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The Implementation Mechanism and Effectiveness of a National Plan of a Digital Competence Training Program for Chinese Primary and Secondary School Teachers

Qian Shi [1], Min Lan [1,2,*] and Xiulan Wan [1]

[1] College of Education, Zhejiang Normal University, Jinhua 321004, China; shiq@zhejiangedu.com (Q.S.); wanxiulan@zjnu.edu.cn (X.W.)
[2] Key Laboratory of Intelligent Education Technology and Application of Zhejiang Province, Zhejiang Normal University, Jinhua 321004, China
* Correspondence: lanmin@zjnu.edu.cn

Abstract: This study investigated the implementation and effectiveness of a national plan for a digital competence training program (DCTP) aimed at Chinese teachers. A relational content analysis was performed using policy documents, observations, and assessments to identify four DCTP implementation stages. Local educational departments and training institutes were afforded a moderate degree of autonomy to organize training activities. A t-test indicated disparities in the effectiveness of training between privately funded and publicly funded institutes, with the latter demonstrating stronger assessment outcomes in certain subject areas. The study examined the advantages and disadvantages of this implementation process, proposing collaborative efforts between privately funded and publicly funded training institutions.

Keywords: digital competence; digital literacy; training program; implementation mechanism; impact evaluation; national plan

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1. Introduction

Teachers are essential in the incorporation and execution of educational technology in classrooms. The effectiveness of teachers has been linked to student achievements, motivation, and self-efficacy [1]. Thus, in the digital age, it is imperative that teachers possess appropriate and effective digital skills to incorporate and utilize technology in a pedagogical manner [2].

When discussing digital competence (DC), various related concepts including digital literacy, ICT competencies, and internet skills are sometimes used interchangeably [3]. The distinction between DC and digital literacy (DL) can be unclear [4]. DC often refers to the skills individuals need in today's digital society [5], while DL integrates multiple kinds of literacy, like information and media literacy [6]. From an academic and policy perspective, this study adopts the definition of digital competence (DC) provided by the European Union Council [7] (p. 9), which outlines DC as "the safe, critical, and responsible use and interaction with digital technologies for learning, work, and participation in society." It comprises skills such as information and data literacy, communication and collaboration, media literacy, digital content creation (including programming), security (including digital well-being and cybersecurity-related skills), intellectual property issues, problem-solving, and critical thinking.

DC is a fundamental competency that educators must possess in the future society [8,9]. Research has shown that teachers, as learners, prefer obtaining these skills through guided programs [10]. Nevertheless, there is a worldwide concern regarding the inadequacy of training for the development and improvement of digital competencies among teachers, which may not fulfill their needs [11]. For example, Spain has launched a national plan for

digital competencies aimed at promoting sustainable and inclusive economic growth by transforming and improving education [12]. While the importance of digital competence for teachers is recognized worldwide, corresponding teacher training remains a challenge [13]. One significant contributing factor to digital competence could be the quality and quantity of in-service training [14]. This can lead to teachers feeling unprepared and overwhelmed when implementing online or remote teaching strategies and methods [15]. To ensure effective education in the digital era, there is a need for greater emphasis on digital competence training programs with practical application in teaching processes [11].

Digital competence training is a crucial aspect of Educational Informationization for primary and secondary educators in China. The Ten-Year Development Plan for Educational Informationization (2011–2020) recognizes the development of digital competence as a key element in enhancing the soft power of the education sector, promoting curriculum reform, and advancing teacher professional development. To accomplish the objective of advancing educational technology, a nationwide program was introduced to enhance primary and secondary educators' proficiency in employing information technology.

However, there is a dearth of studies clarifying the operational mechanism of a national plan and the effectiveness of such a plan in improving teachers' digital competence. Thus, this study aimed to investigate the implementation and effectiveness of government-led digital competence improvement projects through a case study using multiple sources for analysis. The study is noteworthy because it outlines the operational procedures of a national plan from multiple stakeholder perspectives. The evaluation of the program's impact at the national level could predict the challenges faced by policymakers regarding DCTP and complicate its implementation for school leaders globally.

2. Literature Review

Based on a limited number of previous empirical studies regarding the implementation of the digital competence training program (DCTP) mechanism and DCTP impact evaluation, our study identified two areas of knowledge gaps that need to be addressed. Additionally, this section provides a summary of the research questions that our study endeavors to explore.

2.1. Knowledge Gap 1: Plenty of Research on DC Frameworks but a Paucity of Studies on DCTP Implementation

Various countries have adopted diverse frameworks and models to indicate the domain content in which teachers should receive training [9]. The United Nations Educational, Scientific, and Cultural Organization (UNESCO) proposed a three-phase digital competency framework [16]. The first phase focuses on digital literacy, which helps students use technology more efficiently. The second phase is about deepening knowledge and understanding in various disciplines. The third phase emphasizes efficient knowledge management, where the effective use of technology enables the creation of new knowledge built upon existing knowledge. However, the 2018 update of the framework emphasized the importance of teachers' technological training for their professional growth, according to [17].

Bennett [18] examined the applicability of Sharp and Beetham's digital literacy framework for university teachers. The four layers of the framework—access, skills, practices, and attributes—were explored. The model highlights how access can drive the development of skills from the bottom up and how a learner's attitude towards technology can motivate the top–down acquisition of new practices, skills, and access. The study emphasized that undergoing professional development training in digital competence (DC) could enhance not only teachers' DC but also their willingness to integrate technology in their instructional practices.

Blayone [19] utilized the "General Technology Competency and Use" (GTCU) framework to conceptualize and measure the digital competence of university instructors. This framework encompasses three dimensions: epistemological processes (i.e., hypothesis

development, data analysis, and problem-solving), informational storage (i.e., effective evaluation, synthesis, searching, and knowledge production), and social transmission (i.e., collaboration, publication, and effective digital communication).

In accordance with Martínez-Bravo et al. [20], six dimensions of DL, namely critical, cognitive, social, operative, emotional, and projective dimensions, are classified based on eight DC frameworks. Assessing and teaching 21st-century skills is a critical aspect of education in the digital age. Several frameworks have been developed, including enGauge 21st Century Skills: Literacy in the Digital Age, the National Assessment of Educational Progress in Technological Literacy and Engineering Framework for 2018, and the National Educational Technology Standards. Furthermore, the OECD Future of Education and Skills 2030, the Partnership for 21st Century Skills, and the UNESCO global framework of reference on digital literacy skills for indicator 4.4.2 have also contributed to the development of these skills. Lastly, Digital Competence for Lifelong Learning, DigComp, is an essential tool for educators to help their students achieve excellence in the field of technology.

In 2014, the Chinese Ministry of Education promulgated the standard for primary and secondary school teachers' ability to apply information technology (Trial), hereafter referred to as the "ability standard" (see Appendix A). The Ministry of Education subsequently developed the training curriculum standard for primary and secondary school teachers' ability to apply information technology (Trial), hereafter referred to as the "training curriculum standard" (see Appendix B), based on this standard. The training curriculum standard has categorized the digital competency of teachers into five dimensions: technical literacy, planning and preparation, organization and management, assessment and diagnosis, and learning and development.

Above all, scholars and policymakers have proposed a range of frameworks outlining the various dimensions of digital competencies that teachers need to possess. However, the exact mechanisms for operating a DCTP, especially in the context of a national plan that requires collaboration among different stakeholders (e.g., contextual, organizational, and collective aspects), remain unclear [21]. Based on the standards for ability and training curricula, this study aims to address the implementation gap of the national-level DCTP.

2.2. Knowledge Gap 2: Inconsistent Findings on DCTP Effectiveness for Teachers

Within the limited number of empirical studies on DCTP, the majority have focused on pre-service teachers [22–24]. As an example, Reisoğlu et al.'s [23] study utilized the DigComp framework as the theoretical basis for their pre-service teacher training program. The training comprised 30 hours of theoretical coursework and 40 hours of applied courses, with modules covering (a) information and data literacy, (b) communication and collaboration, (c) digital content creation, (d) safety, and (e) problem-solving. Through a case study, it became evident that the instructional design of these training courses is crucial, as pre-service teachers perceive them as models to emulate. Furthermore, theoretical knowledge and hands-on learning activities should be provided [22].

Few empirical studies have examined the effectiveness of the training program for enhancing digital competencies, and those studies that have been conducted on the effectiveness of DCTPs have produced inconsistent findings. According to Moreno Guerrero et al. [22], the DCTP provided in a Master's program for future teachers did not exert a significant impact on the enhancement of teachers' digital literacy. Cañete Estigarribia and colleagues [24] recommend continuous digital competence training programs (DCTP) based on their findings that increased training and frequency of ICT use correlate with heightened digital competence development. Cantabrana and Cervera [25] surveyed university teachers, school tutors, and students and found positive perceptions of the training programs aimed at improving digital competence. A recent qualitative study in Sweden contributes to the understanding of contextual factors that influence teachers' digital competence [21]. The study examines institutional, technological, social, and pedagogical aspects and sheds light on how these factors relate to infrastructures for teaching and working.

