step.

Figure 1. Mobile courses using EdApp.

EdApp is an online platform that converts class materials into a form that enables mobile learning. The textbook presents detailed teaching and learning courses and teaching and learning activities for teachers to conduct field classes. We have produced a mobile course that allows all classes with EdApp. In the textbook proposed in this study, various worksheets were included as appendices to promote teacher convenience. Through the provided template, the worksheets were produced using a Miricanvas that can efficiently produce various documents or materials that require design, such as study materials, presentation materials, and posters. We produced the worksheet using several fonts and colors to increase students' concentration and participation in class. We also developed classroom guidelines for class, class materials to help them understand concepts, materials for learning games, and unpluggable materials for small muscle development. **Figure 2** is part of the unplugged worksheet using the Miricanvas.

Figure 2. Unplugged worksheets using Miricanvas.

The fifth step is the step of inducing learner participation. The textbooks encouraged learners to participate in classes by increasing learners' interest in DTx, a relatively unfamiliar concept. Kim and Park proposed to induce student participation from the perspective of activism, cognitivism, and constructivism for effective teaching and learnin[24]. In this study, according to the behaviorist perspective, it was suggested that the class textbook in this study provides quick feedback on the student's responses. Therefore, it was recommended to provide this feedback systematically from a quantitative and qualitative perspective based on evaluation tools such as self-evaluation, peer evaluation, and reflection journals of students and the results collected through teacher observation. In addition, various teaching and learning activities and materials were proposed to maximize the learning effect on future information technology, a relatively unfamiliar concept according to the cognitive perspective. Also, video production activities were designed to increase interest and help them immerse themselves in learning, and learning games were developed. Through this process, it was judged that learners could link new knowledge to player knowledge that they already knew and transfer what they learned from short-term memory to long-term memory. According to the constructivist perspective, various opportunities for students to experience and perform themselves were provided away from simple

lecture-type classes. These learning opportunities could instill confidence in students to connect what they learned with behavior when they faced a situation where they would use information technology.

The final step is evaluation and revision. As a way to evaluate the textbook itself, an effectiveness analysis analyzes the application results of teachers after applying the textbook. Based on this result, future textbooks can be modified and advanced. Therefore, this study analyzed how the teacher's competency changed compared to the intelligent information society and how the information teaching efficacy improved while applying the textbook to students.

3.2. Textbook content composition

The ADHD DTx principle textbook for elementary school teachers provides a curriculum proposal and materials that can be taught in four classes. The first session focuses on understanding the basic principles of ADHD DTx and conducts a debate on the pros and cons of ADHD treatment through games. The second session is about applying ADHD DTx; students experience attention-improving games. The third session examines the application case of ADHD DTx and performs an unplugged learning game that can understand the brain-computer interface. Finally, the fourth session is based on the future of ADHD DTx, and students draw their future ADHD treatments using artificial intelligence tools.

The DTx principle textbook corresponding to digital dramas for middle school teachers presented three classes. The first session is designed to understand the principles of cyberbullying and DTx, with the theme of understanding DTx in response to digital dramas. In the second session, students experience creating cyber violence prevention videos to create DTx corresponding to digital dramas indirectly. Finally, in the third session, students share opinions on how to respond effectively to digital dramas. **Table 3** shows the main contents of each session proposed in the textbook.

Table 3. Curriculum for understanding DTx principles.

Level	Topic	Class	Contents
Elementary school	Understanding ADHD DTx basic principles	1/4	• Understanding ADHD DTx basic principles • How to treat neurodevelopmental disorders through digital technology and gaming with a selective stimulus management engine
	Application of ADHD DTx	2/4	• ADHD DTx cases • Effective communication skills using sandwich methods
		3/4	• Three-dimensional multi-object tracking principles • BCI as a game to explore cognitive improvements
	Future of ADHD DTx	4/4	• Prospect of development of ADHD DTx • Effective ways to treat ADHD
Secondary school	Understanding DTx against digital drama	1/3	• Differences between digital drama and cyberbullying • DTx concepts
	Development of DTx against digital drama	2/3	• DTx cases to prevent cyberbullying • Examples of DTx that treat victims of digital drama or prevent digital drama
	Proposal for digital drama response plan	3/3	• Production of digital drama prevention education video using an artificial intelligence platform • Discuss ways to respond to and prevent digital dramas effectively

4. Research methodology

4.1. Study design

This paper aims to develop creative information education textbooks under the theme of DTx for elementary and secondary school teachers and verify their effectiveness. To this end, the study was designed

in **Figure 3**.

