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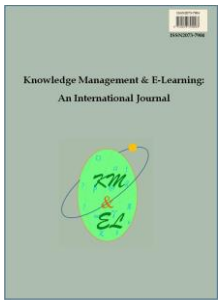


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# Integrating online training and knowledge sharing among teachers through a cloud-based video platform

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**Abstract:** This study integrates knowledge sharing into traditional teacher training to enhance teachers' professional development. It addresses the research gap in implementing such integration by developing a video cloud platform that supports online training and knowledge-sharing among teachers. The proposed approach combines the SECI model (socialization, externalization, combination, and internalization) with the video cloud platform to create a new model of teacher e-learning, fostering collaborative learning among teachers in a remote and interactive context. To demonstrate the effectiveness of this approach, the study conducted experiments with Chinese primary and secondary school teachers. The new model was applied in an online professional competence-oriented supporting environment. The results showed a significant improvement in organization and management skills, and a moderate increase in technical literacy, learning, and development capabilities among the participating teachers. These findings have important implications for professional development of teachers, particularly in the context of the ongoing epidemic and the shift towards a networked and intelligent world. By integrating knowledge sharing into traditional training, teachers can enhance professional competence and adapt to the changing educational landscape. The video cloud platform is a valuable tool for facilitating collaborative learning and knowledge creation among teachers.

**Keywords:** Video cloud platform; Blended learning; Teacher professional development; Knowledge sharing; SECI model

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## 1. Introduction

### *1.1. Research background*

Since the 20th century, China has been dedicated to enhancing teachers' effective utilization of information technology. In 2004, the Chinese Ministry of Education introduced the Educational Technology Competence Standards for primary and secondary school teachers, integrating teachers' educational technology proficiency into the scientific evaluation and guidance system. It stressed the importance of teachers embracing modern education and fostering their professional growth by continuously enhancing educational technology skills. In 2014, the Standard of Information Technology Application Ability of Primary and Secondary School Teachers was issued, placing IT (information technology) competency at the forefront as an indispensable skill for teachers in the era of information. Consequently, a new era of primary and secondary school teacher training emerged in China.

In early 2021, the Chinese Ministry of Education launched a pilot national intelligent platform for teacher training, facilitating online teaching and research by leveraging extensive classroom teaching behavior data and resource-based blended training. As a result, blended training, integrating online virtual environments with offline practical settings, has emerged as a crucial strategy to support teachers in China. This blended approach tackles the traditional trainings disconnect between learning and practical application (Singh, 2021) and meets the demand for extensive, flexible, and multi-level training while augmenting teachers' practical knowledge (Zhang & Liu, 2019).

However, the online training process lacks in-person learning experiences, leading to challenges such as the absence of real-world scenarios during activities and the necessity for platform-driven exercises (Yoon et al., 2020). Moreover, conventional blended training often overlooks the post-training phase, during which trainees apply the knowledge, skills, behaviors, and attitudes acquired. While teachers may consciously implement their learning in the short term, they frequently revert to their pre-training state over time.

### *1.2. Research objectives*

Teaching practice constitutes the touchstone of teacher training, and the efficacy of teacher training is manifested in how well the knowledge teachers acquired during training is applied in actual teaching scenarios. This fosters a more profound comprehension and utilization of training content and assesses the training's effectiveness. Enhancing teachers' skills hinges on harnessing intelligent online platforms and learning spaces, bridging the virtual realm with the physical classroom, and orchestrating collaborative "online + offline" learning encounters.

However, traditional video service systems with fixed resource allocation encounter challenges in storing and accessing extensive process data, resulting in limited video interaction, a substantial content storage burden, and insufficient control in online teaching. The introduction of video cloud technology is poised to catalyze the transformation of teacher training platforms, nurture innovation in research and training content, and contribute to overarching enhancements in training quality. Consequently, the exploration, design, and development of video cloud platforms tailored to the age of intelligence is a pivotal focal point for integrating technology and teacher education (Agbo et al., 2021).

Scholars posit that the training platform is a potent arena for knowledge dissemination among teachers. Through the networking capabilities of virtual platforms, teachers can share knowledge, exchange ideas, and even reconfigure and innovate knowledge (Brav et al., 2018; Razmerita et al., 2016). While this form of training accounts for the fusion of instruction and practice, reinforcing contextual experiences, it encounters challenges like the lack of synergy between online learning and offline application, and a disconnect between the novel technological environment and traditional application models. In response, certain scholars have crafted a more comprehensive, technically streamlined, and stable training platform (e.g., the Moodle platform), encompassing essential services like online lectures, student management, and virtual communication (Diaz-Arevalo et al., 2021). This platform incorporates intelligent features like student progress tracking and learning problems diagnosis. Nonetheless, a dearth of pertinent practices remains grounded in this platform (Chen et al., 2019; Fang et al., 2021).

Therefore, this study aims to amalgamate the novel technology of video cloud platforms with the knowledge sharing model (SECI) to establish a fresh paradigm for teacher network training, bolstering the efficacy of blended teacher training.

### *1.3. Research questions*

Current research on teachers' online training generally concludes that teachers' interactive behaviors, knowledge sharing, and the transformation of tacit knowledge within the platform contribute to learning. However, the process of knowledge transformation is limited in face-to-face environments (Tamjidyamcholo et al., 2014). A thorough examination of practical online training unveils a series of realistic challenges: more replication of existing learning materials and fewer creators of autonomously processed knowledge; simpler interpersonal connections and fewer interactions that foster deep learning and discussions; more one-way knowledge sharing and less two-way knowledge sharing (Mott & Wiley, 2009). The effectiveness of knowledge application varies significantly and is primarily linked to knowledge sharing among teachers. The awareness and implementation of knowledge sharing highlight the absence of theoretical

and practical guidance for teacher training in the new technological landscape (Soon & Fraser, 2011).

The SECI (Socialization, Externalization, Combination, and Internalization) model is a prominent concept concerning establishing knowledge sharing. This model delineates the process of knowledge transformation and furnishes methodologies to enhance knowledge sharing. In this era of the Internet, the SECI model, as adopted in this study, provides a robust analytical framework for comprehending the teachers' knowledge transfer process. It aids in elucidating the essence of teacher knowledge sharing and offers strategies to facilitate teaching practice.

This study primarily centers on the following questions (RQs):

***RQ1***: How can online training and knowledge sharing among teachers be integrated through a cloud-based video platform?

***RQ2***: To what degree does the proposed approach effectively enhance teacher professional development?

## 2. Literature review

### *2.1. knowledge sharing*

knowledge sharing encompasses the exchange and generation of knowledge between individuals, as well as the propagation of individual knowledge within an organization (Zhang & Liu, 2019). Scholars have proposed diverse models of knowledge sharing from various standpoints, including the Evolutionary Game model (Chang et al., 2021), the Complex Network knowledge sharing model grounded in trust mechanisms (Cowan & Jonard, 2004), the System Dynamics model (Luo et al., 2019), the Differential Game model (Xu et al., 2022), and the SECI (Socialization, Externalization, Combination, and Internalization) model. Nonaka (1998) introduced the SECI model as a theory of communicative interaction in knowledge sharing, highlighting the interplay between tacit and explicit knowledge. The Evolutionary Game model centers on the knowledge sharing process as a strategic game between two vested parties, whereas the Trust Mechanism models, and System Dynamics models delve into the factors influencing knowledge sharing. The Differential Game model, while mathematically structured, exhibits limited practical applicability. The SECI model has garnered substantial attention from researchers because it offers a dependable analytical framework for comprehending the teacher knowledge transformation process, elucidating the essence of teacher knowledge sharing, and furnishing pragmatic implementation strategies. There are two trends in applying the SECI model: firstly, it serves as a novel research perspective to explore various issues; secondly, it forms the basis for constructing new models that address emerging research subjects.

