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Teacher Video Learning Research Overview and Insights

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Abstract

Under the dual development of technology application and theoretical research, studies on teacher video learning have become increasingly mature with corresponding theoretical reserves and application experiences. Based on 59 studies on teacher video learning, this paper summarizes four types of videos in teacher video learning: focused video, integrated video, scripted/analog video, and 360˚ panoramic video. Then, it summarizes three types of video applications in teacher video learning: video-based focused instructional investigation, virtual instructional practice, and video-based facilitated instructional coaching. On this basis, three inspirations for teachers' video learning are summarized: vision guidance: "lens" layout and "angle" setting, practice approximation: "virtual" and "simulated" field creation, and facilitation: "focus" maintenance and "atmosphere" construction.

Keywords

Video, Teacher Learning, Video Applications, Case Studies, Teacher Professional Development

1. Introduction

Video learning for teachers can be traced back to the micro-teaching in the 1960s (Sherin, 2003), which focused on the external teaching behaviors of teachers. Behavioral learning theory is also known as "stimulus-response theory" (Shan, 2021). The theory believes that learning is the connection between stimulus and response. Behaviorists believe that the external environment is a stimulus, and the individual behavior caused by the stimulus is a response (Shan, 2021). In education, the development and emergence of behaviorist psychology highlight the use of stimuli and feedback to shape and en-

hance learning behavior, as well as the use of conditioned stimuli to teach new behaviors and skills. In this way, teacher educators were influenced by behaviorism and believed that teachers would become proficient at teaching through repeated observation and deliberate practice of a range of skills using modern audio-visual tools.

Since the 1970s, due to the development of cognitive psychology, cognitivism which means learning is an internal process that involves memory, thinking, reflection, abstraction and motivation (Ally, 2004) has become the dominant learning theory in education, and teacher educators have begun to target teacher professional development at changing teachers' perceptions. It was hoped that by improving teachers' classroom observation and reflection skills, this would in turn facilitate the acquisition and development of teachers' knowledge and skills. Based on this, classroom observation and analysis methods have diversified from focusing solely on teacher behavior to focusing on teachers and students and using coding to analyze specific classroom interactions. For example, Professor David Clarke of the University of Melbourne, Australia, initiated the Learners' Perspective Study (LPS), which is a qualitative analytical project that utilizes learners' perspectives to analyze teaching interactions in junior high school mathematics classrooms from 13 countries and regions.

Teacher professional development is defined as a process of accumulating skills, professional knowledge, values and personal qualities that enables teachers to continually adapt within the educational system (Sancar, Atal, & Deryakulu, 2021). Research on teacher knowledge demonstrated the importance of teachers' practical knowledge, and teacher educators began to understand that teacher education should be a kind of practice-based teaching, and that the improvement of teachers' professional knowledge and skills should ultimately be rooted in classroom teaching practice. At the same time, they began to focus on the leading and guiding role of expert teachers' "practical wisdom" and the collaborative construction of knowledge in the teacher community, forming an expert-constructed video learning model for teacher communities, which have become an important turning point in teacher education and pedagogical research. The use of videos in pedagogical research and for teacher education has also been documented by scholars (Ling & Leonard, 2021) which demonstrates video, could develop teacher thinking. (Sherin & Han, 2004) documented how the use of videos accompanying microteaching and lesson analysis which focus on how teachers behave, think and reflect. For example, the video-based teacher professional development project "Geography: Teaching with the Stars", designed a series of activities and tasks, requiring participating teacher groups to conduct collaborative analysis and learning around the videos showing the classroom teaching of "star" teachers, and integrating the learned professional knowledge and skills into their own teaching practice.