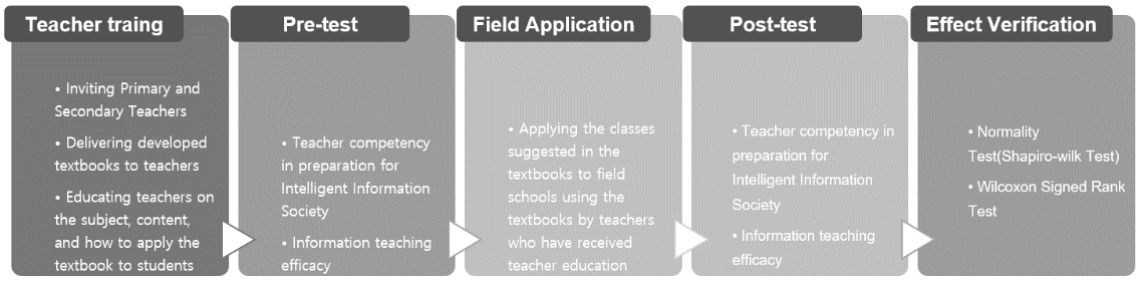

Figure 3. Research process.

Teacher education was conducted to apply the developed to achieve the purpose of the study. First, we recruited elementary and secondary school teachers to participate in the study, and textbooks developed were provided to them. In teacher education, we explained the contents of textbooks and textbooks on DTx, ADHD, and digital dramas and gave detailed lectures on how to apply textbooks in field schools. After returning to school, each teacher performed a preliminary examination before giving a class to the students. Teachers tested teachers competencies necessary for an intelligent information society and information teaching efficacy. After completing all the pre-examinations, the teachers provided the students with teaching materials. Teachers conducted face-to-face, non-face-to-face, or blended classes according to the field school situation and used teaching and learning materials provided by textbooks. After completing the field application, the teacher performed one more test of the same question as the pre-test. Finally, we conducted an effectiveness analysis based on the test results of teachers.

4.2. Test subjects

The study subjects were limited to elementary and middle school teachers in Korea, and 18 elementary school teachers, 15 middle school teachers, and 33 teachers were recruited. They knew general information technology, but they were new to DTx. Elementary school teachers provided education to their homeroom class students, and middle school teachers provided education during the subject class because the students they taught differed depending on the subject. Middle school teachers participated in digital drama digital therapy textbook classes for middle school teachers, including Korean, ethics, and informatics subjects pointed out as related subjects.

4.3. Research instruments

The textbooks of DTx developed in this paper aim to enhance the understanding of intelligent information technology of elementary and secondary school teachers and to design classes that can positively affect students' learning motivation and achievement. Therefore, to analyze the effectiveness of teachers' application to the development of DTx principles textbooks in response to ADHD and digital dramas, teachers' teaching and learning capabilities and information teaching efficacy were analyzed compared to the intelligent information society.

As the test papers for participants in the study, the competency and behavioral indicators teachers should have in the intelligent information society school education presented by Hong et al. were used[25]. The competencies presented in this study consist of 14 behavioral indicators, including continuous professional development, social paradigm change response, information ethics, curriculum restructuring, learning ecosystem creation and management, customized learning design, actual learning problem development, learning resource utilization, empathetic communication, class problem solving, facilitation, learning performance evaluation, data-based learner diagnosis, big data interpretation, and utilization abilities. The validity average for 14 competencies was 3.85, the content validity ratio was 0.99, the validity average for 32

behavioral indicators was 3.71, and the content validity ratio value was 0.98, which can be seen as proving the validity of the question.

The second research tool for teachers is to measure information teaching efficacy. This study used the teaching efficacy tool focused on information education proposed by Park et al.[26]. This research tool consists of information teaching values, information teaching strategies, and information infrastructure utilization factors, including nine questions for information teaching strategies, six questions for information teaching values, and three questions for information infrastructure utilization[26]. As a result of the reliability analysis of this measurement tool, it can be seen that the information teaching strategy has a high reliability of 0.927 Cronbach's 9, 0.851 information class value, and 0.822 in information infrastructure utilization, with an average of 0.867.