### *2.2. knowledge sharing and the SECI model*

Transmission of knowledge facilitates knowledge sharing within organizations, and the dissemination of outcomes fosters the creation of another layer of knowledge. According to Nonaka and Takeuchi (1995), these interactions manifest through four knowledge-creation processes. As Hislop, Bosua, and Helms (2018) emphasized, the most influential knowledge conversion theory is Nonaka's knowledge creation theory (Nonaka, 1998; Nonaka & Takeuchi, 1995). This theory introduces a knowledge spiral that transforms

tacit knowledge into explicit knowledge and vice versa, serving as the cornerstone for individual, group, and organizational innovation and learning.

Teachers' theoretical knowledge is generally explicit, shared among teachers and professional theorists, and readily comprehensible due to its external, explicit, systematic, and articulable nature. Conversely, teachers' practical knowledge is often tacit, stemming from personal experiences and reflecting individual attributes. This form of knowledge remains concealed within everyday teaching contexts and actions. It remains unspoken, unsystematic, and latent, rendering its capture challenging (Mendoza et al., 2022).

The SECI model, pioneered by Nonaka, underscores the transformation of tacit and explicit knowledge into organizational knowledge through four modes (Menkhoff et al., 2022):

i. Socialization (S): from tacit knowledge to tacit knowledge
ii. Externalization (E): from tacit knowledge to explicit knowledge
iii. Combination (C): from explicit knowledge to explicit knowledge
iv. Internalization (I): from explicit knowledge to tacit knowledge

Educational research has underscored the significance of collaborative learning structures in enhancing teachers' capacity to address the escalating learning requirements of students (Khan et al., 2022). Through the process of internalization (converting explicit knowledge into tacit knowledge), teachers assimilate knowledge into their teaching and learning practices to enhance student learning outcomes (Kolb, 1984).

Another pivotal and foundational concept in knowledge creation is "ba." Ba provides individuals with the capability, context, and milieu to share and transform knowledge, thereby propelling the knowledge spiral (Nonaka & Konno, 1998). There exist four categories of ba: originating ba, dialoguing ba, systemizing ba, and exercising ba. With the rapid evolution of information technology, scholars contend that the concept of "field" within the SECI model should encompass more than just an abstract concept (Schmitt, 2016), and that technologies such as the Internet and cloud computing must be fully integrated into the process of knowledge creation.

While the SECI model elucidates the knowledge exchange process and furnishes strategies to augment knowledge sharing, it is circumscribed by face-to-face contexts (Tamjidyamcholo et al., 2014). As remote knowledge transformation has become prevalent, there arises a need to adapt the SECI model to the new technological landscape. Technological progress has spurred continuous enhancements to the SECI model. This model accentuates technical support, encompassing both content and process. The former facilitates the integration of existing elements into a novel environment, while the latter expedites the translation of knowledge across domains. An SECI-based model infused with technological support affords deeper insights for this study.

### *2.3. Use of video cloud platforms to improve knowledge sharing*

This study leverages a cloud computing-based video cloud service, a teacher training platform built upon emerging technologies such as big data, cloud computing, 5G, and artificial intelligence. The platform encompasses various foundational functions, including remote control and centralized management of cloud classrooms, efficient transmission of video streams, integration with third-party platform services, slicing, annotation, and analysis of streaming videos, as well as efficient distributed cloud storage for educational videos (Germain-Renaud & Rana, 2009).

The video cloud platform serves as an intermediary scenario to augment the perception and reality of classroom interactions. It captures intricate data on teaching activities, analyzes the teaching process from diverse perspectives, and provides teacher training data. Moreover, it facilitates comprehensive discussions by comparing teacher behaviors depicted in video resources with standard norms (Hosp, 2012).

Video cloud services offer substantial learning support for individual teachers, rendering knowledge acquisition and access expedient and swift. These fosters learning in tandem with the metamorphosis of knowledge. Video cloud services reshape the conventional interaction model by accentuating the digitization and standardization of teachers' intellectual assets. Open sharing on the Internet facilitates seamless dissemination across regions and organizations, granting learners the freedom to select educational services at their convenience and from any location (Al-Faifi et al., 2018). On one hand, teachers can manage their knowledge, express their viewpoints, and elaborate on their ideas within this environment (Wang et al., 2017), establishing a bedrock for knowledge sharing. On the other hand, teachers can employ this platform to share interpersonal interactions, knowledge resources, and learning trajectories.

Based on the preceding analysis, knowledge sharing can be comprehended as a process wherein knowledge providers and recipients interact and transform knowledge. Within this process, learners generate content and engage in interactions, thus optimizing the transfer and circulation of knowledge. The conversion and flow of knowledge are intrinsically linked to context and medium, and online training platforms' communication, learning, and recording functions meet this demand. Although differences exist in the knowledge sharing process between virtual media and face-to-face interactions, knowledge sharing within online training platforms aligns with the trend of amalgamating online and offline components in extensive teacher training (Li et al., 2016). The distinctions in knowledge sharing between the video cloud platform and traditional internet platforms are delineated in Table 1.

**Table 1**
The differences in knowledge sharing between the video cloud platform and the traditional Internet platform

| Element | Traditional Internet Platform | Video Cloud Platform |
|---|---|---|
| Provider | • Definite or indefinite | • Definite, the provider of knowledge has sufficient knowledge with the receiver in terms of needs and conditions, etc |
| Content | •Determined by the provider | • Determined by both the provider and the receiver of knowledge |
| Environment | •Uncontrolled environment | • Controlled environment with extensive recording of trainers' learning behaviors |
| Interaction | •One-way or two-way, possibly without feedback | • Two-way communication, with feedback |
| Organization | • Individual-based | • Learning community-based |

## 3. Design and implementation of the cloud-based video platform

### *3.1. Conceptual design of the platform*

As illustrated in Fig. 1, rooted in the SECI model theory and fortified by the support of the video cloud platform, a teacher knowledge sharing model attuned to the requisites of professional development has been fashioned by the authors. The model encompasses an

environment layer, an interaction layer, and a sharing layer. At its core lies the platform, serving as the underpinning and domain, while secondary interactions impel knowledge sharing and generation. The SECI process assumes a pivotal role in the nucleus of knowledge sharing. It is worth noting that knowledge does not materialize in isolation; it hinges on specific contextual conditions (Ba), where information acquires significance through interpretation within the domain and subsequently morphs into knowledge (Hosseini, 2010).

The SECI process occupies a central locus in the model, and the video cloud platform engenders four domains: Originating Ba, Interacting/Dialoguing Ba, Cyber/Systemizing Ba, and Exercising Ba, spanning both physical realms (cloud classrooms, conference rooms, etc.) and virtual realms (network training platforms, etc.). Within these "Ba" settings, knowledge is harnessed, shared, and forged. The impetus of the model is provided by "secondary interaction." In intra-group interactions, knowledge gets relayed among individuals within the group, resulting in "primary amplification"; when knowledge crosses group boundaries in inter-group interactions, it leads to "re-amplification." As knowledge transfers from one individual to another, learners cyclically transition between the roles of knowledge providers and recipients (Lin et al., 2014). Within the SECI process, knowledge takes both explicit and implicit forms and is disseminated through socialization, externalization, combination, and internalization (Ahmad et al., 2016). Learning is not a linear process marked by a definite commencement and termination; instead, it involves constant iteration and spiraling.