Subsequently, video-based case studies became the main mode of application of video learning for teachers. In video case studies, teachers analyze and reflect on their own or others' videos based on a specific learning goal or teaching practice problem in order to achieve professional knowledge development or teaching problem solving. A typical and representative example is the "video club" teacher professional development program proposed by Sherin in 2004. In this program, outside experts and participating teachers meet at specified times to analyze and discuss classroom videos of participating teachers. The study showed that the professional perspectives of the participating teachers were developed through the video club (Sherin & Han, 2004). With the development of technology, computer-supported video case learning environment has been applied and developed, such as the use of virtual reality and other technologies to create virtual classrooms, simulation classrooms and animation teaching to assist teachers in the acquisition and development of professional knowledge and skills (Dieker, Hynes, Hughes et al., 2015), which is becoming one of the emerging and highly potential application forms of teacher video learning.

In general, teachers have a long history of using classroom video for their professional development, and their use of it has been refined and enriched by the evolution of both technology and theoretical research on teacher learning. Classroom video has great potential for teachers' professional development, as it captures complex and realistic classroom situations that can be paused, annotated, edited, and managed so that teachers can analyze and learn from them. In fact, scholars have gradually enriched and deepened the application and research of video-based teacher professional development, and have developed certain practical approaches and experiences that can be drawn upon in their actual teaching applications and project-based research.

However, there is a lack of depth of discussion on video-based teacher professional development and direct guidance on the application of video to practice. In a study by Gaudin & Chaliès (2015) conducted a detailed literature review on the effects of video viewing on teacher education and professional development, where they explored the characteristics of teachers' classroom video-viewing activities and their roles and impacts on teachers' professional development, as well as differentiating between different types of videos on the level of the video subject, including videos of unfamiliar teachers, videos of teachers' peers, and their own videos. But also, as they mentioned, how to select different types of video clips to support teacher learning? How to design and implement video-based teacher professional development activities have not been sorted out. Based on this, the following two questions guided our research review process:

1) What are the types of videos used in video-based teacher professional development research?

2) What are the typical application models for video-based teacher profes-

sional development?

2. Methodology

Regarding to answer the research questions, we adopted literature research method because this approach could aid in understanding previous research, identifying research gaps, and informing the design and implementation of new studies. The Web of Science database was selected as the source of literature and searched using the following keywords: "video," "video-based," "teacher professional development," "teacher education," "professional education", a total of 487 pieces of related literature were searched, and the following criteria were subsequently set for the inclusion of the literature: 1) only high-quality articles written in English were included; 2) only studies published from 2004-2021 were considered to ensure the comprehensiveness of the literature review; and 3) the articles described in detail the empirical research methodology and the research process. Based on the above criteria, the papers were initially screened by their titles and abstracts and, if necessary, the full text. The excluded papers were double-checked to confirm that they did not meet the inclusion criteria, and the final screening yielded 59 papers. The paper search and screening process is shown in Figure 1.