Choudhary and Bansal [26] summarized that several factors at different levels have the potential to impact the efficacy of DCTP. Lack of collaborative cooperation among stakeholders is a primary reason for program failure, per policy perspective. Moreover, program policies that were not planned [27], too much autonomy awarded to local implementers [28], and unclear guidelines for stakeholder involvement [29] could all affect the program implementation process. The training program suffers from poor efficacy caused by its design [30,31], trainers with limited education and expertise [32], and a lack of standardization in evaluation and feedback mechanisms [33]. Participants may additionally experience hindrances to their ability to learn, which stem from factors such as their cultural or environmental orientation [34], educational level [35], and motivation levels. Some researchers have emphasized the necessity of designing personalized training plans [2,8]. Tomte et al. [36] observed that certain teacher training programs were insufficiently integrated in practice and could merely encourage teachers to improve their digital competency in the short run. Basilotta-Gómez-Pablos et al. [2] recommended that the DCTP be arranged and financed as a sustained, long-term endeavor.

The overwhelming majority of DCTPs mentioned were conducted in a singular program with limited participation (e.g., a Master's program for pre-service teachers). At the national level, the implementation of DCTP is undeniably complex, yet no study has quantified the extent of its influence on teachers. This research fills the void by evaluating the learning outcomes of teacher participants in the national-level DCTP.

2.3. Present Study

The Chinese Ministry of Education initiated the DCTP for primary and secondary school instructors back in 2005. Despite its almost two-decade existence, little research has been conducted to explore the implementation and effectiveness of this nationally led governmental project. This study focuses on the DCTP case among Chinese instructors with two main objectives. Furthermore, there is a scarcity of related studies conducted globally.

The DCTP is a national program incorporating stakeholders from the government, schools, teachers, and students. The micro level employs a digital empowerment learning framework to guide training and teaching. However, there is uncertainty regarding the implementation, improvement, and top-down feedback of this government-led digital empowerment program at the macro level. Therefore, the first objective of this study is to elucidate the roles and corresponding accountabilities of each stakeholder, as well as to examine how they collaborate and cooperate in this particular project (see Figure 1). To this end, we formulate our first research question (RQ1):

RQ1: How was a national-level training program for enhancing teachers' digital competencies implemented?

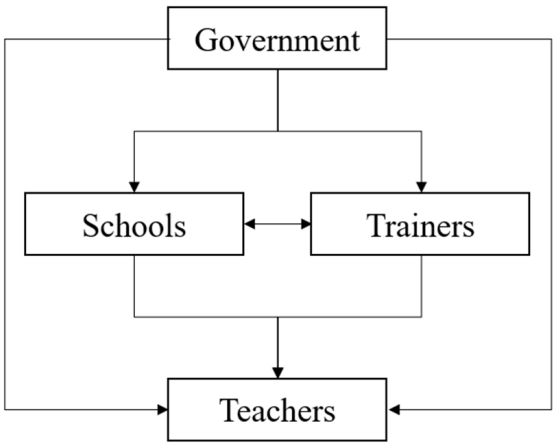

Figure 1. National-level training program implementation mechanism.

Second, now that existing frameworks have reached a period of stability, the focus should be on assessing their effectiveness in promoting digital skills and literacies [37]. With numerous stakeholders involved in such national-level projects, various factors could potentially impact the project's final outcome. Moreover, as the recipients of the program possess diverse subject matter and personal backgrounds, it is unclear how a national government-oriented initiative will influence their digital teaching capabilities. Consequently, the second objective of this study is to assess the project's impact on teachers' digital competence subsequent to their training. The study's second research question (RQ2) is the following:

RQ2: To what extent does the implementation of this DCTP impact teachers' digital competence?

Although education policies and their implementation vary across countries, there exists a common global vision to digitally empower teachers. Examining China's approach provides valuable insights and advice for other nations.

3. Materials and Methods

This study utilized a mixed-method approach to address the two research questions. The initial phase employed a naturalistic inquiry case study, incorporating various official documents, direct observation, and insights from the program coordinator (i.e., the first author), to investigate and streamline the national program implementation mechanism. Second, we conducted a formal assessment of the national DCTP plan in Zhejiang Province, China by testing the performance of teachers' DCs from the perspective of subjects and training models. We aimed to demonstrate the implementation mechanism and evaluate the impact of this DCTP (refer to Figure 2 for the workflow).

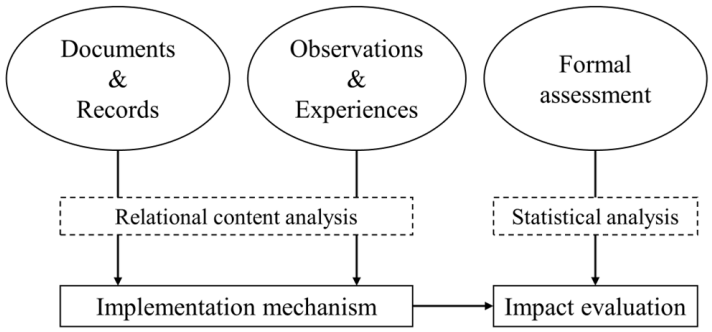

Figure 2. Workflow in the case study of naturalistic inquiry.

3.1. Study Context

Zhejiang Province, China implemented the first phase of the DCTP program in 2015. Funded and private training institutes, such as universities and for-profit educational centers, provided training courses. The courses were delivered in a blended learning format, which combined online learning with offline practices. According to the training curriculum standard, the contents focus on objectively applying information technology to optimize the class teaching process, transforming students' learning styles, and supporting the development of teachers. Refer to Appendix B for 27 topics under the three themes. All other provinces in China share similar implementation mechanisms and training curriculum standards. The policy implementation experience and issues in Zhejiang Province are largely representative of China.

3.2. Participants

A total of 45,648 teachers participated in the DCTP from 11 cities in Zhejiang Province. Of these, 11,623 were pre-school teachers, 12,147 were primary school teachers, 6240 were middle school teachers, and 15,638 were high school teachers. These teachers taught a

variety of subjects, including Chinese, Mathematics, English, Science, and more. These educators participated in one of three training course themes, which included simple multimedia instruction, interactive digital whiteboard instruction, and web-based and mobile learning (refer to Table 1 for specifics).

Table 1. Background information of participants.

Backgrounds	Number of Teachers	Percentage
School level they worked		
Pre-school	11,623	25.46%
Primary school	12,147	26.61%
Middle school	6240	13.67%
High school	15,638	34.26%
Subjects they taught		
Kindergarten	11,623	25.46%
Chinese	8174	17.91%
Mathematics	6493	14.22%
Language	4700	10.30%
Science	5096	11.16%
Music	1049	2.30%
Art	983	2.15%
Physical education	1937	4.24%
Technology	1772	3.88%
Others	3821	8.37%
City they lived		
Hangzhou	9694	21.24%
Ningbo	7176	15.72%
Wenzhou	8026	17.58%
Shaoxing	4581	10.04%
Huzhou	1466	3.21%
Jiaxing	2915	6.39%
Jinhua	3738	8.19%
Quzhou	959	2.10%
Taizhou	4148	9.09%
Lishui	2533	5.55%
Zhoushan	412	0.90%
Course they participated		
Simple multimedia instruction	23,451	51.37%
Interactive digital whiteboard instruction	13,217	28.95%
Web-based learning and mobile learning	8980	19.67%

3.3. Data Collection and Procedure

The coordinator of the project in Zhejiang Province (i.e., the first author) possesses extensive information regarding the project, including pertinent policy documents released by the government, details on bid and tender processes administered by local authorities, training programs and plans established by training institutions, and information concerning training arrangements and trainee school performance. The following section outlines the specific procedure utilized.

From the qualitative aspect, we primarily gathered all official government plan documents and implementation guidelines related to the program, as they constitute the essential resource for constructing the program's implementation mechanism (see Figure 3). The official documents comprise materials issued by the Ministry of Education, such as the Digital Enhancement Plan, the curriculum design for the Enhancement Plan, and the content and corresponding standards related to competency enhancement. Additionally, they incorporate organizational plans for the project issued by each local government. The first author served as the program coordinator in Zhejiang Province, providing valuable information for the study. Through firsthand experience, the author was able to comprehend, observe, and document the program's implementation in the region. In addition, the author quickly identified key issues in project implementation. At the same time, he

was able to observe the instructional and learning effectiveness of the trainers and trainee teachers in the program to the extent permitted by ethical considerations.

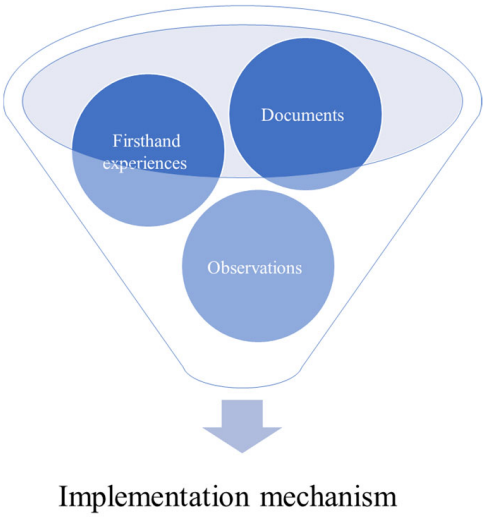

Figure 3. Qualitative data collection.