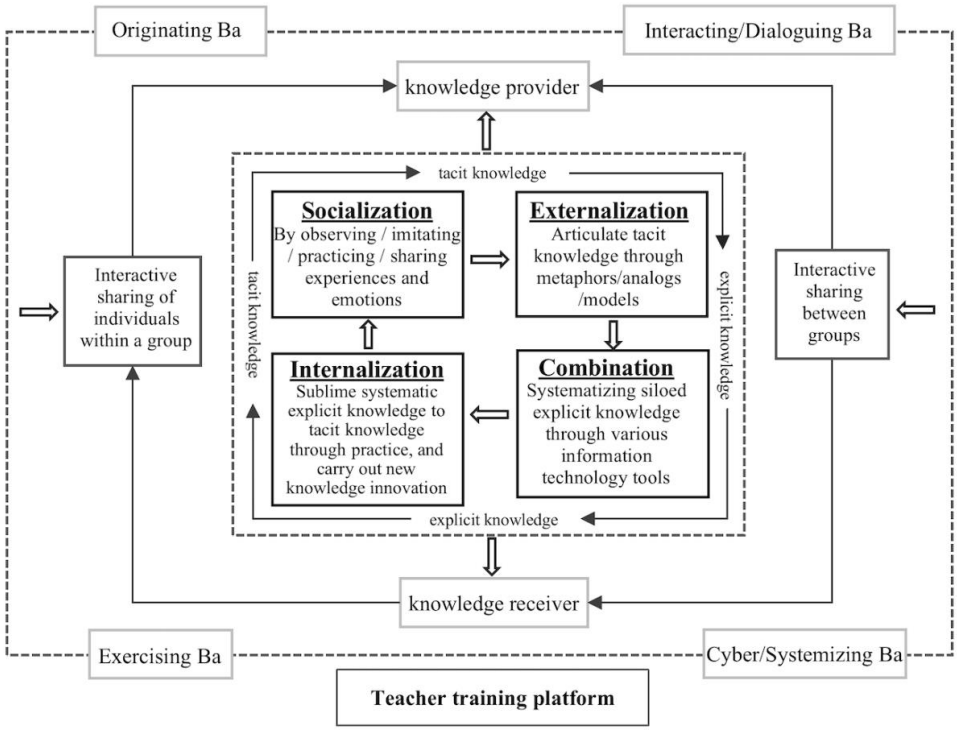


**Fig. 1.** Improving teacher knowledge sharing model based on video cloud platform

### *3.1.1. Environment layer*

Teacher training occurs within a distinct milieu, and the training endeavors encompass a series of learning interactions that unfold between teachers and the training environment (Bratić et al., 2020). For a training environment to facilitate knowledge sharing and expedite knowledge transformation, it must meet the requisites of the Originating Ba, Interacting/Dialoguing Ba, Cyber/Systemizing Ba, and Exercising Ba. The components intertwined in the training process entail an intricate interplay of knowledge, technology, and society (Mäkinen et al., 2019). The video cloud platform functions as an extensive and systematic repository of knowledge. It transcends being a mere tool for teachers' engagement; rather, it acts as a conduit for cultivating reciprocal relationships among educators. Furthermore, it exists as a distributed environment encompassing individuals, tools, services, and resources. At its heart, the training environment is shaped by cloud classrooms and platforms, proffering three critical types of tools hinging on cloud computing, streaming media, and big data: instruments for information acquisition, information creation and editing, and communication (Dai et al., 2020).

*Originating Ba.* Teachers can engage in observation and imitation during live and on-demand broadcasts. To capture and analyze elusive and fleeting moments, the video-slicing tool can precisely locate and extract relevant details and content (Calandra et al., 2014). Additionally, the platform offers various functions such as group aggregation, electronic whiteboard, document sharing, collaborative browsing, desktop sharing, text discussion, private chat and interaction, and annotation tools. Teachers with similar interests and hobbies can form online groups by identifying learners' attributes, trust values, and language preferences. On-site training is also an essential component of the Originating Ba, serving to create a conducive environment for sharing tacit knowledge among knowledge providers (Nonaka et al., 2000).

*Interacting/Dialoguing Ba.* The Interacting/Dialoguing Ba is crucial in facilitating the conversion of tacit knowledge within the organization into explicit knowledge (Anshari & Hamdan, 2022). The platform offers notable features that support the Interacting/Dialoguing Ba, including classroom observation techniques and methods based on big data. Classroom outcomes can be obtained through these features, and teachers' practical knowledge (often considered invisible knowledge) can be visually represented in data form.

*Cyber/Systemizing Ba.* The Cyber/Systemizing Ba facilitates the transformation of fragmented knowledge within teachers' knowledge into a systematic and structured direction (Shaarawy & Abdelghaffar, 2017). Learners utilize various knowledge integration tools to organize the acquired explicit knowledge systematically and logically, forming new explicit knowledge. The platform offers a built-in search function that enables learners to retrieve specific necessary information, such as notes, logs, pictures, and videos. Additionally, the system displays the relationships between these pieces of information in a network diagram, aiding in the systematic output of teachers' knowledge.

*Exercising Ba.* The Exercising Ba embodies a practical environment that encourages the translation of explicit organizational knowledge into teachers' practical behaviors (Hosseini, 2010). Establishing an atmosphere of exploration and practice within the Exercising Ba is crucial, as it facilitates the internalization of explicit knowledge into teachers' teaching concepts and behaviors. The platform offers two levels of training methods to support this process. Firstly, it provides the option to record and broadcast lessons, enabling teachers to reflect on and analyze their own teaching practices. Secondly, it offers simulation, role-playing, and gamified learning experiences, providing opportunities for teachers to participate in simulated teaching scenarios and interactive games to enhance their practical skills and knowledge.

### *3.1.2. Interactive layer*

The interactive layer bridges the sharing layer and the environment layer, facilitating knowledge sharing through diverse interactive activities within specific contexts. The video cloud platform encompasses a variety of social functions across different tiers, delivering essential network services to promote knowledge interaction among individuals (Dai et al., 2016). These social functions empower teachers to participate in collaborative endeavors, share their expertise, and build meaningful connections, thereby fostering effective knowledge exchange and sharing.

*Interaction between individual trainees.* Interaction serves as the essential foundation and primary mechanism for linking information resources (Basioudis & de Lange, 2009). The platform adeptly tackles the constraints of relatively closed school-based teaching and research, surmounting challenges like interactive uniformity and information seclusion. Its openness allows each trainee to actively engage in network communication and interaction, seamlessly integrating them into the learning ecosystem. Using the platform's interactive functionalities, trainees can participate in collaborative discussions, share ideas, and access diverse information and viewpoints, enhancing and enriching their learning journeys.