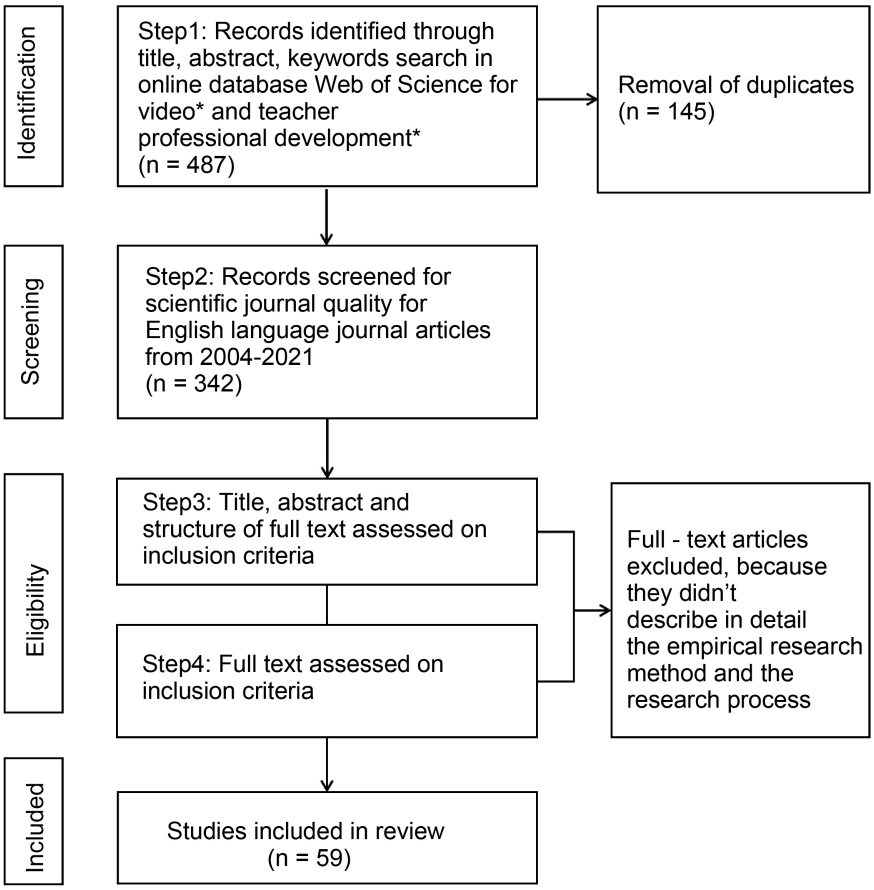

Figure 1. Screening process.

3. Results

3.1. Types of Video

Video as a medium does not have the potential for learning, but must be designed and developed in order to be transformed into a learning resource that facilitates the achievement of teachers' learning goals (Sherin, Linsenmeier, & Van, 2009). Through the analysis of 59 papers published from 2004 to 2021, four types of videos applied in teachers' video learning are summarized and refined, which are focused video, integrated video, scripted/simulated video, and 360˚ panoramic video, as shown in Table 1 summarizes the purpose, application methods, and application characteristics of the above four types of videos.

3.1.1. Focused Video

Focused videos are video clips that have been carefully selected and edited to reflect key events and important features of the classroom. In order to support teachers in accomplishing their professional development goals more efficiently and adaptively, and to better target their actual teaching problems, researchers believe that it is necessary to extract classroom activities clips from teachers themselves or others that are worth observing and analyzing (Sherin, Linsenmeier, & Van, 2009). These video clips are usually organized into teaching activities or tasks

Table 1. Summary of types of videos and their applications.

Video Type	Application purpose	Application method	Application Features
Focused video	Supporting teachers in accomplishing their professional development goals more efficiently and adaptively, and in solving their practical teaching problems in a more targeted manner	Video clips that need to be carefully selected and edited to reflect key events and important features of the classroom	Demonstrate the most significant teaching activities or tasks in the classroom from multiple perspectives
Integrated video	Supporting teachers' contextualized understanding of teaching and learning, as well as self-directed exploration and learning of complex, ill-structured constructs of teacher expertise	Linking videos and various types of classroom background information	Enrich video-centered instructional support that creates a cognitively resilient learning environment
Scripted video/Analog video	Training and testing (pre-service) teachers' professional knowledge and skills	Developing instructional scripted or simulation videos based on evidence from theoretical research and practical experience	The presentation of a pre-planned, artificial classroom situation is a manifestation of practice approximation
360˚ panoramic video	Providing teachers with real-life-like sensory and imaginative experiences that promote embodied reflection	Record and capture all aspects of the classroom using a 360˚ camera, and observe using a VR headset or a device that supports 360-degree video playback	Enrich video presentation perspectives, based on real classrooms for a more immersive experience

to demonstrate the most significant teaching interactions in the classroom (Zhang, Lundeberg, & Eberhardt, 2011). Focused, multi-scene, multi-granular classroom videos provide teachers with a view of multiple levels of instructional practice and possible learning opportunities for students (Kang & Van, 2019).