4.4. Data analysis

The quantitative analysis method was used to verify the effectiveness of the textbooks in this study. As an analysis method of quantitative research, the Shapiro-Wilk test was performed for the normality test, and descriptive statistics and Wilcoxon signed-rank test, a nonparametric test, were performed. Since the number of samples was less than 30, a nonparametric test was conducted. The tool used for the analysis is the SPSS 24.0 program.

5. Result and discussion

A total of 33 teachers participated in the study, 18 elementary school teachers and 15 secondary school teachers, and all participants faithfully responded and used all the response results for analysis. Therefore, the results of the effectiveness analysis of the textbook are divided into the analysis of the results of teachers' teaching and learning competencies preparing for the intelligent information society and the analysis of the results of information teaching efficacy.

5.1. Analysis result of teachers' teaching and learning competencies preparing for the intelligent information society

Since the research sample of elementary school teachers who are the subjects of the study was less than 30, it was necessary to verify the normality of the group. Accordingly, the Shapiro-Wilk test was performed on the pre-test results, and the normality of all factors was not secured ($p < 0.05$). Therefore, Wilcoxon signed-rank test was performed in the analysis of the results of the teaching and learning competency test of intelligent information society teachers.

As a result of the test, the factors with the highest pre-average score were the learning ecosystem creation and management and empathetic communication ability factors (mean = 3.56, standard deviation = 0.705). It was found that the factor with the highest post-test average score was the learning performance evaluation ability factor (mean = 4.00, standard deviation = 0.840). The factor with the lowest pre-average score was responding to social paradigm changes response capability (mean = 2.44, standard deviation = 0.616), and the factor with the lowest post-average score was big data interpretation and utilization ability (mean = 2.72, standard deviation = 0.752). In most factors, it was confirmed that the average score after application increased compared to before application. However, the average scores of the pre-and post-test were the same at 3.56 for the creation and management of the learning ecosystem and the factors of sympathetic communication. Among the 14 factors, continuous professional development, social paradigm change response, curriculum restructuring, and data-based learner diagnosis ability factors showed an increase in average values before and after the test ($p < 0.01$). In addition, the average value of learning performance evaluation ability factors was also improved afterwards, and statistically significant results were found ($p < 0.05$). Other factors, such as information ethics, customized learning design, actual learning problem development, learning resource

utilization, class problem solving, facilitation, and big data interpretation and utilization, increased teachers' teaching and learning ability to prepare for an intelligent information society before using ADHD digital therapy principles. **Table 4** shows the analysis of the results of the teachers' teaching and learning competencies test intelligent information society of elementary school teachers. **Figure 4** schematically shows the changes in the teaching and learning capabilities of elementary school teachers for preparing the intelligent information society of elementary teachers.

Table 4. Changes in the teaching and learning capabilities of elementary school teachers for preparing the intelligent information society ($N = 18$).

		Mean	**Standard deviation**	***z***	***p***
Continuous professional development	Pre	3.00	0.594	−2.725**	0.006
	Post	3.78	0.732		
Social paradigm change response	Pre	2.44	0.616	−3.244**	0.001
	Post	3.67	0.970		
Information ethics	Pre	3.50	0.618	−0.277	0.782
Information ethics	Post	3.56	0.616	-	-
Curriculum restructuring	Pre	2.50	0.924	−2.893**	0.004
	Post	3.39	0.778		
Learning ecosystem creation and management	Pre	3.56	0.705	0.000	1.000
	Post	3.56	0.616		
Customized learning design	Pre	2.61	0.698	−1.833	0.067
	Post	3.17	0.707		
Actual learning problem development	Pre	3.33	0.767	−1.155	0.248
	Post	3.56	0.616		
Learning resource utilization	Pre	3.39	0.698	−1.710	0.087
	Post	3.83	0.786		
Empathetic communication	Pre	3.56	0.705	0.000	1.000
	Post	3.56	0.511		
Class problem solving	Pre	3.61	0.608	−0.302	0.763
	Post	3.67	0.485		
Facilitation	Pre	3.11	0.758	−1.645	0.100
	Post	3.67	0.907		
Learning performance evaluation	Pre	3.44	0.705	−2.233*	0.026
	Post	4.00	0.840		
Data-based learner diagnosis	Pre	2.56	0.856	−2.709**	0.007
	Post	3.61	0.850		
Big data interpretation and utilization	Pre	2.50	0.786	−0.922	0.356
	Post	2.72	0.752		

*$p < 0.05$, **$p < 0.01$.