*Interaction between different training groups.* The interactive environment forged by the platform facilitates groups in monitoring the advancement and contributions of each member. Learners are empowered to gain deeper insights into the works and knowledge shared by fellow group members that pique their interest. Group members can seamlessly partake in "dual-track" interactions within the training environment. One track involves interactions between any pair of group members, while the other entails interactions encompassing the entire group. This dual-track approach allows real-time feedback and suggestions to flow during intra-group and inter-group interactions.

Significant disparities manifest among inter-group interactions based on the video cloud platform, inter-group interactions steered by core members, and open learner interactions unrestricted by group confines, as delineated in Table 2.

**Table 2**
Comparison of interaction types between groups

| Interactive type | Interaction mode | Normalization | Knowledge's Creativity |
|---|---|---|---|
| Based on video cloud | Any member as a bridge | Order | Obvious complementary advantages |
| Based on core members | Core members are the bond | Order | knowledge sharing has attenuated severely |
| Open no group | Any learner connection | Out-of-order | Less creative |

### *3.1.3. Sharing layer*

The sharing layer constitutes the central element of the SECI model, wherein knowledge is shared and generated with the bolstering "Ba" facilitated by the environment layer and propelled by the interaction layer. Within the video cloud platform, the import of external knowledge from the organization assumes paramount importance, emerging as a pivotal wellspring for knowledge innovation (Nonaka & Krogh, 2009). Thus, the sharing layer is pivotal in optimizing the benefits derived from knowledge sharing and creation within this platform.

### *3.2. Implementation of the platform*

The SECI model elucidates the process of reciprocal transformation between tacit knowledge and explicit knowledge during knowledge sharing, providing a systematic depiction of the underlying mechanisms. Building upon this model, the procedural activities of teacher training have been devised, as illustrated in Fig. 2.

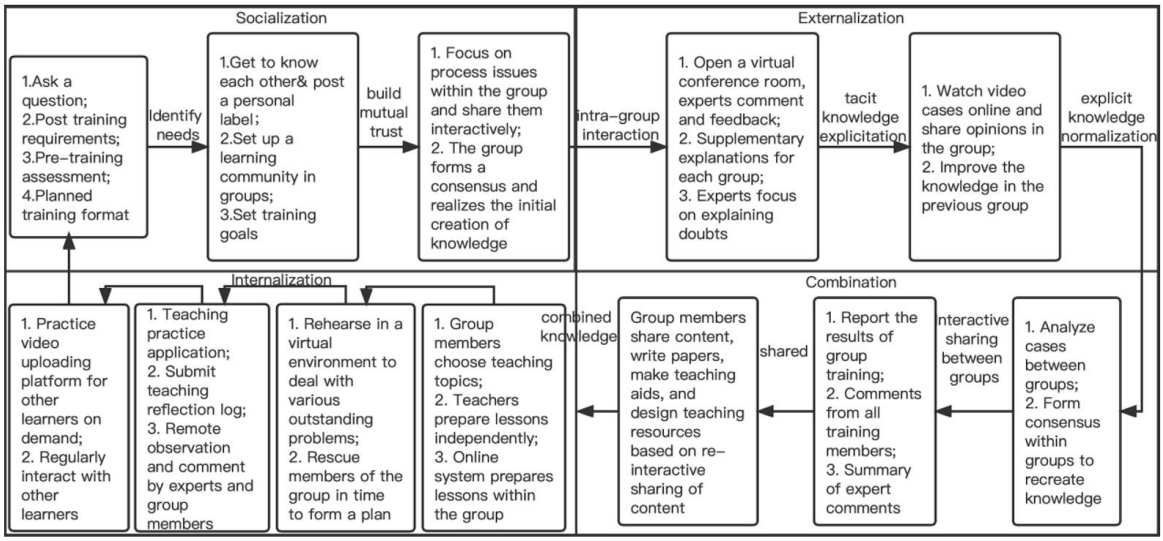


**Fig.2.** Design of teacher training based on the platform

#### *3.2.1. Socialization stage*

The socialization stage is segmented into three key components: identifying training needs and shaping training formats, forming training groups, outlining training objectives, and concentrating on the training process and interactive exchange. To streamline this stage, the researchers have crafted an array of online training initiatives, encompassing sharing teaching queries, conducting assessments of training requirements, fulfilling preliminary training evaluations, establishing interactive tasks, and delivering resource suggestions. Learners can establish or join groups based on live videos, trust values, and individual information. Throughout this stage, teachers share their implicit knowledge with fellow group members, stimulating the initial stages of knowledge creation through participant interactions.

#### *3.2.2. Externalization stage*

During group interactions, participants employ electronic whiteboards, document sharing, and desktop sharing to enrich the discussion process through analogies and visual aids. Experts play a vital role in facilitating interactive activities by posing questions and reinforcing their own interpretations. The roles of both group members and experts evolve throughout these interactions, with individuals alternating between the roles of knowledge providers and recipients.

#### *3.2.3. Combination stage*

Recreating knowledge case analysis among groups involves two or more groups collaborating to form a learning community, where they share their perspectives on the same case. This collaborative approach expands problem-solving capabilities, deepens understanding, and enhances the group's collective knowledge capacity and quality (Erden et al., 2014). Through joint discussions of video cases, teams engage in questioning and negotiation to consistently improve their group knowledge and achieve knowledge re-creation.

The open sharing of knowledge reports on group training outcomes involves the group conducting a phased "launch" through a live video tool, allowing learners and experts outside the group to observe and provide comments from various terminals. Using big data mining technology, colleagues continually extract essential keywords from the comments and establish relevant connections to help trainees grasp the context and core ideas of the group's knowledge. This process aids in contextualizing the knowledge reports and ensures that trainees understand the group's knowledge outcomes.

#### *3.2.4. Internalization stage*

Teaching practice in real situations, remote live broadcast co-evaluation, and co-appreciation: Classroom practice serves as a vital testing ground for evaluating the effectiveness of teachers' learning (Zou & Bai, 2015). The recording and broadcasting system extends teachers' classroom teaching to cloud-based terminals, enabling experts and teachers to observe and provide feedback. Following the class, teachers reflect and improve based on the feedback collected from the cloud platform. Practical videos are available for on-demand viewing, and regular interactive training extends beyond the immediate context. Well-crafted practical case videos become valuable resources for other learners and groups, facilitating the next SECI cycle by enabling the widespread sharing of implementation processes. Based on feedback from readers, teachers engage in regular remote video interactions to bridge the gap between unseen members of interest groups and clusters (Fu, 2011).

### *3.3. Application cases*

#### *3.3.1. Famous teachers' live class*

The famous teacher' live classes aim to provide students in educationally disadvantaged areas with high-quality teaching comparable to their urban counterparts. Within the video cloud platform, the famous teachers' class transcends physical boundaries and extends from the campus to the online network, allowing the educational ideas of famous teachers to be externalized and embraced by a wider audience. The teacher training program based on the famous teachers' live classroom is illustrated in Fig. 3.

- *Socialization (S)*: The famous teachers deliver lectures in the cloud classroom, which are recorded by the video casting system and broadcast live in real-time. This process facilitates the socialization of the famous teachers' tacit knowledge through training activities.
- *Externalization (E)*: Learners actively participate in the activity as a group and communicate with both internal members of their group and members from other groups during the live broadcast. After the live class, instructors participate in online seminars that elaborate on teaching ideas, processes, and methods.

Furthermore, the instructors interact with the group online, answering learners' questions.