3.1.2. Integrated Video

Integrated video refers to a collection of hypermedia resources formed by linking video with various types of information carriers, such as audio, video, graphics, animation and text. For example, the Elementary and Secondary Teacher Educational Program (eSTEP), developed by the University of Wisconsin and Rutgers University, has built a hypermedia library centered on classroom videos. In this online library, developers embed conceptual knowledge, such as learning sciences, into videos for teachers to learn from, and Goeze et al. (2014) built video lessons embedding teachers' and students' ideas and conceptual knowledge based on cognitive resilience theory, and teachers use the videos and their textual hyperlinks to conduct classroom analyses and group discussions.

3.1.3. Scripted Video/Analog Video

Scripted videos, also known as analog videos, are human-designed, choreographed, performative classroom videos. The steps in developing a scripted video include: 1) selecting evidence-based practice, 2) script development, and 3) video production (Dieker et al., 2009). Scripted videos can be used to illustrate exemplary practices or problematic teaching situations (Goeze et al., 2014). They can also be used to develop (Dalinger et al., 2020) and test the professional knowledge and skills of pre-service teachers (Codreanu et al., 2020).

3.1.4. 360˚ Panoramic Video

Due to the development of technology, 360˚ panoramic video cameras are also making their way into the classroom to support teachers' classroom observation and reflection. In teacher education, 360˚ panoramic video can provide teachers with a multi-directional and multi-angle view of classroom observation, bringing sensory and imaginative experiences similar to those in real classrooms, thus facilitating embodied reflection (Walshe & Driver, 2019).

3.2. Typical Application Cases

Under the dual development of video technology and teacher learning theory, the types of videos have been expanded and enriched, and the applications of videos have been developed and improved accordingly. After sorting out and analyzing related researched, it is found that the current video applications of teacher video learning can be mainly divided into three aspects: video-based focused teaching investigation, virtual teaching practice, and video-based facilitated teaching tutoring.

3.2.1. Video-Based Focused Pedagogical Exploration

In video-based focused pedagogical exploration, teachers focus on a clear inves-

tigative goal and gather evidence around a video clip or a structured set of videos or a hypermedia repository of linked textual resources to support an instructional exploration. In this video application mode, emphasis is placed on the fit of the goal to the selected video clip and the collaborative knowledge building of the teacher community.

The project reported by Johnson & Mawyer (2019) demonstrated a typical video-based focused pedagogical exploration. Before the project began, the preservice teachers identified video learning objectives, and then the preservice teachers selected a 5 - 8 minute video clip from one of their lessons. Over the course of the sessions, teachers took turns presenting their chosen video clip and presenting background knowledge of their classroom, including learning objectives and how they incorporated elements of core teaching practices. Teacher participants look for evidence from the video clips to focus on and document important classroom events.

The preservice teachers in the above case study gathered evidence to support their reflection and thinking around content-specific video clips based on the purpose of the inquiry. A high degree of fit between the content of the video presentation and the inquiry goal is a necessary prerequisite for focused inquiry, and as Colestock & Sherin (2009) found in her study, videos that provide limited visibility into students' thinking and reasoning provide less insight into effective inquiry into the relationship between teaching and learning. Indeed, teachers also give careful consideration to the selection of video clips for their investigations to ensure that the videos they choose are highly supportive of the inquiry goals. For example, video clips showing classroom problematic practices (e.g., distracted students, classroom disruptive events, etc.) were utilized to support teachers' investigations of classroom problematic practices in the study reported by Wolff et al. (2017). And Walkoe et al.'s (2017) study showed video clips of students' activities in the classroom to support teachers' attention to student thinking and deeper reasoning inquiries. Santagata & Bray (2016) used videos focusing on students' math errors to support teachers' inquiry into student thinking. The videos and their roles in research are shown in **Table 2**.