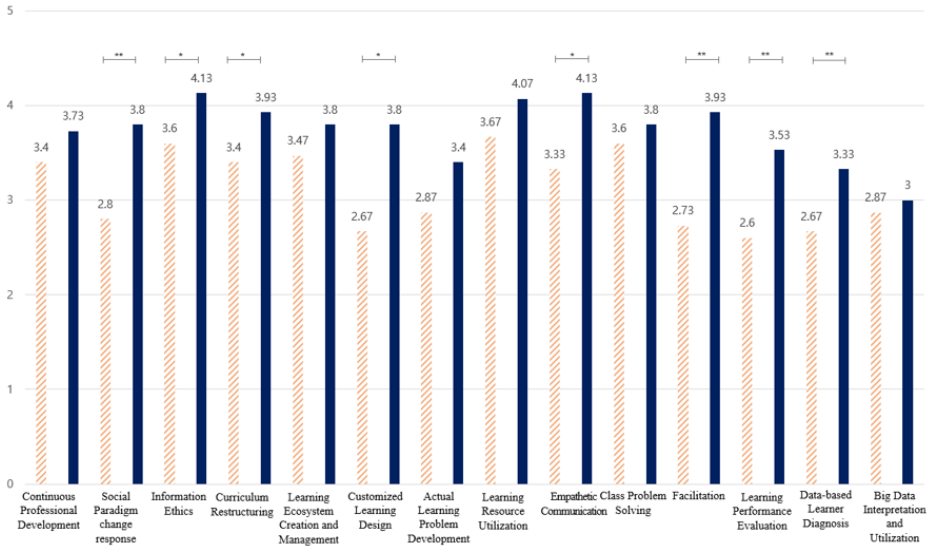

Figure 4. Diagram for changes in the teaching and learning capabilities of elementary school teachers for preparing the intelligent information society (N = 18).

Since the number of samples of secondary school teachers is 15 to 30 or less, normality verification is required. However, as a result of the Shapiro-Wilk test, the probability of significance of all factors was lower than 0.05, so it can be seen that normality was not secured. Therefore, Wilcoxon signed-rank test was also performed in a study on elementary school teachers.

As a result of the test, the highest pre-average score was the use of learning resources utilization (mean = 3.67, standard deviation = 0.617), and the highest post-average score was information ethics (mean = 4.13, standard deviation = 0.834) and empathetic communication (mean = 4.13, standard deviation = 0.640). However, the factors with the lowest pre-average score aggregated were customized learning design and data-based learner diagnosis (mean = 2.67, standard deviation = 0.617). For all factors, the average score increased posteriorly than beforehand. It was found that the average score of social paradigm change response, facilitation, learning performance evaluation, and data-based learner diagnosis improved statistically ($p < 0.01$). In addition, information ethics, curriculum restructuring, customized learning design, and empathetic communication also showed statistically significant improvements in the changes in pre-and post-tests ($p < 0.05$). The average score of learning ecosystem creation and management, actual learning problem development, learning resource utilization, class problem solving. Big data interpretation and utilization abilities increased after applying DTx digital drama textbook, but it was not statistically significant. However, all factors were elevated before and after the application of the textbook. **Table 5** is a detailed result of changes in secondary school teachers' teaching and learning capabilities before and after applying the DTx digital drama textbook. **Figure 5** schematically shows the changes in the teaching and learning capabilities of elementary school teachers for preparing the intelligent information society of secondary teachers.

Table 5. Changes in the teaching and learning capabilities of secondary school teachers for preparing the intelligent information society (N = 15).

		Mean	Standard deviation	z	p
Continuous professional development	Pre	3.40	0.632	−1.311	0.190
	Post	3.73	0.704		
Social paradigm change response	Pre	2.80	0.676	−2.879**	0.004
	Post	3.80	0.676		
Information ethics	Pre	3.60	0.632	−2.530*	0.011
	Post	4.13	0.834		

Table 5. (*Continued*).