- *Combination (C)*: With the assistance of big data technology, the core ideas, essential vocabulary, and main thoughts of the training are visualized, providing learners with a reference at the end of the training.
- *Internalization (I)*: Demonstrating a master live classroom triggers subsequent reactions. Learners integrate what they have learned from the training into their own teaching practices and make them available for evaluation by peer teachers in live or recorded formats. This interactive exchange allows learners to internalize their knowledge.

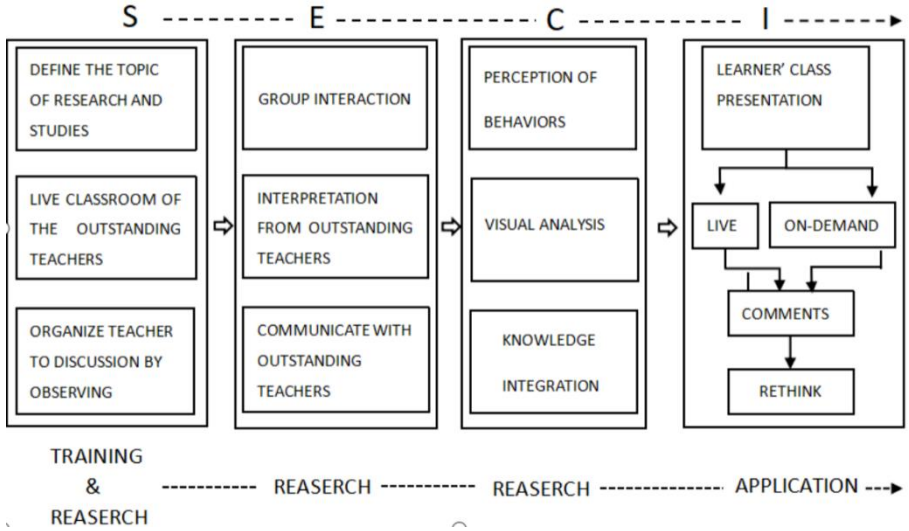


**Fig. 3.** Teacher training based on the famous teachers' live classroom

### *3.3.2. Heterogeneous class*

A heterogeneous class is a class where different teachers prepare and teach the same subject based on their own context and understanding. Within the video cloud platform, the heterogeneous class expands the training scope, enabling teachers to teach the same content in cloud classrooms located in different areas without interference from other teachers in the class. The teacher training program based on the heterogeneous class is illustrated in Fig. 4.

- *Socialization (S)*: Instructors deliver live online classes, allowing for interaction and discussion between experts and learners through the platform.
- *Externalization (E)*: Learners actively participate in group seminars, engage with the viewpoints of other members, and express their own opinions. They also submit question requests to experts, fostering the externalization of the instructors' knowledge.
- *Combination (C)*: After engaging with lessons online, evaluating them, and participating in interactions, learners organize their knowledge based on the data provided by the training platform. This helps them better connect the new

knowledge with their existing experiences, strengthen their ideas, and achieve a combination of knowledge.

- *Internalization (I)*: Learners select the same teaching content and attempt to teach it independently. The cloud classroom's recording system records these lessons as video resources, which are then uploaded to the training platform after appropriate editing for peer and expert review.

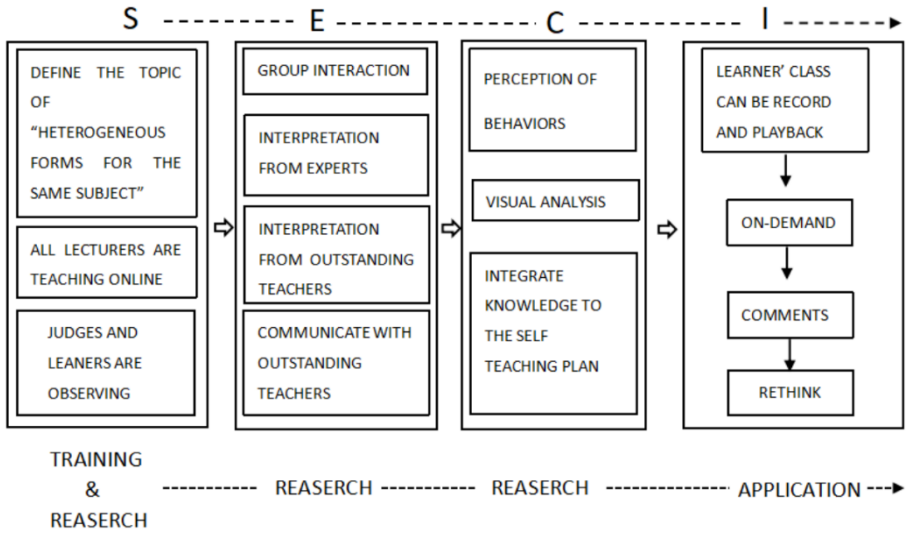


**Fig. 4**. Teacher training based on heterogeneous class

## 4. Evaluation method

### *4.1. Participants*

This research was conducted as part of the "Information Technology Application Ability Improvement Project for Primary and Secondary School Teachers (ITAAIP)". The project included both online and offline training components. Since 2021, 15 pilot schools have been established in the City of Zhuhai, China, to implement teacher knowledge sharing training as part of the project to improve teachers' information technology application abilities. The project is still ongoing.

Nonprobability sampling was employed, where teachers from the participating schools were invited to participate in the survey. The sample size was determined based on the need for factor analysis, which requires a minimum of 300 samples (Oktari et al., 2021). Teachers who agreed to participate were included in the study, resulting in 412 participants from the pilot schools, while the control group consisted of 453 teachers. The training methods used by these teachers were not strictly regulated during the experiment. Table 3 presents the demographic information of the participants.

**Table 3**
Description of participants

| Demographic variables | Category | Experimental group (%) | Control group (%) |
|---|---|---|---|
| Gender | Male | 34.75 | 36.28 |
| | Female | 65.25 | 63.72 |
| Educational stages | Primary | 45.6 | 43.7 |
| | Secondary | 54.4 | 56.3 |
| Age | 20-30 | 37.07 | 35.16 |
| | 31-40 | 45.68 | 46.78 |
| | 41-50 | 14.66 | 13.27 |
| | Above 50 | 2.59 | 4.79 |
| Teaching years | 1-5 | 34.48 | 35.28 |
| | 6-10 | 13.79 | 14.87 |
| | 11-15 | 22.42 | 20.94 |
| | Above 15 | 29.31 | 28.91 |
| Discipline | English | 54.83 | 53.27 |
| | History/Geography | 27.7 | 28.19 |
| | Chemistry/Biology | 17.47 | 18.54 |
| Professional title | Senior | 23.89 | 22.74 |
| | Intermediate | 36.28 | 38.61 |
| | Junior | 24.78 | 23.14 |
| | Others | 15.05 | 15.51 |

### *4.2. Evaluation model*

Presently, there are four prominent evaluation models in education, both domestically and internationally. These models include the Kirkpatrick Hierarchical Evaluation Model, the CIPP (Context Evaluation, Input Evaluation, Process Evaluation, Product Evaluation) Model, the CIRO (Context Evaluation, Input Evaluation, Reaction Evaluation, Output Evaluation) Model, and the Guskey Model. These models are outlined in Table 4. Among these, the Kirkpatrick Evaluation Model stands out as the most extensively employed assessment tool for training worldwide.