While the goal of the focused inquiry in the above studies was primarily to promote teachers' classroom insight and to enhance their reflective thinking, a group of researchers, represented by Pinter et al. (2015), used the results of the focused inquiry as feedback on their practice to improve the quality of teaching and learning, with Pinter reporting on a video-learning research project for in-service teachers with the primary goal of improving teachers' ability to use praise effectively in their teaching. In an ongoing cycle of inquiry, teachers watch videos of themselves teaching, survey and assess their own use of praise in classroom teaching, set goals for the next day's teaching through the results of that survey and assessment, and subsequently survey their practice teaching again, realizing an iterative cycle of teaching practice that continues to be refined. In addition, with the development of technology, which has injected new life into focused teaching surveys, teachers can conduct surveys based on

Table 2. Selected videos and their objectives.

Content of the video	Video role (objectives)	Literature sources
Videos of problematic classroom incidents (e.g., distracted students, classroom disruptions, etc.)	Supporting teachers' understanding and interpretation of problematic classroom events	(Wolff, Jarodzka, & Boshuizen, 2017)
video clips of students' activities in the classroom	Support teachers in focusing on students' thinking and reasoning deeply	(Goeze et al., 2014) (Tekkumru-Kisa& Stein, 2017)
Video clips of teacher-student interactions and teacher differentiation of instruction	Supporting Teachers' Professional Perspectives on inclusive Classrooms	(Kang & Van, 2019)
Video clips of teachers conducting classroom management	Supporting teachers' professional vision of classroom management	(Prilop, 2021)
Demonstrates core instructional practices in which teachers attempt to guide student thinking or support ongoing changes in student thinking	Supporting teachers to attend to student thinking in their teaching practice and to reflect critically on their own teaching behaviors	(Johnson& Mawyer, 2019)
Videos showing students' math errors	Supporting teachers' professional vision of student thinking	(Yeh & Santagata, 2015)

digital hypermedia learning environments. For example, the Multimedia Interactive Learning Environment (MILE) developed by the Freudenthal Institute in the Netherlands collects and packages more than 3500 video clips or classroom footage in a structured way. Preservice or inservice teachers can conduct full-text searches through classroom dialogues, course summaries and course clips to support their guided investigations related to teaching and learning issues (Hollingsworth & Clarke, 2017).

Focused, structured video clips or collections of video clips capture specific classroom scenarios, providing teachers with the opportunity to observe the actual details of the classroom and the various possible perspectives in teaching. And through collaborative analysis from different teacher subjects, teaching and learning experiences with individualization are brought together into a collective space of inquiry, thus enabling professional inquiry between multiple subjects to collide and merge with each other, generating new meanings of pedagogical inquiry (Zhang, Lundeberg, & Eberhardt, 2011). For example, Kleinknecht and Gröschner (2016) reports on a practical teaching course for advanced pre-service physical education teachers (secondary schools) in a southern German city. In this course, participants engaged in a "video feedback cycle" (VFC), which involved: 1) recording and uploading video clips of their own classroom practice, lesson plans and other materials used in the course (e.g., task sheets) to a software program, "V-Share" (a video-based online platform developed by the researcher); 2) based on a web-based interface where participants engaged in

self-reflection: annotating specific events in the video that they wanted to share; 3) peer feedback: peers comment on the video clip and written self-reflection; 4) expert feedback: experts comment on the video clip and written self-reflection; 5) viewing the video a second time, self-reflecting, and responding to peer and expert feedback, a step designed to achieve feedback balance, including the extent to which the comments given by peers and experts are considered helpful.

Another example is the pedagogical inquiry project around trainee teachers reported by Masats and Dooly (2011), which is based on a web-based online platform where trainee teachers select a clip of their good teaching or one that they think needs to be improved and their own pedagogical puzzles or questions after each teaching placement and post it on the platform in order to discuss the inquiry with their peers and experts in order to support pedagogical improvement.

Research in classroom inquiry, supported by technology, has also driven research advances in classroom analysis tools and methods. The perspective of classroom inquiry is beginning to shift towards an effective combination of spatio-temporal and bi-directional analyses, e.g., Shapiro and Garner (2021) demonstrated a classroom analysis methodology for interactional geography, which allowed teachers to transcribe and interactively visualize classroom teacher-student locations, conversations, and audio-visual data in space and time. In addition, 3D panoramic cameras are entering the classroom, and classroom video shot with panoramic cameras can capture the classroom from all sides, giving teachers a dual perspective of independent inquiry in both temporal and spatial dimensions (Walshe & Driver, 2019).