		Mean	Standard deviation	*z*	*p*
Curriculum restructuring	Pre	3.40	0.507	−2.309*	0.021
	Post	3.93	0.458		
Learning ecosystem creation and management	Pre	3.47	0.516	−1.291	0.197
	Post	3.80	0.561		
Customized learning design	Pre	2.67	0.617	−2.910*	0.004
	Post	3.80	0.676		
Actual learning problem development	Pre	2.87	0.640	−1.903	0.057
	Post	3.40	0.737		
Learning resource utilization	Pre	3.67	0.617	−1.613	0.107
	Post	4.07	0.704		
Empathetic communication	Pre	3.33	0.816	−2.389*	0.017
	Post	4.13	0.640		
Class problem solving	Pre	3.60	0.828	−0.749	0.454
	Post	3.80	0.775		
Facilitation	Pre	2.73	0.594	−2.994*	0.003
	Post	3.93	0.594		
Learning performance evaluation	Pre	2.60	0.507	−2.810**	0.005
	Post	3.53	0.640		
Data-based learner diagnosis	Pre	2.67	0.617	−2.673**	0.008
	Post	3.33	0.488		
Big data interpretation and utilization	Pre	2.87	0.743	−0.540	0.589
	Post	3.00	0.535		

*$p < 0.05$, **$p < 0.01$.

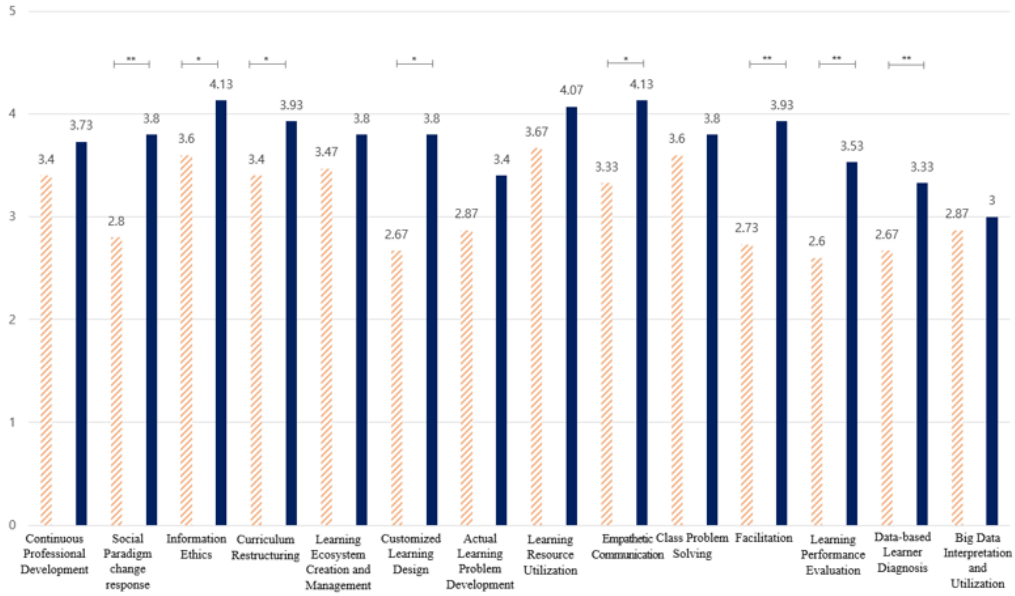

Figure 5. Diagram for changes in the teaching and learning capabilities of secondary school teachers for preparing the intelligent information society ($N = 15$).

5.2. Analysis result of teachers' information teaching efficacy

We first performed normality verification to analyze the results of the information teaching efficacy test

of elementary school teachers. Shapiro-Wilk test was performed on the pre-test results, and the normality of all factors was not satisfied ($p < 0.05$). Thus, the results were analyzed using the Wilcoxon signed-rank test, a non-parametric statistical method.