**Table 4**
Common evaluation models

| Evaluation Form | Evaluation Model | Evaluation Content |
|---|---|---|
| Decision making mode | CIPP model (Akpur et al., 2016) | Context Evaluation, Input Evaluation, Process Evaluation, Product Evaluation |
| | CIRO model (Newman et al., 2011) | Context Evalution, Input Evalution, Reaction Evalution, Output Evalution |
| Gola free | Kirkpatrick model (Kirkpatrick, 2009) | Trainees' reactions (satisfaction level), learning (gains in knowledge, skills, attitudes, behavioral styles), behavior (improvement of behavior at work), the impact of the outcome (management knowledge gained by the trainees) on the organization |
| | Guskey model (Guskey, 2002) | Learner response, learner learning, organizational support and change, learner application of new knowledge and skills, student learning outcomes |

In order to assess the effectiveness of the training mode, this study incorporated the Kirkpatrick evaluation model. It considered the actual improvement of information technology application ability, the feasibility of evaluation, and expert suggestions, all without compromising the validity of the application effect evaluation. The SRRBA (Study, Result, Reflection, Behavior, Achievement) evaluation model was proposed, as depicted in Fig. 5.

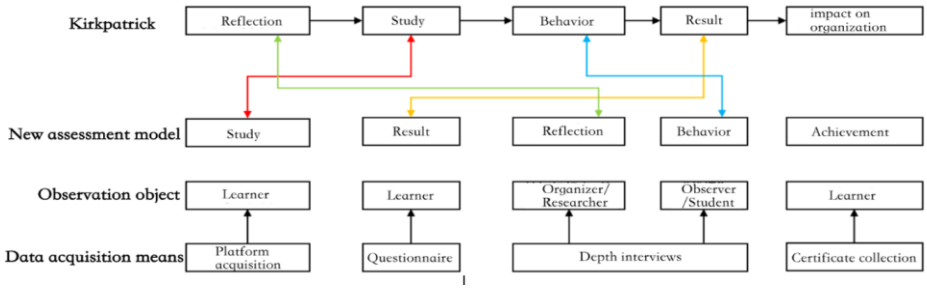


**Fig. 5**. SRRBA evaluation model

In the SRRBA evaluation model, 'Study' represents the learning process of the participants, 'Result' reflects the degree of achievement attained through the training of teachers' information technology application ability, 'Reflection' captures the perspectives and attitudes of the training stakeholders, 'Behavior' encompasses the teaching practices of the teachers, and 'Achievement' encompasses the various outcomes attained by the teachers. The method of data collection for each dimension depends on the target audience. The study process data is automatically obtained through the platform, the level of teachers' information technology application ability is assessed through questionnaire surveys, the evaluation of teachers' teaching behavior is gleaned through in-depth interviews, and the results of teachers' research and training are collected through issued notices.

## *4.3. Measures and instruments*

By collecting and analyzing the process data of teachers' training and their information technology application ability, this research aims to conduct comparative research and comprehensive evaluation to determine whether differences exist in teachers' behavior and their information technology application ability. The data for quantitative analysis are obtained through automatic data collection on the platform and online questionnaire surveys.

### *Automatic platform data collection*

The conventional process data used by the experimental and control groups were collected for analysis. These process data include average daily study time, the number of discussions on specific topics, the number of questions answered, the number of posts sent or returned, the number of peer comments, and the number of resource uploads or downloads. SPSS 19.0 was used to calculate the mean analysis results.

### *Questionnaire survey*

The questionnaire aims to understand the influence of different platforms on improving teachers' information technology application abilities. The survey was conducted among teachers who participated in the study. Pre-test and post-test questionnaires were

designed for the 'Primary and Secondary School Teachers' Information Technology Application Ability Promotion Project in China' and the ICT-TPCK framework. The questionnaires have good reliability and validity, consisting of five dimensions: technical literacy, planning and preparation, organization and management, assessment and diagnosis, and learning and development. The questionnaires used a five-point Likert scale, ranging from 1 (very inconsistent) to 5 (very consistent). The practical results were obtained by collecting teachers' data from various activities.

A total of 865 questionnaires were returned in the study. After careful inspection, 13 questionnaires with abnormal data were excluded, resulting in 852 valid responses with an effective rate of 98.50%.

### *In-depth interview*

Quantitative analysis alone cannot explain the reasons behind the differences in teachers' behavior and ability levels. Therefore, qualitative analysis through in-depth interviews is conducted (Wang et al., 2017). The interviews focus on (a) respondents' attitudes towards the new teacher training platform and (b) changes in teachers' teaching behaviors. Fifteen teachers were randomly selected as interviewees. The interviews were guided by a wide-ranging questionnaire including questions about:

- The overall evaluation of the training platform (for example, what was your opinion on the function and content? How frequently were formal or virtual meetings held to discuss new ideas? What did you think is the difference between the new training platform and traditional one? How did you feel about your performance in the training process?);
- Attitudes towards the application of ICT in teaching (for example, what changes the new training platform has brought? What were the changes in your peers around you? What were the characteristics of your classroom teaching? How has the new training platform improved your ICT application capability? To what extent did this participation develop ability to apply IT? In your opinion, to what extent did joining activities support teaching process innovation?).

The authors followed Thomas's (2006) approach to analyse qualitative evaluation data via a general inductive approach. The general inductive approach involves condensing the raw data into a brief summary format, establishing connections between the research objectives and those summaries, and finally, developing a framework or model about the underlying structure of the experiences or processes apparent in the raw data (Bezençon et al., 2023). The investigators used Nvivo 7.0 (Edwards et al., 2018) to code the content of the interview responses and could see patterns from which we derived major themes. A total of 132 evaluations were obtained, which were categorized into 8 themes (Fig. 6 illustrates the results of the evaluation analysis).

## *4.4. Procedure*

This research was conducted as part of the ITAAIP project, encompassing both online and offline training components. The video cloud platform has been integrated into the project since early 2021 to enhance teachers' information technology application abilities, and this implementation is still ongoing. Data collection for this study occurred from January 2021 to September 2021, involving participating teachers from various districts and counties in Zhuhai, China. The ITAAIP project explicitly follows a blended approach that combines online and offline elements, with a total training duration of 80 hours.

Among these, online training on the network platform spanned 56 hours, while the remaining 24 hours were allocated for offline training.

In the initial month, a diagnostic assessment was conducted to help teachers identify their areas of improvement. This enabled them to select relevant online courses, each consisting of 14 hours out of a total of 36 hours. Throughout the subsequent five months, teachers completed the online courses, submitted teaching designs, and recorded classroom sessions as required on the platform. In the final three months, teachers engaged in offline courses, which included expert-led training sessions, teacher discussions, instructional guidance, and assessments. The training environments for the experimental and control groups were fundamentally similar, except for the experimental group's use of the video cloud platform.