3.2.2. Virtual Teaching Practices

Virtual pedagogical practice is a new practice-based application of video learning for teachers that has been developed in recent years and is characterized by the virtual nature of pedagogical practice. In this environment, learners are guaranteed "safe" practical experimentation at low risk, where they can try out different behaviors and observe their possible outcomes without any real and serious pedagogical consequences (Kaufman & Ireland, 2016). The model is based on Kolb's (1984) learning-by-doing theory of the cycle of learning experiences, which consists of four phases: engaging in concrete experiences (situations), engaging in reflective observation, conceptualization, and practice through active participation in similar simulations or types of situations in the natural environment. Some of the more typical virtual teaching platforms are the mixed reality simulations TLE TeacheLivE, TeachMe Lab, Mursion, and the online virtual reality platforms Second Life and OpenSimulator (Lindgren et al., 2016).

The first virtual pedagogical practice is the mixed reality simulation represented by TLE TeachLivE, a mixed reality simulation platform developed by the University of Central Florida as an immersive environment consisting of digital video technology and physical components, as shown in **Figure 2**. The

Figure 2. Virtual teaching practices.

platform uses "digital puppets" in the form of virtual students or an avatar of the virtual teacher to form a virtual classroom, and these avatars can interact with the (pre-service) teacher in two ways, either through a pre-programmed code that is controlled in advance, or behind the scenes by a live interactant who uses Skype to control the behavior of the avatar (Bautista & Boone, 2015), so the interactors need to prepare for the simulation and plan the simulation scenarios, and they also need to be well versed in the avatars' respective personalities and backstories in order to make the virtual students more realistic (Dieker et al., 2015). In the simulation, the (preservice) teacher walks into a lab that looks like a middle school classroom and interacts with virtual students projected on a screen. Under the control of the behind-the-scenes interactors, the avatars can respond to the (preservice) teacher's various teaching behaviors in real time, just like the real children in the classroom. During this process, the (preservice) teachers can reset the program and start again at any time, so they can teach the same lesson over and over again until they are confident that the lesson is going well (Dalinger et al., 2020).

Dieker describes TLE TeacheLivE as a "sandbox technology" (Dieker et al., 2015). This technology is primarily aimed at preservice teachers to provide them with targeted skill practice. For example, when Perterson used TLE TeacheLivE with special education preservice teachers, the simulation provided practice in using strategies to increase student engagement (Peterson-Ahmad, 2018); Garland et al. (2016) had special education preservice teachers use TLE TeachLivE to practice specific strategies used in implementing individualized clinical coaching; Ferguson (2017) also used TeachMe Labs to support elementary preservice teachers in practicing reading assessment administration.

In addition to targeted training, these mixed reality simulation platforms can provide preservice teachers with opportunities for practice modification and re-

petition. Dieker et al. (2014) particularly emphasize the pause and restart features of TLE TeachLivE because they allow pre-service teachers the opportunity to repeat skill practice until they reach proficiency. In contrast to with a real-time live classroom, in a mixed reality classroom, the instructor can pause the current scenario at any time in order to provide coaching to the preservice teacher, or even restart the scenario if the preservice teacher is experiencing particular difficulties (Damewood, 2016). In addition, Damewood argues that pre-service teachers receiving immediate feedback from peers and teachers during their simulation practice facilitates simulation learning and allows pre-service teachers to engage in meaningful reflection based on their performance (Dalinger et al., 2020). This opportunity to re-try simulation scenarios based on feedback and reflection fosters preservice teachers' growth.

In summary, mixed reality simulations provide pre-service teachers with a realistic classroom environment by combining live interactors with digital technology to gain authentic skill practice through live interactions with avatar-style virtual students.