From the quantitative aspect, program participants were required to participate in a final program learning performance test at the end of the program. The study was conducted by a team of university professors specialized in educational technology. They utilized three sets of exam questions to assess the efficacy of training in three different technology-enhanced learning environments, including basic multimedia instruction, interactive digital whiteboard instruction, web-based learning, and mobile learning. Customized questions were developed for each setting and varied in grade level and subject matter (see Appendix C). However, the test consists of three modules: planning and preparation, organization and management, and evaluation and diagnosis. Teachers from the same grade level and subject who participated in comparable technology-enhanced educational environments utilized the identical test, regardless of whether they were trained by publicly funded or private institutions. All tests have reached an acceptable level of reliability (refer to Table 2 for the reliability of each individual test).

3.4. Data Analysis

To answer our first research question (RQ1), a relational content analysis was conducted based on the different document data and the coordinator's perceptions and observations to map out the structure of the implementation mechanism of this national-level government-led DCTP. More specifically, to begin, the first author reviewed all the relevant policy documents and training proposal records to identify a draft socio-ecological system structure that includes different stakeholders that may be involved in the implementation. Second, the first author went through all the relevant documents again in addition to her understanding, experiences, and interpretations of the DCTP implementation as a core role of coordinator, to scrutinize the workflow and operational mechanism based on the draft structure. Third, the first author discussed with the other authors the key processes of the workflow and the role duties of different stakeholders in this implementation. Any controversial labels on these key processes reached a consistent decision.

To answer the second research question (RQ2), the teacher participants' learning outcomes were statistically described based on their formal assessment organized by the Zhejiang Teacher Education Quality Control Centre. As the training courses were provided by funded and private training institutes, we particularly investigated the impact of the two types of training providers through an independent-sample t-test. Levene's test was conducted to test whether the variance of scores for the two groups was the same and the t-test was for equality of means. Moreover, effect size was provided to show the magnitude

of the difference between groups. Cohen's d is the appropriate effect size measure if two groups have similar standard deviations and are of the same size. For the independent sample t-test, Cohen's d was determined by calculating the mean difference between the two groups and then dividing the result by the pooled standard deviation. According to Cohen [38], Cohen's d = 0.20 refers to a small effect, 0.50 refers to a moderate effect, and 0.80 or greater represents a large effect.

Table 2. Reliability (Cronbach's Alpha) of each test.

Subjects		Simple Multimedia Instruction	Interactive Digital Whiteboard Instruction	Web-Based Learning and Mobile Learning
	Kindergarten	0.90	-	-
Primary school				
	Chinese	0.83	0.77	0.82
	Math	0.79	0.84	0.83
	Language	0.80	0.69	0.73
	Science	0.82	0.72	0.73
	Music	0.72	0.69	0.69
	Art	0.80	0.75	0.73
	Physical education	0.73	0.71	0.70
	Others	0.71	0.62	0.63
Middle school				
	Chinese	0.87	0.82	0.82
	Math	0.80	0.87	0.83
	Language	0.77	0.77	0.76
	Science	0.73	0.73	0.74
	Music	0.73	0.68	0.78
	Art	0.82	0.71	0.71
	Physical education	0.71	0.81	0.77
	Others	0.70	0.62	0.63
High school				
Science	Chinese	0.72	0.82	0.80
	Math	0.81	0.78	0.82
	Language	0.76	0.73	0.89
	Physics	0.69	0.72	0.73
	Geography	0.71	0.67	0.75
	Chemistry	0.74	0.80	0.74
	Biology	0.72	0.75	0.72
	Music	0.77	0.71	0.64
	Art	0.64	0.76	0.67
	Physical education	0.63	0.70	0.70
	ICT	0.75	0.74	0.73
	Others	0.62	0.62	0.61

4. Results

4.1. Implementation Mechanism of a National-Level DCTP

The implementation mechanism, which is structured based on relevant policy documents, training proposal records, and observations and experiences of DCTP coordinators, is shown in Figure 4. The stakeholders in this national plan for DCTP included government (e.g., the Ministry of Education, and the provincial education department), local community (e.g., district teacher development centers), schools (i.e., local kindergartens, primary and secondary schools), training institutes (i.e., funded and for-profit institutes), and teacher participants. The processes consisted of policy making (e.g., guidelines, standards, and measurement design) and program implementation (e.g., selecting training institutes through a bidding mechanism, training progress evaluation, and monitoring).

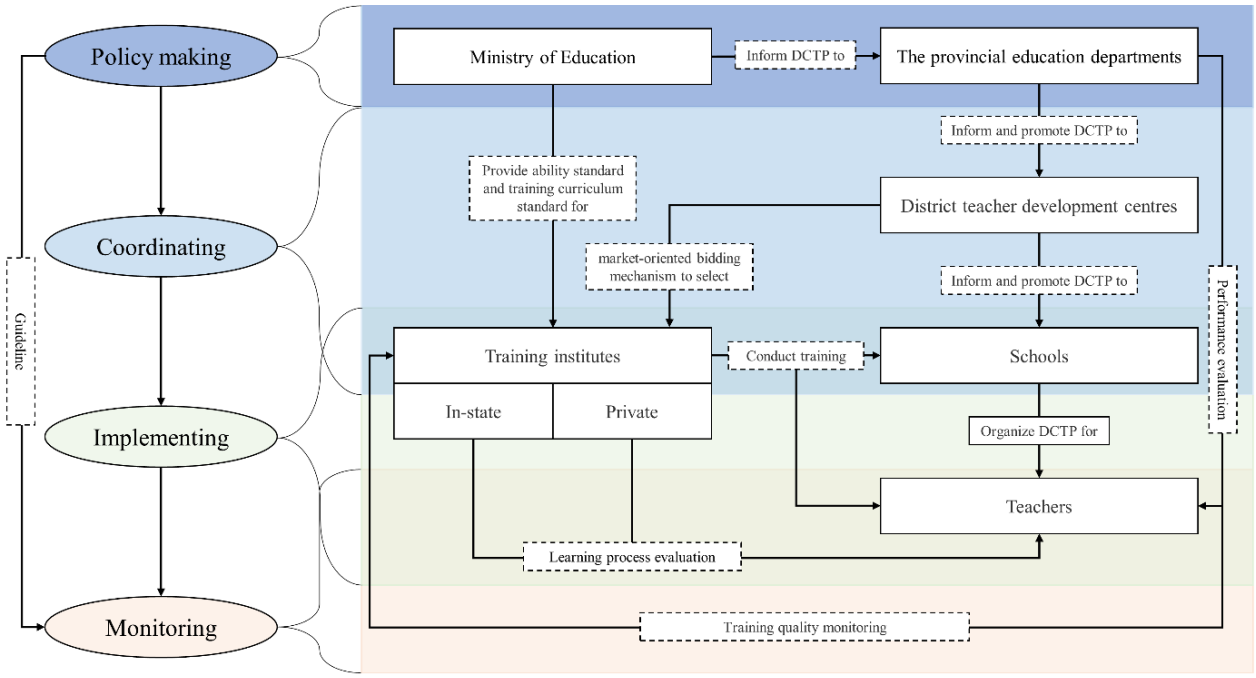

Figure 4. Implementation mechanism of a national plan for DCTP.

4.1.1. The Role of the Government: Policy Maker, Evaluation Developer, and Program Monitor

The major role of the government for a national-level DCTP is to create guidelines and standards for the training curriculum, designing the evaluation, and monitoring the program implementation. For instance, the Chinese Ministry of Education has developed ability standards and curriculum standards to guide the implementation of this DCTP for the provincial education department and training institutes. To assess teachers' learning outcomes, the Ministry of Education issued an assessment guideline, which consists of diagnostic assessment, process assessment, and development assessment. The diagnostic assessment included the status quo of teachers' digital competence level and ICT skills level, teachers' readiness for using ICT in teaching and learning, and ICT equipment in their school. The emphasis of the process assessment was to measure the formative performance of teachers' participation in the training, which included teachers' online learning outcomes, offline practical tasks, and digital competence levels. The development assessment focused on providing evaluation services for teachers organized by the Teacher Education Quality Monitoring Centre to help other stakeholders understand teachers' improvement of digital competence from a scientific perspective.

For different provinces, their education departments would promote these standards to their teacher development centres in different districts. For training institutes, no matter funded or for-profit institutes, these standards guided them to design training courses. According to the assessment requirement, both funded and private training institutes need to conduct the corresponding training evaluation for all the participating teachers. For the provincial education department, e.g., the Zhejiang Province education department, the government officials would monitor the quality of the DCTP implementation by evaluating the training program proposal before the program implementation, monitoring the running of the learning platforms, course materials, and learning performance data during the implementation, and assessing the learning outcomes after the training.