As a result of the verification, among the three factors, the factor with the highest pre-average was the factor of infrastructure utilization (mean = 3.33, standard deviation = 0.686). Similarly, the factor with the highest post-average was the factor of information infrastructure utilization (mean = 4.00, standard deviation 0.767). Furthermore, in all factors of teaching values, information teaching strategies, and information infrastructure utilization, the average score increased afterward, and only the information infrastructure utilization factor showed a significant change in statistics ($p < 0.05$). As a result, the average of all factors of information teaching efficacy of teachers using the DTx ADHD textbook increased afterward than before. **Table 6** shows the changes in the efficacy of elementary school teachers' information teaching. **Figure 6** illustrates the changes in elementary school teachers' information teaching efficacy.

The same normality test was conducted to analyze the efficacy of information teaching in middle school teachers, and the Shapiro-Wilk test showed that normality was not satisfied ($p < 0.05$). Therefore, Wilcoxon signed-rank test was used when analyzing the pre-post test results of information teaching efficacy on the application of the DTx principle textbook of digital drama.

Table 6. Changes in the information teaching efficacy of elementary school teachers ($N = 18$).

		Mean	Standard deviation	*z*	*p*
Information teaching values	Pre	3.06	0.725	−1.428	0.153
	Post	3.39	0.608		
Information teaching strategies	Pre	2.83	0.857	−1.889	0.059
	Post	3.33	0.767		
Information infrastructure utilization	Pre	3.33	0.686	−2.166*	0.030
	Post	4.00	0.767		

*$p < 0.05$.

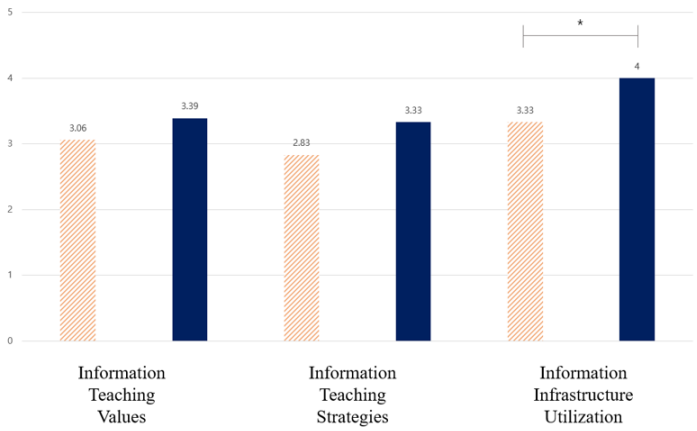

Figure 6. Diagram for changes in information teaching efficacy of elementary school teachers ($N = 18$).

As a result of the test, the factor with the highest pre-average was information infrastructure utilization (mean = 3.53, standard deviation = 0.516), and the factor with the highest post-average was information infrastructure utilization (mean = 4.53, standard deviation = 0.516). In contrast, the factor with the lowest pre-average was the information teaching strategies (mean = 2.60, standard deviation = 0.507), and the factor with the lowest post-average was the information teaching values factor (mean = 3.67, standard deviation 0.617). As a result of the information teaching efficacy test for secondary school teachers, it was found that statistically

significant improvement occurred afterward compared to beforehand in all factors. In particular, it was analyzed that the factors of information infrastructure utilization were the most significantly increased ($p < 0.001$). **Table 7** shows the changes in the efficacy of secondary school teachers' information teaching. **Figure 7** illustrates the changes in secondary school teachers' information teaching efficacy.

Table 7. Changes in the information teaching efficacy of secondary school teachers ($N = 15$).

		Mean	Standard deviation	*z*	*p*
Information teaching values	Pre	3.13	0.640	-2.271^{*}	0.023
	Post	3.67	0.617		
Information teaching strategies	Pre	2.60	0.507	-3.270^{**}	0.001
	Post	3.93	0.594		
Information infrastructure utilization	Pre	3.53	0.516	-3.638^{***}	0.000
	Post	4.53	0.516		

$^{*}p < 0.05$, $^{**}p < 0.01$, $^{***}p < 0.001$.