The second type of virtualized instructional practice is the virtual reality simulation. Online virtual reality simulation tools that have been used for pre-service teacher education include Second Life and OpenSimulator. Unlike the previously discussed mixed reality simulations, in which pre-service teachers maintain a real physical presence and operate in a physical environment to interact with digital avatars in a virtual environment, pre-service teachers in virtual reality environments are fully engaged in a multiplayer virtual world where each participant teacher adopts the identity of an avatar and interacts with the simulation through that avatar (Gallego, Bueno S, & Noyes, 2016). For example, in the case of Second Life, the teacher enters the simulation with a "present" avatar and interacts with the avatar via voice or text during the virtual practice session to gain appropriate skills (Dieker et al., 2014).

Hybrid virtual reality simulations offer teachers a more immersive and realistic teaching experience, but virtual reality simulations tend to be less expensive to develop (Dieker et al., 2014) and can also be practiced over and over again for specific teaching skills. Studies such as those by Knutzen and Kennedy (2012) and Kim and Blankenship (2013) have demonstrated that the use of Second Life can be effective in enhancing the instructional practices of teachers of second language learners and has the potential to support teachers' immersive experiences in virtual reality-based environments, but Dieker et al. (2014) have also cautioned that a certain level of skepticism is still required when teachers type or speak as avatars in Second Life of game-based skepticism.

While the mixed reality virtual platforms and virtual reality platforms mentioned above are designed to target pre-service teachers to practice specific classroom teaching behaviors, there are other platforms that focus on teacher training in instructional design, such as LessonSketch (Herbst et al., 2011), an online instructional design platform for teachers developed by the University of Michi-

gan, which allows teachers to build, visualize, annotate, share, and talk about representations of teaching. The LessonSketch platform contains a library of many pedagogical representations such as teachers, students, desks, chairs, speech bubbles, etc. Users can utilize these audio-visual pedagogical representations to create a virtual classroom based on a comic book-formatted scenario of teaching practice. As shown in **Figure 3**, a virtual lesson plan designed by a pre-service teacher. These audio-visual representational tools can help pre-service teachers to observe teaching and learning, explore tactical strategies in teaching and learning, as well as support pre-service teachers in rehearsing instructional interactions (Herbst et al., 2011), and can also enhance pre-service teachers' classroom attention and instructional decision-making skills to a certain extent (Lee, 2021).

Although virtual teaching practice is a hands-on simulation of learning, related studies have shown that teachers' learning from virtual practice-based