4.1.2. The Role of District Centres and Schools: Project Promoters

To encourage participation and seek support from society, the government officials in different districts conducted a market-oriented bidding mechanism to select the training proposal from different training institutes that could meet their needs. A workflow example

is shown in Table 3. After they selected the training institutes, they promoted schools in their districts to participate in the DCTP for their credits of teachers' professional continued education. Then, the schools followed the instructions of the relevant policy documents to promote the DCTP for teachers.

Table 3. Workflow of district teacher development center.

Phase	Task Details
Phase I: Training preparation	1. Create a new teacher portal on the provincial training management platform 2. Select school management personnel (key trainers) and report to the training institute 3. Formulate district project research plan and schedule 4. Inform and organize the training of key trainers in the region 5. Review the registration of trainees in the region
Phase II: Comprehensive course research and study	1. Monitor the research and training progress of each school 2. Forward the notices of training institutes to schools, such as the solicitation of excellent course examples (including teaching design, courseware and video) and the selection of excellent trainees and key trainers
Phase III: Diagnostic evaluation	Forward the notice of the provincial DCTP office and training institutes on the organization of diagnostic assessment to schools
Phase IV: Thematic course training	1. Inform all schools to organize teachers to participate in the study of thematic courses, school-based research, and training, and implement these activities according to the schedule 2. Responsible for local training quality guidance and management, strengthening supervision, guidance, and evaluating thematic course learning, school-based research, and classroom practice application 3. Monitor and supervise the progress of each school every two weeks, and prepared briefs for publication 4. Organize the school experience and knowledge exchange meeting according to the research and study progress
Phase V: Project summary	1. Supervise and inspect the whole process of teachers' participation in training and school-based training in each school, and keep the record as indicators to assess school-level performance 2. Summarize the research plan and implementation plan of the regional project
Phase VI: Developmental evaluation	Inform and organize the teachers of this district to participate in the evaluation of development

The principal of primary and secondary schools is the first person responsible for the implementation of the DCTP in their schools. The principals need to improve the school system and assign a project manager for their school. The duties of the school-level project manager are shown in Table 4.

4.1.3. The Role of Training Institutes: Training Designers and Operators

Training institutes were responsible for all teacher training in this national plan. First, these training institutes need to comprehend the policy documents, course development standards (see Table 5), and requirements to design their corresponding training proposals. After winning the bid in the district, these training institutes conduct training for teachers based on their proposals. Therefore, the training institutes were required to conduct the process evaluation designed by the government. Due to the different backgrounds and goals of the in-state training institutes and private training institutes, they had different training designs that probably impacted the training effectiveness differently.

Training institutes needed to develop training courses based on the course development standard. The content of the training courses should contain four different application contexts: simple multimedia instruction, interactive digital whiteboard instruction, web-based learning, and mobile learning. Training institutes were requested to take into account the different backgrounds of participating teachers so as to meet their needs.

Table 4. Workflow of primary and secondary school project manager.

Phase	Task Details
Phase I: Training preparation	1. Forward district information updates and course selection notices, and then organize teachers to complete them as required 2. Formulate and publish the study plan of the school 3. Organize the registration and review of the school's course selection
Phase II: Comprehensive course research and study	1. The school organizes in-house training to guide teachers to become familiar with the online training platform and how to join workshops 2. Provide guidance to teachers on how to navigate on the platform 3. Monitor teachers' progress in the comprehensive curriculum
Phase III: Diagnostic evaluation	1. Forward the notice for diagnostic assessment organization work to schools 2. Organize teachers to complete the diagnostic evaluation on time and make personal study plans based on the results
Phase IV: Thematic course training	1. Monitor and supervise teachers' research and study progress of special courses regularly 2. Issue the allocation table of teaching and research topics 3. Guide and support various research groups of the school to carry out cooperative lesson preparation and lecture presentation activities 4. Organize teachers to discuss topics in groups (teaching practice, teaching reflection, lesson case review, etc.)
Phase V: Project summary	1. Review and identify the school-based research record, select and submit excellent cases and outstanding teachers to the local teacher development center for record 2. Summarize the experience of school-based research and study and form an activity report
Phase VI: Developmental evaluation	Inform and organize teachers to participate in a developmental evaluation to assess their learning outcomes after the training

4.2. Impact Evaluation of the National-Level DCTP

4.2.1. Descriptive Statistics

All kindergarten teachers only participated in the digital competence training of simple multi-media instructions. Their mean score of learning outcomes was 67.30 (SD = 8.18, N = 11,623).

In the training of simple multi-media instructions for primary school teachers, the mean scores of teachers from different subjects ranged from 62.96 (SD = 7.26, Chinese teachers) to 71.11 (SD = 8.45, math teachers, see Table 6 for details). For middle school teachers, their mean scores varied from 64.24 (SD = 10.62, physical education teachers) to 71.36 (SD = 9.14, Chinese teachers). For high school teachers, their mean scores varied from 67.01 (SD = 7.94, physical education teachers) to 71.30 (SD = 6.22, Chinese teachers) and 71.55 (SD = 8.41, information technologies and communications teachers).

Regarding the training of interactive digital whiteboards for primary school teachers, the mean scores of teachers from different subjects varied from 60.72 (SD = 6.74, Chinese teachers) to 72.56 (SD = 7.17, music teachers, see Table 7 for details). For middle school teachers, their mean scores varied from 64.46 (SD = 9.74, physical education teachers) to 70.85 (SD = 8.90, Chinese teachers) and 71.06 (SD = 9.26, teachers of other subjects). For high school teachers, their mean scores varied from 63.44 (SD = 8.89, physical education teachers) to 71.38 (SD = 6.57, Chinese teachers) and 71.39 (SD = 8.14, ICT teachers).

Regarding the training of web-based and mobile learning for primary school teachers, the mean scores of teachers from different subjects varied from 60.29 (SD = 6.89, Chinese teachers) to 71.99 (SD = 8.33, music teachers, see Table 8 for details). For middle school teachers, their mean scores varied from 65.80 (SD = 9.30, physical education teachers) to 71.50 (SD = 8.21, Chinese teachers). For high school teachers, the mean scores varied from 64.60 (SD = 8.55, physical education teachers) to 71.48 (SD = 7.23, Chinese teachers) and 71.95 (SD = 8.14, ICT teachers).

Table 5. Curriculum themes developed by training institutes based on competence standards.

Category	Course Series	Course Content	Corresponding Ability Standard
Comprehensive courses	Introduction to the application of information technology in education	GI Interpretation of "ICT competency Standards for primary and secondary teachers (Trial)"	N/A
		G2 Information technology brings about a revolution in teaching and learning	I1, II1
		G3 Process and method of information teaching design	I6, I7
		G4 Current situation and development of educational information technology	I2-I4, II2-II4
	Use information technology to promote the professional development of teachers	P1 Teacher's independent professional development in a technological environment	C21, C23, C24
		P2 Online study community and teacher professional development	C21, C22, C23
		P3 Implementation and management of ICT-supported school-based research and study	C21, C25
Thematic training courses	Use information technology to optimize classroom teaching	T1 Change in teaching preparation	I8, I9
		T2 The design of pedagogical situations	I12
		T3 Changes in the presentation of teaching content	I12
		T4 Design that encourages student participation	I12, I13, I16
		T5 Reform of teaching evaluation and management	I12, I13, I14, I17, I18, I19, I20
		T6 Design and implementation of classroom observation	I14, I18
		T7 Misconceptions and countermeasures of information technology education application	I10, I11, I15
	Use information technology to transform learning style	L1 The transformation of traditional classroom learning methods	II6, II7, II13, II18
		L2 Blended learning design combining online and offline	II6, II7, II8, II12, II13, II18
		L3 Implementation of blended learning	I19, II10, II11, II15, II16
		L4 Online learning design	II6, II7, II8, II12, II13, II18
		L5 Online learning student guidance and support	II5, II9, II10, II11, II15, II16
		L6 Management and monitoring of the learning process	II5, II10, II11, II15, II20
		L7 Evaluation and analysis of learning activities	II14, II17, II19
Practical courses	Practice of information technology education application	According to the development plan of school education informatization, application conditions, teachers' application ability level and characteristics, design classroom teaching practice and school-based research theme in accordance with the characteristics of different disciplines.	Refer to the corresponding standards for comprehensive and Thematic training courses.
Supportive courses	Information technology literacy	S1 Awareness and literacy of information technology application	I1, I4, II11, II14
		S2 Information environment and equipment use	I2, II2, II3, II11
		S3 Digital education resource production and management	I4, II4
		S4 Selection and use of educational software	I3, II3
		S5 Information diagnosis and evaluation	I3, II4, II9, I20, II20
		S6 Communication and collaboration supported by information technology	I5, II4

Note. The ability standard refers to the standard of a teacher's ability to apply information technology in primary and secondary schools (Trial). See Appendix A for details. For instance, I1 refers to the standard in the first item in dimension I, i.e., understanding the role of information technology in improving classroom teaching and arousing the consciousness of using information technology to optimize classroom teaching actively.