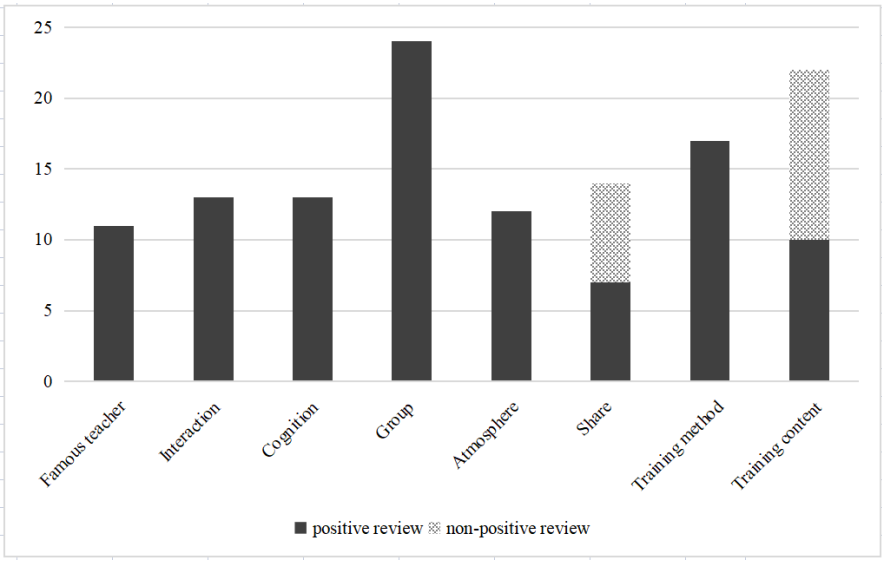


**Fig. 6**. Evaluation of the training by video cloud platform

## 5. Results

### *5.1. Teachers' daily activities on the platform*

The descriptive statistics highlight that, except for the 'average daily training time,' the experimental and control groups demonstrated a general similarity. However, in other aspects, the experimental group exhibited notably higher values compared to the control group. This suggests that the experimental group engaged in the broader spectrum of training behaviors within the same training time frame.

The *t*-test outcomes are summarized in Table 5. From the provided data, it is evident that there was no significant difference in the average daily training time between the experimental and control groups. Nevertheless, significant disparities were observed in the average number of discussions on specific topics, the count of answered questions, the volume of posts (replies), the quantity of peer reviews, and the tally of resource uploads (downloads). The experimental group consistently showcased significantly higher values in all these dimensions as opposed to the control group.

**Table 5**
Descriptive statistics and *t*-test of daily activities

| Dimension | Group | *F* | *t* | df | Mean | Sig. (Bilateral) |
|---|---|---|---|---|---|---|
| Average training time per day | experimental group | 1.439 | -.366 | 863 | .400 | .715 |
| | control group | | -.366 | 859.633 | .402 | .714 |
| Average number of discussions on a topic | experimental group | 150.308 | 70.876 | 863 | 7.53 | .000 |
| | control group | | 69.366 | 668.819 | 1.49 | .000 |
| Number of questions answered | experimental group | 41.773 | 40.365 | 863 | 8.45 | .000 |
| | control group | | 39.848 | 762.429 | 3.54 | .000 |
| Number of Posts | experimental group | 232.525 | 39.080 | 863 | 14.18 | .000 |
| | control group | | 37.989 | 593.122 | 6.97 | .000 |
| Number of peer reviews | experimental group | 204.211 | 83.668 | 863 | 35.18 | .000 |
| | control group | | 85.943 | 698.668 | 9.84 | .000 |
| Number of resource uploads | experimental group | 140.625 | 36.859 | 863 | 65.65 | .000 |
| | control group | | 37.683 | 753.674 | 31.87 | .000 |

### *5.2. Teachers' information technology application ability*

Prior to the presentation of survey data, the descriptive statistical outcomes pertaining to teachers' information technology application abilities in the experimental and control groups are outlined in Table 6. It can be observed that the standard deviation for each dimension within both the experimental group and the control group generally fell within the range of 0.02. This suggests that the initial levels of information technology application abilities were similar between the two groups (Pre-test). Following the training, the experimental and control groups demonstrated comparable performance in most dimensions, with the exception of the 'assessment and diagnosis' dimension, where the experimental group's scores surpassed those of the control group. Overall, in the remaining dimensions, the experimental group showcased higher scores (Post-test).

**Table 6**
Descriptive statistics of teacher information technology application ability

| Dimension | Group | Pre-test | | Post-test | |
|---|---|---|---|---|---|
| | | *N* | Mean | *N* | Mean |
| Technical literacy | experimental group | 407 | 1.869 | 407 | 2.627 |
| | control group | 446 | 1.892 | 445 | 1.892 |
| Planning and Preparation | experimental group | 407 | 2.071 | 407 | 2.085 |
| | control group | 445 | 2.037 | 445 | 2.042 |
| Organization and Management | experimental group | 407 | 2.078 | 407 | 2.917 |
| | control group | 445 | 2.086 | 445 | 2.091 |
| Assessment and Diagnosis | experimental group | 407 | 1.987 | 407 | 1.981 |
| | control group | 445 | 1.970 | 445 | 1.873 |
| Learning and Development | experimental group | 407 | 1.510 | 407 | 2.122 |
| | control group | 445 | 1.519 | 445 | 1.524 |
| Total score | experimental group | 407 | 9.497 | 407 | 11.733 |
| | control group | 445 | 9.505 | 445 | 9.524 |

The *t*-test results are displayed in Table 7, highlighting significant distinctions between the experimental and control groups in various aspects. Specifically, the experimental group demonstrated notably higher scores than the control group in technical quality, planning and preparation, organization and management, learning and development, and the overall total score. Notably, no significant differences emerged in

the assessment and diagnosis dimensions. This pattern suggests that the network research model of knowledge sharing among teachers effectively bolsters teachers' information technology application abilities, particularly in enhancing their technical literacy, planning and preparation, organization and management, and learning and development competencies. It is noteworthy that the traditional platform yielded comparable results to the new platform in terms of evaluation and diagnostic abilities.

**Table 7**
The t-test results of information technology application capability

| Dimension | Group | *F* | *t* | df | Mean | Sig. (Bilateral) |
|---|---|---|---|---|---|---|
| Technological literacy | experimental group | .338 | 56.727 | 850 | 2.628 | .000 |
| | control group | | 56.717 | 842.690 | 1.893 | .000 |
| Planning and Preparation | experimental group | 7.395 | 2.968 | 850 | 2.085 | .003 |
| | control group | | 2.954 | 819.658 | 2.042 | .003 |
| Organization and Management | experimental group | .681 | 58.717 | 850 | 2.917 | .000 |
| | control group | | 58.618 | 836.521 | 2.091 | .000 |
| Evaluation and Diagnosis | experimental group | 1.470 | .552 | 850 | 1.981 | .581 |
| | control group | | .553 | 848.896 | 1.973 | .580 |
| Learning and Development | experimental group | .219 | 48.678 | 850 | 2.122 | .000 |
| | control group | | 48.634 | 839.909 | 1.524 | .000 |
| Total Score | experimental group | .009 | 72.140 | 850 | 11.733 | .000 |
| | control group | | 72.091 | 840.809 | 9.524 | .000 |

## *5.3. Interview results*

### *5.3.1. Overall evaluation of the new training platform*

The qualitative interviews largely confirm that teachers enjoyed the new teacher training platform. Teachers particularly appreciated the technological features of the "Atmosphere" and "Training Method and Content" themes. From the interview transcripts, it was evident that teachers acknowledged the advantages of the knowledge sharing training model. The school-based training, rooted in knowledge sharing, allowed for intensive mentorship by master teachers, a feat not attainable through traditional training methods.