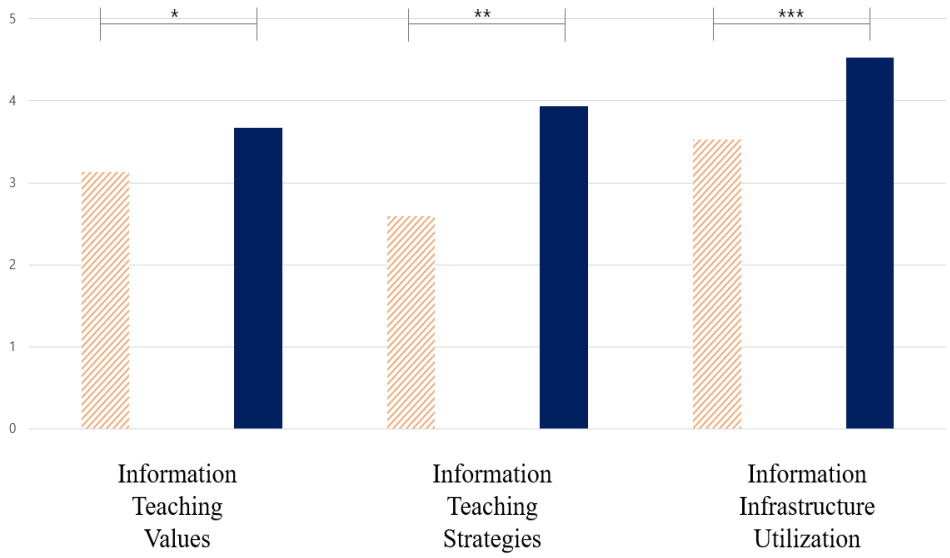

Figure 7. Diagram for changes in information teaching efficacy of secondary school teachers ($N = 15$).

6. Discussion

In information technology is constantly changing over the years, and the pace of change is gradually accelerating. In addition, understanding of information technology is making such a big difference in our daily lives that it controls our lives. And the degree of this impact is expected to increase in the future. In the end, information technology is not only the expertise that related experts should know, but also an essential concept that young students who will live in the future should understand[27].

In particular, DTx play an important role in the medical industry to the extent that they are the future of the medical community and are a convergent product of information technology and medical technology. As DTx are located at the beginning of research and the possibility of future growth is predicted to be very high, public attention is urgently needed[28].

In this paper, teacher textbooks that can teach students the principles of DTx that can treat ADHD and digital dramas, which have recently emerged as major problems in Korea, were developed and their effectiveness was analyzed. Textbooks that teach knowledge related to artificial intelligence and software can be found in recent studies, but the significance of this study can be found in that there are few studies on the development and effectiveness of textbooks related to digital treatments.

However, there is a limitation that the number of samples of teachers participating in the study is not large enough, and the teacher uses this textbook to conduct classes, and as a result, no research has been conducted on whether there has been a change in students.

7. Conclusion and future work

In the era of the fourth industrial revolution, the main body that leads innovation and value creation is considered to be intelligent information technology based on artificial intelligence technology. In line with social changes, the educational community has much to offer. Therefore, it is necessary to cultivate talented people who have developed related competencies and knowledge that lead the intelligent information society by preemptively responding[29].

This study attempted to develop information education textbooks and verify their effectiveness in strengthening teachers' capabilities in line with the rapidly changing intelligent information society. DTx, promising information technologies, were selected as the central theme of the textbook, and the textbook for elementary school teachers was based on the principle of ADHD DTx. The textbook for secondary school teachers was based on the principle of digital drama DTx. In addition, we proposed a class designed for third or fourth classes in the textbooks so that teachers can efficiently conduct information education in field schools. Based on the conceptual learning of information technology, the class is organized to understand the importance and principles of technology and induce constructivist learning through various experience-oriented activities, including artificial intelligence tools, learning games, and discussion. In addition, specific measures were provided to conduct education using an online platform so that contextualized learning could be possible even in remote classes.

The developed textbooks were applied to elementary and secondary teachers, and analyzed the results. Overall, it was confirmed that the textbooks proposed in this paper effectively improve teaching and learning capabilities to prepare for the intelligent information society and information teaching efficacy of elementary and secondary school teachers. In particular, the efficacy of information teaching among secondary school teachers improved statistically in all factors.

However, the subjects of this study were 18 elementary and secondary school teachers and middle school teachers. Therefore, there are 15 teachers, a total of 33. Since the sample of the subjects is not sufficiently secured, it is difficult to say that this study represents the overall opinions of Korean teachers. Therefore, in future studies, it is necessary to secure a broad sample and analyze the research results according to the characteristics of various teachers, such as teaching experience, region, and gender.

Acknowledgments

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Conflict of interest

The authors declare no conflict of interest.

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