Table 6. Training for simple multimedia instruction.

Teachers	Statistics	Chinese	Math	Language	Science	Music	Art	PE	ICT	Others
Primary school	N	1572	1024	362	240	251	215	295	-	126
	Mean	62.96	71.11	68.22	69.25	69.80	68.00	64.05	-	70.02
	SD	7.26	8.45	6.16	7.74	7.81	6.79	8.47	-	10.51
	Min	37	2	35	36	39	42	38	-	40
	Max	85	85	82	86	82	80	79	-	82
Middle school	N	284	287	266	325	78	64	190	-	558
	Mean	71.36	69.43	66.11	64.58	70.13	68.67	64.24	-	69.86
	SD	9.14	9.06	9.41	9.86	7.83	8.17	10.62	-	9.69
	Min	36	39	37	0	42	42	36	-	33
	Max	85	83	82	79	81	80	81	-	82
High school	N	1062	958	975	1201	51	37	150	576	681
	Mean	71.30	69.56	70.12	68.20	70.98	68.16	67.01	71.55	67.19
	SD	6.22	8.97	7.94	7.77	7.31	7.05	7.94	8.41	7.57
	Min	1	28	0	34	43	43	36	34	32
	Max	82	84	85	83	82	80	81	85	82

Table 7. Training for interactive digital whiteboard instruction.

Teachers	Statistics	Chinese	Math	Language	Science	Music	Art	PE	ICT	Others
Primary	N	2009	1373	410	337	255	235	286	-	160
	Mean	60.72	71.49	68.06	69.50	72.56	68.86	65.41	-	71.97
	SD	6.74	8.00	5.98	8.00	7.17	7.40	7.38	-	7.66
	Min	37	0	34	12	38	40	37	-	39
	Max	80	86	80	84	83	84	79	-	81
Middle	N	351	421	336	373	59	54	171	-	636
	Mean	70.85	70.71	67.63	66.31	67.29	68.09	64.46	-	71.06
	SD	8.90	9.97	8.63	8.65	8.87	8.86	9.74	-	9.26
	Min	5	3	37	38	42	35	37	-	36
	Max	83	86	84	87	80	80	82	-	83
High	N	914	1180	1055	1352	36	40	80	523	571
	Mean	71.38	69.73	70.07	68.82	69.42	67.85	63.44	71.39	66.54
	SD	6.57	9.13	7.08	7.82	11.66	8.79	8.89	8.14	7.44
	Min	40	22	34	38	42	42	44	36	36
	Max	84	85	86	83	82	82	80	82	84

4.2.2. Final Training Performance Comparison between Private and Funded Training Institutes

Independent-sample t-tests were conducted to compare the digital competence test after training between participants trained by private institutes and those by funded institutes.

Simple multi-media instruction. Regarding the training for simple multi-media instruction, there was a significant difference in test results between the private training institutes and the funded training institutes for kindergarten teachers. The effect size, as measured by Cohen's d, was d = 0.22, indicating a small effect.

For primary school teachers, there was a significant difference in test results between the private training institutes and the funded training institutes for Chinese teachers (the effect size was small, Cohen's d = 0.32), math teachers (the effect size was small, Cohen's d = 0.29), science teachers (the effect size was small, Cohen's d = 0.40), and music teachers (the effect size was small, Cohen's d = 0.44). For other subjects' teachers, there was no statistically significant difference in test results between the private training institutes and the funded training institutes (See Table 9 for details).

Table 8. Training for web-based learning and mobile learning.

Teachers	Statistics	Chinese	Math	Language	Science	Music	Art	PE	ICT	Others
Primary school	N	1031	531	261	190	210	216	365	-	193
	Mean	60.29	71.32	68.48	70.06	71.99	66.81	64.92	-	70.53
	SD	6.89	7.67	6.67	6.87	8.33	8.14	7.34	-	10.05
	Min	32	38	44	42	35	39	37	-	0
	Max	84	86	82	85	84	81	80	-	82
Middle school	N	246	184	231	242	53	62	251	-	518
	Mean	71.50	69.78	68.43	67.59	69.34	69.05	65.80	-	70.89
	SD	8.21	9.76	7.36	7.87	8.00	7.75	9.30	-	9.33
	Min	39	33	43	40	41	41	19	-	37
	Max	84	83	84	81	80	78	84	-	83
High school	N	705	535	804	836	56	60	149	673	378
	Mean	71.48	70.75	70.02	68.45	69.80	69.00	64.60	71.95	66.96
	SD	7.23	9.47	7.08	7.44	6.38	8.69	8.55	8.82	7.88
	Min	21	41	10	28	47	41	42	20	15
	Max	82	85	87	85	83	82	80	84	82

Table 9. Training for a simple multimedia teaching environment.

Teachers	Subjects	Training Providers	Number of Participants	Mean Score after Training	Std. Deviation	*t*-Value	df	Sig. (2-Tailed)	Cohen's d
Kindergarten		Private institutes	7148	66.64	8.62	−11.45	10,610.52	0.000	0.22
		Funded institutes	4475	68.36	7.32				
Primary school	Chinese	Private institutes	879	61.96	7.32	−6.25	1570	0.000	0.32
		Funded institutes	693	64.24	6.98				
	Math	Private institutes	586	70.11	9.60	−4.68	1008.79	0.000	0.29
		Funded institutes	438	72.45	6.37				
	Language	Private institutes	207	67.75	6.61	−1.74	356.77	0.08	0.18
		Funded institutes	155	68.85	5.44				
	Science	Private institutes	156	68.23	8.32	−2.83	238	0.005	0.40
		Funded institutes	84	71.15	6.14				
	Music	Private institutes	138	68.31	8.36	−3.48	248.88	0.001	0.44
		Funded institutes	113	71.62	6.69				
	Art	Private institutes	122	67.62	6.93	−0.93	213	0.353	0.13
		Funded institutes	93	68.49	6.62				
	Physical education	Private institutes	157	63.31	8.68	−1.61	293	0.109	0.19
		Funded institutes	138	64.89	8.19				
	Others	Private institutes	95	70.05	10.41	0.05	124	0.957	0.01
		Funded institutes	31	69.94	10.95				

Table 9. *Cont.*

Teachers	Subjects	Training Providers	Number of Participants	Mean Score after Training	Std. Deviation	*t*-Value	df	Sig. (2-Tailed)	Cohen's d
Middle school	Chinese	Private institutes	155	69.63	10.81	−3.76	248.41	0.000	0.44
		Funded institutes	129	73.44	6.01				
	Math	Private institutes	161	68.40	9.71	−2.24	284.21	0.026	0.26
		Funded institutes	126	70.74	8.01				
	Language	Private institutes	157	64.63	10.29	−3.30	263.29	0.001	0.40
		Funded institutes	109	68.24	7.52				
	Science	Private institutes	172	62.96	10.99	−3.25	312.19	0.001	0.36
		Funded institutes	153	66.41	8.07				
	Music	Private institutes	47	69.83	7.87	−0.41	76	0.681	0.10
		Funded institutes	31	70.58	7.86				
	Art	Private institutes	40	69.00	7.77	0.41	62	0.682	0.10
		Funded institutes	24	68.13	8.95				
	PE	Private institutes	121	63.26	10.72	−1.69	188	0.093	0.26
		Funded institutes	69	65.96	10.28				
	Others	Private institutes	363	68.19	10.58	−6.50	539.85	0.000	0.54
		Funded institutes	195	72.97	6.76				
High school	Chinese	Private institutes	670	70.78	6.92	−3.97	1039.68	0.000	0.24
		Funded institutes	392	72.19	4.66				
	Math	Private institutes	560	68.86	9.23	−2.92	895.08	0.004	0.19
		Funded institutes	398	70.55	8.50				
	Language	Private institutes	527	69.70	8.69	−1.81	968.86	0.071	0.12
		Funded institutes	448	70.61	6.92				
	Science	Private institutes	774	67.94	7.92	−1.55	1199	0.123	0.09
		Funded institutes	427	68.66	7.48				
	Music	Private institutes	31	69.39	8.48	−2.00	49	0.052	0.61
		Funded institutes	20	73.45	4.05				
	Art	Private institutes	23	67.91	7.54	−0.27	35	0.787	0.09
		Funded institutes	14	68.57	6.43				

Table 9. *Cont.*

Teachers	Subjects	Training Providers	Number of Participants	Mean Score after Training	Std. Deviation	*t*-Value	df	Sig. (2-Tailed)	Cohen's d
	PE	Private institutes	79	67.38	8.96	0.61	148	0.546	0.10
		Funded institutes	71	66.59	6.67				
	ICT	Private institutes	162	69.87	10.68	−2.57	221.20	0.011	0.26
		Funded institutes	414	72.21	7.23				
	Others	Private institutes	398	66.66	8.00	−2.24	655.83	0.026	0.17
		Funded institutes	283	67.94	6.85				

For middle school teachers, there was a significant difference in test results between the private training institutes and the funded training institutes for Chinese teachers (the effect size was small, Cohen's d = 0.44), math teachers (the effect size was small, Cohen's d = 0.26), language teachers (the effect size was small, Cohen's d = 0.40), science teachers (the effect size was small, Cohen's d = 0.36), and others (the effect size was medium, Cohen's d = 0.54). For other subjects' teachers, there was no statistically significant difference in test results between the private training institutes and the funded training institutes (See Table 9 for details).