Regarding the themes of "Famous Teacher" and "Sharing," teachers sensed the presence of their peers and developed greater trust and closer relationships. When sharing personal insights, esteemed teachers exhibited more confidence and proactively shared their experiences. In contrast, experienced teachers tended to be more reserved. Younger teachers with limited experience focused more on learning than on sharing their own perspectives. Concerning training methods, some middle-aged and older teachers found the content to be reasonable and aligned with their needs, while others believed that specific "difficult, heavy, and urgent" issues required further development. A self-evaluation by the renowned teachers themselves mentioned "a broader range of personal influence."

Teachers also welcomed the shift from a more serious atmosphere to a more playful interaction model. For instance, someone noted: "not feeling marginalized," "face-to-face communication," and "convenient interaction."

Among the 15 teachers, three mentioned negative evaluations about "non-sharing" and "incomplete content." This was primarily due to their concerns about insufficient teaching experience, knowledge, and expertise, resulting in a lack of confidence in sharing. One individual remarked: "insufficient coverage of certain topics" and "failure to present urgently needed problem-solving content."

Overall, the video-based training model was highly appreciated, particularly for its interactivity, technological features, atmosphere, and reliance on group dynamics.

### *5.3.2. Attitudes towards the application of ICT in teaching*

The interview results are presented in Table 8. The interviewed teachers acknowledged the information technology application abilities and classroom teaching behavior of the teachers in the experimental group. Regarding the impact on teaching behavior, interviewees believe teachers directly observe the teaching process from real classrooms. These changes are consistent with teachers' ability to apply technology to carry out classroom teaching, organization, and management, and enhance learning and development ability.

**Table 8**
Teacher comments on the advantages of the ICT in teaching

| Theme | Illustrative example | Frequency | |
|---|---|---|---|
| | | Experimental Group ($N$ = 75) $K$(%) | Control Group ($N$ = 75) $K$(%) |
| Famous teacher | Individual teaching can be reviewed and guided by many experts. | 8(10%) | 3(4%) |
| Interaction | In terms of classroom teaching, teachers were more willing to organize students to carry out group learning, and paid attention to the interaction between teachers and students. | 13(17%) | 0(0%) |
| Cognition | More accurate cognition of classroom details, such as what technology to use, how to use, how to use it. | 11(15%) | 3(4%) |
| Group | Be able to know what peers are doing on the network, so as to clarify the individual needs to follow the teaching behavior norms and tasks. | 21(28%) | 3(4%) |
| Share | It is convenient to communicate and interact with other teachers, and my classes are favored by teachers from other schools, and my academic circle is wider. | 8(10%) | 6(8%) |

*Note*. $N$ = total number of responses; $K$ = number of responses under each theme; % = K/N

In addition, all communication is based on the actual teaching classroom of offline teachers, and the communication is mainly two-way or even multi-directional. Video can reflect the entire communication process, and the knowledge embedded in the teacher's body language and expressions can be extracted through the video. This can then be complemented with oral language and written communication to transform teachers' tacit knowledge into explicit knowledge.

Some of the interviewed teachers also mentioned, "The teachers in the experimental group were noticeably more willing to use technology to support the classroom and alter the teaching process in the classroom. In contrast, the teachers in the

control group only used technology as an auxiliary tool for classroom teaching, and technology did not provide significant benefits."

## 6. Discussions

### *RQ1. How can online training and knowledge sharing among teachers be integrated through a cloud-based video platform?*

This study addresses concerns raised in previous research regarding dissatisfaction with existing teacher training platforms. These platforms often suffer from lengthy video lessons, low resource utilization, simple interactive functions, and a disconnection from real classroom experiences (Brav et al., 2018). Similarly, Zhao et al. (2017) have pointed out deficiencies in the current form of ICT application training for new teachers, highlighting the absence of comprehensive and robust content to address critical and challenging topics. In contrast, the experimental group in this study exhibited remarkable improvements across multiple dimensions.

- The experimental group displayed high motivation to discuss the same topics, demonstrating the training environment's positive impact on accelerating the externalization and socialization of teachers' knowledge.
- Their higher participation in answering questions indicated a more open and welcoming attitude toward knowledge sharing, cultivated by the trust established during the school-based training process.
- Active involvement in forums with frequent updates showcased the knowledge sharing training mode's sustained role in breaking interaction boundaries and expanding the scope of teacher engagement.
- Training led teachers to actively externalize knowledge to different fields and exchange insights with peers, thus promoting personal knowledge growth.
- Notably, the experimental group's greater willingness to share resources underscored the supportive role of the technological environment in facilitating resource acquisition and sharing.
- In conclusion, integrating the SECI model in online teacher training effectively addresses the limitations of current knowledge sharing practices, leading to substantial improvements in various aspects.

### ***RQ2**. To what degree does the proposed approach effectively enhance teacher professional development?*

The findings show that incorporating video cloud technology in teacher training platforms positively impacts their effectiveness, promotes collaborative learning, and enhancing teacher professional development. Chen et al. (2019) identified critical factors such as willingness to apply, usage frequency, ICT-based teaching competence, helpfulness level, and contextual application, which influence teachers' adoption of ICT for high-quality teaching activities. The findings of this study corroborate these assertions, demonstrating that teachers who participated in school-based knowledge sharing training effectively tackled the aforementioned challenges and enhanced their information technology application skills.

Incorporating video cloud technology into teacher training platforms yields significant advancements in enhancing IT proficiency for teaching, fostering teacher

collaboration, and promoting overall professional development. Interviews conducted during the study revealed noteworthy distinctions between the experimental and control groups regarding classroom teaching prowess, accompanied by variations in teaching approaches, concepts, and classroom organization. Implementing video cloud training elevates teachers' technological application skills within instructional settings, fueling increased enthusiasm for active engagement in educational activities. Conversely, the control group's technological application within classroom teaching remains relatively straightforward, characterized by limited notable aspects.

Different teacher groups exhibited varying inclinations toward collaborative student group work. The experimental group effectively leveraged cooperative learning to drive problem-solving endeavors and enhance students' higher-order cognitive skills. In contrast, the other group perceived group cooperation merely as a classroom process, failing to harness its potential benefits fully. In essence, the integration of video cloud technology enriches teacher training, yielding improved teaching capabilities and more effective pedagogical practices.

## 7. Conclusions

Existing research on online training emphasizes the significance of teachers' interactive behaviors, knowledge sharing, and tacit knowledge transformation. However, knowledge transformation often remains confined to face-to-face settings, while practical online training uncovers various challenges, including limited autonomous knowledge creation, restricted deep learning interactions, and one-way knowledge sharing. This study aims to bridge these gaps by leveraging the SECI model, which elucidates the knowledge transformation process and offers guidance for effective knowledge sharing. By integrating the SECI model with online teacher training and video cloud technology, this research strives to amplify the efficacy of teacher training platforms, foster collaborative learning, and enable reciprocal knowledge sharing in an interactive remote context.

The outcomes of the data analysis underscore the effectiveness of the proposed approach. The experimental group displayed noteworthy enhancements in motivation, participation, resource sharing, and engagement in meaningful interactions. The video cloud platform delivered visualization, convenience, reliability, and heightened interaction among teachers, ultimately enhancing various facets of their capabilities. However, further investigations are warranted to evaluate the effectiveness of the training in domains such as planning and preparation, evaluation, and diagnosis. Overall, the proposed approach holds promise in addressing research gaps and elevating teacher professional development.

## Author Statement

The authors declare that there is no conflict of interest.

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