For high school teachers, there was only a significant difference in test results between the private training institutes and the funded training institutes for Chinese teachers (the effect size was small, Cohen's d = 0.24) and math teachers (the effect size was small, Cohen's d = 0.19). For teachers of other subjects, there was no statistically significant difference in test results between the private training institutes and the funded training institutes (See Table 9 for details).

Interactive digital whiteboard. Regarding the training for interactive digital whiteboards, for primary school teachers, there was a significant difference in test results between the private training institutes and the funded training institutes for Chinese teachers (the effect size was small, Cohen's d = 0.21), math teachers (the effect size was small, +Cohen's d = 0.18), language teachers (the effect size was small, Cohen's d = 0.23), and science teachers (the effect size was small, Cohen's d = 0.42). For teachers of other subjects, there was no statistically significant difference in test results between the private training institutes and the funded training institutes (See Table 10 for details).

For middle school teachers, there was a significant difference in test results between the private training institutes and the funded training institutes for the teachers of Chinese (the effect size was small, Cohen's d = 0.23), language (the effect size was small, Cohen's d = 0.32), art (the effect size was medium, Cohen's d = 0.68), and others (the effect size was small, Cohen's d = 0.40). For teachers of other subjects, there was no statistically significant difference in test results between the private training institutes and the funded training institutes (See Table 10 for details).

For high school teachers, there was a significant difference in test results between the private training institutes and the funded training institutes for the teachers of Chinese (the effect size was small, Cohen's d = 0.16), math (the effect size was small, Cohen's d = 0.15), and science (the effect size was small, Cohen's d = 0.12). For teachers of other subjects, there was no statistically significant difference in test results between the private training institutes and the funded training institutes (See Table 10 for details).

Table 10. Training for an interactive whiteboard teaching environment.

Educational Level	Subjects	Training Providers	Number of Participants	Mean Score after Training	Std. Deviation	*t*-Value	df	Sig. (2-Tailed)	Cohen's d
Primary school	Chinese	Private institutes	1046	60.06	7.09	−4.63	2003.70	0.000	0.21
		Funded institutes	963	61.44	6.27				
	Math	Private institutes	746	70.84	8.46	−3.37	1369.53	0.001	0.18
		Funded institutes	627	72.27	7.35				
	Language	Private institutes	233	67.48	5.89	−2.28	408	0.023	0.23
		Funded institutes	177	68.82	6.01				
	Science	Private institutes	201	68.21	8.90	−3.93	334.99	0.000	0.42
		Funded institutes	136	71.40	5.98				
	Music	Private institutes	148	71.86	7.59	−1.85	253	0.065	0.24
		Funded institutes	107	73.53	6.45				
	Art	Private institutes	134	68.39	8.12	−1.13	233	0.262	0.15
		Funded institutes	101	69.49	6.32				
	PE	Private institutes	144	64.91	8.25	−1.16	268.70	0.246	0.14
		Funded institutes	142	65.92	6.38				
	Others	Private institutes	122	71.60	8.31	−1.12	158	0.267	0.23
		Funded institutes	38	73.18	4.94				
Middle school	Chinese	Private institutes	191	69.92	9.23	−2.17	346.72	0.031	0.23
		Funded institutes	160	71.96	8.38				
	Math	Private institutes	243	70.43	9.60	−0.67	361.76	0.504	0.07
		Funded institutes	178	71.10	10.47				
	Language	Private institutes	203	66.56	9.28	−2.96	323.21	0.003	0.32
		Funded institutes	133	69.25	7.28				
	Science	Private institutes	220	65.93	8.91	−1.03	371	0.302	0.11
		Funded institutes	153	66.87	8.26				
	Music	Private institutes	36	67.39	9.26	0.11	57	0.914	0.03
		Funded institutes	23	67.13	8.43				
	Art	Private institutes	27	65.22	10.78	−2.50	37.40	0.017	0.68
		Funded institutes	27	70.96	5.18				

Table 10. *Cont.*

Educational Level	Subjects	Training Providers	Number of Participants	Mean Score after Training	Std. Deviation	*t*-Value	df	Sig. (2-Tailed)	Cohen's d
	PE	Private institutes	106	63.44	10.27	−1.83	152.99	0.069	0.28
		Funded institutes	65	66.12	8.64				
	Others	Private institutes	443	70.05	10.15	−5.10	566.10	0.000	0.40
		Funded institutes	193	73.40	6.21				
High school	Chinese	Private institutes	559	70.96	6.53	−2.44	912	0.015	0.16
		Funded institutes	355	72.04	6.59				
	Math	Private institutes	733	69.23	9.12	−2.43	1178	0.015	0.15
		Funded institutes	447	70.56	9.10				
	Language	Private institutes	655	69.89	7.25	−1.08	1053	0.282	0.07
		Funded institutes	400	70.37	6.80				
	Science	Private institutes	922	68.53	7.94	−2.00	1350	0.046	0.12
		Funded institutes	430	69.44	7.51				
	Music	Private institutes	26	68.08	11.64	−1.12	34	0.272	0.42
		Funded institutes	10	72.90	11.54				
	Art	Private institutes	27	66.48	10.08	−1.44	38	0.158	0.54
		Funded institutes	13	70.69	4.23				
	PE	Private institutes	41	62.07	10.14	−1.43	72.307	0.158	0.32
		Funded institutes	39	64.87	7.21				
	ICT	Private institutes	170	70.78	8.91	−1.19	521	0.233	0.11
		Funded institutes	353	71.68	7.73				
	Others	Private institutes	369	66.27	7.71	−1.20	453.06	0.232	0.10
		Funded institutes	202	67.02	6.91				

Web-based and mobile learning. Regarding the training for web-based learning and mobile learning, for primary school teachers, there was a significant difference in test results between the private training institutes and the funded training institutes for Chinese teachers (the effect size was small, Cohen's d = 0.28), math teachers (the effect size was small, Cohen's d = 0.32), language teachers (the effect size was small, Cohen's d = 0.50), art teachers (the effect size was small, Cohen's d = 0.45), and physical education teachers (the effect size was small, Cohen's d = 0.36). For teachers of other subjects, there was no statistically significant difference in test results between the private training institutes and the funded training institutes (See Table 11 for details).

Table 11. Training for web-based and mobile learning instruction.

Educational Level	Subjects	Training Providers	Number of Participants	Mean Score after Training	Std. Deviation	*t*-Value	df	Sig. (2-Tailed)	Cohen's d
Primary school	Chinese	Private institutes	539	59.37	7.17	−4.57	1028.74	0.000	0.28
		Funded institutes	492	61.30	6.44				
	Math	Private institutes	278	70.18	8.21	−3.66	524.76	0.000	0.32
		Funded institutes	253	72.58	6.83				
	Language	Private institutes	128	66.82	6.99	−4.04	249.23	0.000	0.50
		Funded institutes	133	70.08	5.95				
	Science	Private institutes	108	69.26	7.05	−1.85	188	0.066	0.27
		Funded institutes	82	71.11	6.52				
	Music	Private institutes	104	71.32	8.89	−1.16	208	.247	.16
		Funded institutes	106	72.65	7.73				
	Ar	Private institutes	123	65.27	8.35	−3.27	214	0.001	0.45
		Funded institutes	93	68.85	7.42				
	PE	Private institutes	179	63.58	8.27	−3.46	325.97	0.001	0.36
		Funded institutes	186	66.21	6.07				
	Others	Private institutes	120	70.24	9.13	−0.51	191	0.613	0.07
		Funded institutes	73	71.00	11.46				
Middle school	Chinese	Private institutes	129	70.38	9.07	−2.26	244	0.025	0.29
		Funded institutes	117	72.73	6.99				
	Math	Private institutes	109	69.10	10.01	−1.14	182	0.258	0.17
		Funded institutes	75	70.76	9.35				
	Language	Private institutes	106	67.21	7.87	−2.34	229	0.020	0.31
		Funded institutes	125	69.46	6.76				
	Science	Private institutes	124	66.21	8.76	−2.85	227.50	.005	0.36
		Funded institutes	118	69.03	6.55				
	Music	Private institutes	26	66.69	8.35	−2.48	51	0.016	0.68
		Funded institutes	27	71.89	6.84				
	Art	Private institutes	35	68.57	8.56	−0.55	60	0.585	0.14
		Funded institutes	27	69.67	6.67				
	PE	Private institutes	143	65.04	9.58	−1.48	249	0.139	0.19
		Funded institutes	108	66.80	8.87				
	Others	Private institutes	336	69.56	10.24	−5.04	497.80	0.000	0.44
		Funded institutes	182	73.34	6.71				

Table 11. *Cont.*

Educational Level	Subjects	Training Providers	Number of Participants	Mean Score after Training	Std. Deviation	*t*-Value	df	Sig. (2-Tailed)	Cohen's d
High school	Chinese	Private institutes	408	71.00	7.62	−2.05	703	0.041	0.16
		Funded institutes	297	72.13	6.61				
	Math	Private institutes	305	70.48	9.45	−0.77	533	0.444	0.07
		Funded institutes	230	71.11	9.52				
	Language	Private institutes	406	69.77	7.70	−1.02	802	0.309	0.07
		Funded institutes	398	70.28	6.38				
	Science	Private institutes	567	68.27	7.39	−1.06	834	0.291	0.08
		Funded institutes	269	68.85	7.52				
	Music	Private institutes	36	70.22	6.49	0.66	54	0.515	0.18
		Funded institutes	20	69.05	6.26				
	Art	Private institutes	46	68.76	9.41	−0.38	58	0.703	0.13
		Funded institutes	14	69.79	5.91				
	PE	Private institutes	86	63.93	8.76	−1.11	147	.267	0.19
		Funded institutes	63	65.51	8.23				
	ICT	Private institutes	204	70.62	10.79	−2.28	297.95	0.023	0.20
		Funded institutes	469	72.53	7.76				
	Others	Private institutes	220	67.11	8.56	0.43	376	0.665	0.05
		Funded institutes	158	66.75	6.83				

For middle school teachers, there was a significant difference in test results between the private training institutes and the funded training institutes for the teachers of Chinese (the effect size was small, Cohen's d = 0.29), language (the effect size was small, Cohen's d = 0.31), science (the effect size was small, Cohen's d = 0.36), music (the effect size was medium, Cohen's d = 0.68), and others (the effect size was small, Cohen's d = 0.44). For teachers of other subjects, there was no statistically significant difference in test results between the private training institutes and the funded training institutes (See Table 11 for details).

For middle school teachers, there was a significant difference in test results between the private training institutes and the funded training institutes for the subject teachers of Chinese (the effect size was small, Cohen's d = 0.16) and ICT (the effect size was small, Cohen's d = 0.20). For teachers of other subjects, there was no statistically significant difference in test results between the private training institutes and the funded training institutes (See Table 11 for details).

5. Discussion

5.1. The Implementation Mechanism in a National Plan of DCTP: Pros and Cons

Unlike previous studies that focused more on digital competency enhancement programs in higher education or at a specific institution [2,35], this study focused more on digital competency enhancement among K-12 school teachers at the national level. The key role of teachers in educational information in classes and corresponding demands on training has been recognized by the Chinese government. A series of policies and standards

have been developed to involve almost all the relevant stakeholders on different levels in the DCTP implementation. From an ecological perspective, the Ministry of Education, local teacher development centers, and training institutes played three key roles in the implementation of a national plan. To avoid allowing excessive autonomy to local implementers that may result in ineffective program implementation [27], the policies and standards provided by the Ministry of Education guided the local teacher development center to decide which training institutes can meet their demands. Meanwhile, these policies and standards also guided training institutes to design training activities that may satisfy the bidding reviewers. Based on this mechanism, the autonomy that local implementers had was limited to an appropriate range, and all the relevant implementation and activities should be oriented by core standards. It is confirmed that the responsibility for improving teachers' digital competence lies not only with individuals or individual institutional organizations [21] but also with a synergy between the individual, the school, the local government, and the central government.

However, as the participants, those teachers did not proactively participate in the training because they had few options to select from to accomplish what they actually needed to in practice [11]. Even though those training institutes conducted need assessments of teachers, their purpose for doing this was mainly to demonstrate the process for local teacher development centers to win the bidding. The needs assessment seems like a formality, and it is disjointed from the follow-up course design, goal setting, and content development, which were ineffective for these teacher participants. Moreover, most of the training institutes used the same learning materials that were assumed to be one-size-fits-all for teachers who were from different disciplines. This may lead to ineffective learning outcomes, as teachers had to do the extra work of transferring what they learned in training to their practice during teaching. The characteristics of different disciplines should be taken into account for the integration of training.

As Jimoyiannis et al. [32] indicated, inadequate methods of collecting feedback adversely impact the efficacy of the program. In this national plan, although the government developed a series of policies and standards, these were not outcome-oriented mechanisms. In other words, there was no effective feedback mechanism that showed the government how the effects of training could be transferred to teachers' actual teaching in class. There is no requirement in the governmental standards that guides both local education departments and training institutes to design such feedback loops.

5.2. Impact Factors to the Effectiveness of DCTP

As Nabi-Ranjbari et al. [13] indicated, ICT teacher training is still a challenge for in-service teachers. In this study, the descriptive statistics of the final learning outcomes of the DCTP showed us that the teacher participants did not achieve a high final score after training and that the performance of teachers from different subjects varied. On one hand, it may reflect that the effectiveness of this national plan for DCTP may not be as high as expected, which could be due to many impact factors related to policies or program implementation. On the other hand, as Basilotta-Gómez-Pablos et al. [9] indicated, the final training assessment could reflect that teachers had low digital competence, so DCTP was suggested to be organized and funded as a long-term ongoing task.

Regarding the training effectiveness from different types of institutes, for some subjects (e.g., Chinese, math, music, and science), the teachers who participated in the training provided by funded training institutes performed better in the final assessment than those who participated in private training institutes. As we were limited by the data sources, we were not able to explore the impact factors from participants' teaching subjects and the grade level of their teaching.

From a training course design perspective, the online training courses developed by the private training institutes had three problems. First, their design ignored the characteristics of teachers from different disciplines. According to [39], the use of technology in the classroom varied among different subject groups. For those teachers who may have already

had similar courses, it may be a waste of time for them. For example, one of the institutes set 405 courses for Chinese teachers in junior high schools and physics teachers in senior high schools, but there were 392 (a repetition rate of 96.8%) repeated courses between the two training programs for teachers from two of the disciplines. Second, some institutes did not develop enough course resources for the required study hours. For example, the actual length of courses provided by one private training institute (14.4 min per lesson) was much shorter than half of the standard class hour (i.e., 40 min per lesson). Third, the quality of these online learning materials is uneven. For instance, the picture display form was monotonous and uninteresting, and most of the learning contents were too advanced for training purposes. Therefore, participating teachers could easily become visually fatigued. The image resolution was too low and the image was blurred. Noise reduction was not carried out professionally, and the video sound quality was poor. The quality of such videos would directly affect the learning experience of students participating in the digital competence improvement project.

From the perspective of trainers' characteristics, consistent with [31], we found that the staff of these private training institutes had lower educational backgrounds and less professional experience in ICT in education. Only a few of them had an educational or education-relevant major background, and the majority of their majors were not or only marginally relevant to education. For example, one of the private training institutes trained more than 100,000 teachers for the DCTP, but the educational level of its trainers consisted of 9 Master's degrees, 34 Bachelor's degrees, and 32 junior college degrees. As the goal of these institutes is profit maximization under the guidance of market utilitarianism, private training institutes appear to be dangerous stakeholders that may threaten the training effectiveness in this project because they focused more on the bidding processes and profit rather than training outcome and effectiveness.

As for the participating teachers, most of them lack learning motivation. First, there was no effective publicity before the project was launched to make teachers aware of the importance of improving digital competence and changing their traditional ideological ideas about information technology. Most teachers just treat DCTP as a task about gaining training credits without any expectations regarding their own learning outcomes. On the other hand, from the external motivation aspect, there was no bonus system, since the evaluation results of teachers after the training were not linked to the performance benefits of teachers, such as salaries and professional title promotion. Furthermore, from the utility aspect, teachers cannot see the effectiveness of the new technology in improving students' academic performance and teaching effect in a short period of time. However, as previously indicated [35], teachers' technological, pedagogical, and content knowledge vary depending on their educational level. It is important to note that the project presented here does not consider the teacher's educational and work experience. Therefore, they may not be motivated to develop corresponding digital competencies.

5.3. Limitations

The study used a naturalistic exploratory research methodology, and the main data collected included the self-perceptions and records of the first author as the coordinator of the program. However, the perceptions and records were relatively fragmented because the research matter was not considered before the project started. In the next round of project execution, future research could consider modeling the exploration into document collection, perceived problems and challenges, and other components to model the observations and recordings in order to facilitate the expansion of this exploration in a collaborative team approach.

6. Conclusions

This study constructed a model of a national-level implementation mechanism for digital competency enhancement by exploring a teacher digital competency enhancement program in China, using Zhejiang Province as a case study, and utilizing a variety of

official documentation, facilitator observations, and naturalistic exploratory recordings, as well as student background information and program academic performance that can be leveraged. The model includes a policy formulation phase, a coordination phase with local governments and responsible institutions, an implementation phase, and a monitoring and feedback phase. The mechanism mapped out the government as the playing the key role in this plan, setting up the guidelines and standards for local educational departments and training institutes.

From various sources and records, we can see that the project at this stage is mainly a top–down implementation led by the government. Although policies are relatively based on the needs of teachers in terms of digital competence, these generalized needs do not, to some extent, meet the real needs of teachers at the micro level due to the high heterogeneity of teachers' backgrounds. In the course of implementation, different training providers showed different results, but the quality of the providers was not monitored, leading to significant differences in the performance of the trainees. At the same time, both schools and local government organizations have a very limited choice of training providers. In this nature, once a profit-oriented commercial training provider has been successful in tendering, it is difficult to guarantee the quality of teaching unless there is another regulatory mechanism to monitor and control it.

Based on these findings, we recommend the following: (1) provide digital competency enhancement assistance based on the real needs of teachers; (2) give more autonomy to local governments and educational institutions based on the general direction of the policy, as local governments can truly understand the current situation and culture of the local community; (3) improve the regulatory mechanism and introduce healthy competition to ensure the quality of the training provider's teaching; and (4) build a long-term plan for the enhancement of teachers' digital competency, as the content of the training program itself as well as the skills of the teachers will need to be periodically optimized due to the constant changes in the digital tools and methods.

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Appendix A

The Standard of Teacher's Ability of Applying Information Technology in Primary and Secondary Schools (Trial)		
The Dimension	I. Use information technology to optimize classroom teaching	II. Use information technology to transform learning style
Technical literacy	1. Understand the role of information technology in improving classroom teaching. Arouse the consciousness of using information technology to optimize classroom teaching actively. 2. Understand the types and functions of multimedia teaching environments. Proficient in operating common multimedia teaching equipment.	1. Understand the information age to the new requirements of student training. Have the consciousness of actively exploring and using information technology to change students' learning styles. 2. Familiar with the Internet, mobile devices, and other new technologies, and understand its supporting role in education and teaching.

The Standard of Teacher's Ability of Applying Information Technology in Primary and Secondary Schools (Trial)		
Planning and Preparation	3. Understand the functions and characteristics of general software and subject software related to teaching, and be proficient in application.	3. Explore the use of online teaching platforms to support students' autonomous, cooperative, inquiry learning and other technical resources.
	4. Acquire digital education resources through various ways, and master the tools and methods of processing, making, and managing digital education resources.	4. Use technology to integrate multiple resources, connect school, family, and society, and expand students' learning space.
	5. Have information ethics and information security awareness, and can set an example.	5. Help students to establish information ethics and information security awareness, and cultivate students' good behavior habits.
	6. Based on curriculum standards, learning objectives, student characteristics, and technological environment, select appropriate teaching methods. Identify the convergence point of information technology and teaching.	6. Based on curriculum standards, learning objectives, student characteristics, and technological environment, select appropriate teaching methods. Determine the convergence point of using information technology to cultivate students' comprehensive ability.
	7. Use information technology to design effective teaching processes to achieve learning objectives.	7. Using information technology, design the teaching process and learning activities that help students to learn independently, cooperatively, and inquisitively.
	8. According to teaching needs, choose and use technical resources reasonably.	8. Choose and use technical resources reasonably, and provide students with rich learning opportunities and personalized learning experiences.
	9. Develop digital educational resources that effectively support classroom instruction.	9. Design learning guidance strategies and methods to promote students' cooperation, communication, exploration, reflection, and creation.
Organization and Management	10. Ensure technical equipment and resources are properly used in the classroom environment.	10. Ensure that students have convenient and secure access to the Internet and resources.
	11. Anticipate possible problems in the application of information technology and formulate solutions.	11. Foresee the problems that students may encounter in learning independently and cooperatively in the information environment, and formulate countermeasures.
	12. Use technical support to improve teaching methods and effectively implement classroom teaching.	12. Use technology to support, change learning mode, and effectively carry out students' independent, cooperative, inquiry learning.
	13. Let each student have equal access to technical resources, stimulate students' interest, and keep students' attention on learning.	13. Give students equal access to technical resources and participation in learning activities in groups and individual learning.
	14. In the process of tech-mediated teaching, students' classroom feedback should be observed and collected to effectively adjust the teaching behavior.	14. Use technology tools to collect students' learning feedback effectively, and provide timely guidance and appropriate intervention to learning activities.
	15. Flexibly deal with the unexpected situation caused by technical failure in classroom teaching.	15. Flexibly deal with other unexpected situations that occur when students are engaged in learning activities in an information environment.
	16. Encourage students to participate in the teaching process guide students to improve their technical literacy and give play to their technical advantages.	16. Support students to actively explore the use of new technology resources, and creative participation in learning activities.
Assessment and Diagnosis	17. According to the learning objectives, scientifically design and implement the information teaching evaluation scheme.	17. According to the learning objectives, we should scientifically design and implement the information-based teaching evaluation scheme, and rationally select or process the evaluation tools.
	18. Try to use technology tools to collect students' learning process information, sort out and analyze them, find teaching problems, and put forward targeted improvement measures.	18. Make comprehensive use of technical means to analyze the learning situation and provide the basis for promoting students' personalized learning.
	19. Try to use technical tools to carry out tests, exercises, and other work to improve the efficiency of evaluation.	19. Guide students to use evaluation tools to carry out self-evaluation and mutual evaluation, and do a good job in the process and final evaluation.
	20. Try to establish electronic archives of students' learning to provide support for students' comprehensive quality evaluation.	20. Use technology to collect key information about students' learning process and results, establish electronic files of students' learning, and provide support for students' comprehensive quality evaluation.
Learning and Development (C)	21. Understand the role of information technology in the professional development of teachers, and have the awareness of actively using information technology to promote self-reflection and development. 22. Take advantage of the teacher network training community, actively participate in professional development activities supported by technology, develop the habit of network learning, and constantly improve one's teaching ability. 23. Use information technology to establish and maintain contacts with experts and peers, relying on the learning community to promote professional growth. 24. Master the technical means and methods required for professional development, and improve the ability of independent learning in the information technology environment. 25. Effectively participate in school-based research and study supported by information technology, and combine learning with application.	

Appendix B

Themes and Topics in the Training Program

Themes/Topics	Apply Information Technology to Optimize the Teaching Process in a Classroom Setting	Apply Information Technology to Transform Students' Learning Styles	Apply Information Technology to Support Teachers' Professional Development
Technical literacy topics	T1 Education and teaching reform caused by information technology T2 Multimedia teaching environment cognition and use of common equipment T3 Subject resource retrieval and acquisition T4 Material processing and production T5 Multimedia courseware making T6 Use of subject software T7 Information ethics and information security	T16 The construction and management of network learning space T17 The application of the network teaching platform T18 Suitable for mobile device teaching software applications	T25 Interpretation of the "ICT competency Standards for primary and secondary teachers (Trial)" T26 Teacher workshops and teacher professional development T27 Network study community and teacher professional development
Comprehensive topics	T8 Subject teaching under a simple multimedia teaching environment T9 Subject teaching in an interactive multimedia environment T10 Curriculum teaching supported by discipline teaching resources	T19 Autonomous cooperative exploration of learning in a network teaching environment T20 Autonomous cooperative exploration learning in a mobile learning environment	
Thematic training topics	T11 Classroom introduction of technical support T12 Explain the teaching content of technical support T13 Student skill training and instruction of technical support T14 Summary and review of technical support T15 Teaching evaluation of technical support	T21 Technology supported inquiry learning task design T22 Organization and management of technical support study group T23 Technical support for learning process monitoring T24 Learning evaluation of technical support	

Appendix C

Examples of Test Questions

Environment	Grade Level	Subjects	Test Dimension	Questions
Interactive digital whiteboard instruction	High school	English	Planning and preparation	Mr. Quan used PPT to design the slide as shown in the picture in the second lesson of Unit 2 "Working the land" of the Renjiao version of the second year of high school English Compulsory 4, how would you modify it? 1. Add headings that are relevant to the content; 2. Stretching the background image to the left and right to cover the gaps on both sides; 3. Splitting the text content into two paragraphs; 4. Adding images that are clear and relevant to the topic; 5. Removing the white background color of the text box;
			Organization and management	Mr. Wu would like to show the questions with the highest error rates on the students' unit tests, what would you suggest as a way to present them? 1. Make copies of the wrong questions and distribute one to each student 2. Take a picture of the problem using the tablet and send it to the big screen 3. Use a physical display to show the problems 4. Take a picture with your cell phone and immediately send it to the big screen and annotate it. 5. Put the wrong questions in the classroom.

Examples of Test Questions				
Environment	**Grade Level**	**Subjects**	**Test Dimension**	**Questions**
			Evaluation and diagnosis	After a unit test, Ms. Ji summarizes the students' scores in an Excel spreadsheet and analyzes them statistically. Please evaluate the reasonableness or validity of the following practices. 1. Use charts to show the number of students in different achievement bands 2. Send results to parents so that they can understand their students as well 3. Help individual students analyze the reasons for their unsatisfactory performance 4. Teachers can adjust teaching strategies according to students' performance 5. Compare class averages with other classes.

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