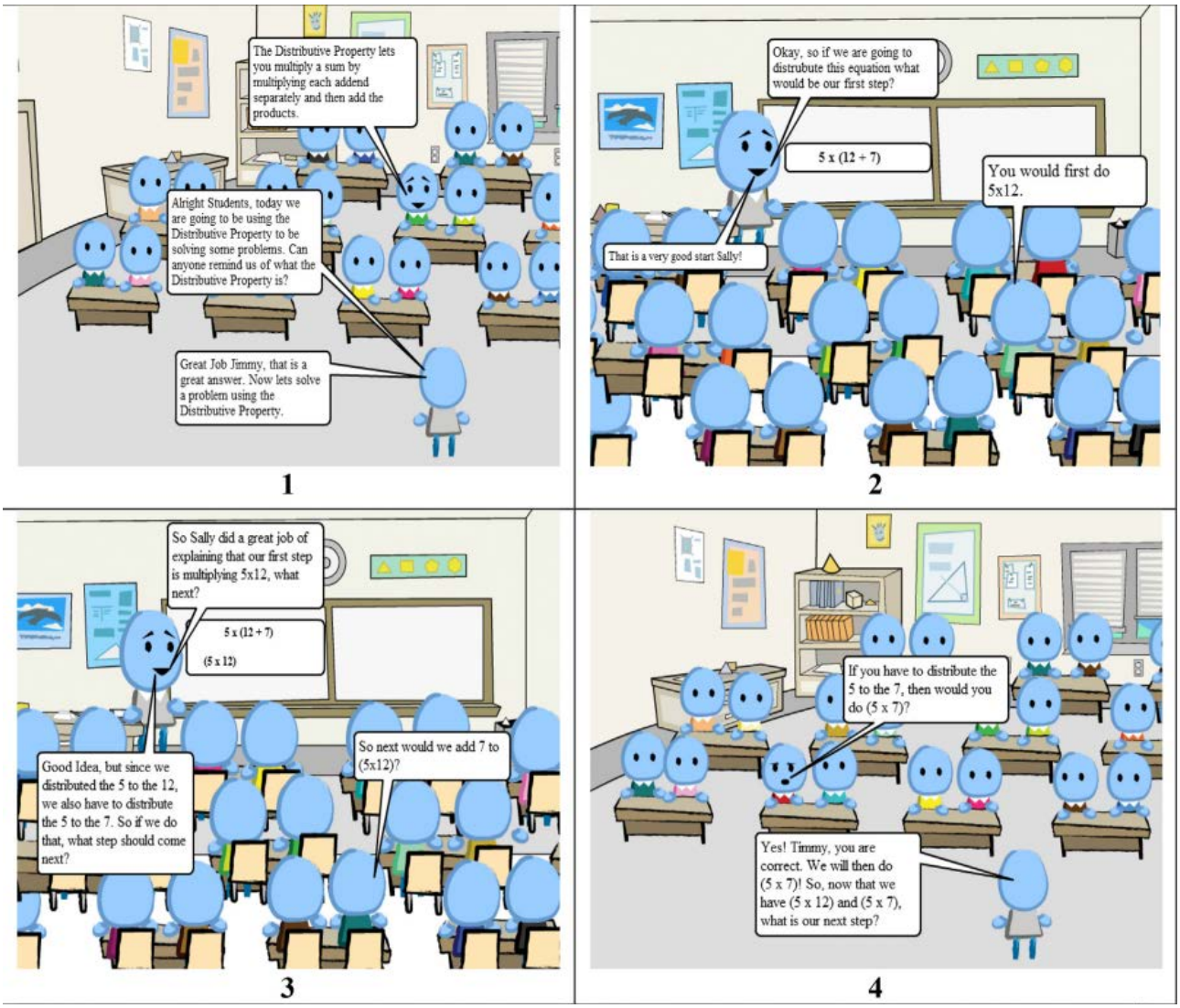

Figure 3. Virtual lesson plan design.

teaching is effectively transferred. For example, Dieker et al. (2014) showed that pre-service teachers' skill practice in TLE TeachLivE classrooms translates well to transfer to the field classroom; Sander (2014) also found that pre-service teachers who participated in the TLE TeachLivE simulation were able to make reflexive connections between their learning during the simulation and their field experience, and that they gained a more realistic understanding of inquiry-based instructional methods. a more realistic understanding; however, the findings of Chini et al. (2016) raise questions about the fidelity of simulation instruction and emphasize the need for further investigation of participating teachers' experiences in simulation and in the field to provide additional insight into simulation design for effective transfer of targeted instructional skills from simulation to the field by novice teachers.

In addition, simulation allows teacher educators to identify areas for improvement in pre-service teachers' skill performance (Chini, Straub, & Thomas, 2016) and allows teacher educators to standardize pre-service teachers' practice experiences, thus contributing to a reliable assessment of pre-service teachers' application of knowledge and skills (Codreanu et al., 2020).

3.2.3. Video-Based Facilitated Instructional Coaching

Facilitated instructional coaching is another approach to video learning that focuses on the role of facilitation in teacher professional coaching. Researchers led by this model argue that teachers have not learned to improve their instructional practices by simply observing and reflecting on classroom videos. These videos need to be carefully selected, sequenced logically, and facilitated through facilitator-led, participant-centered discussions to help teachers notice and reflect on important aspects of teaching and learning in the videos (Blomberg et al., 2013). In the Tekkumru-Kisa et al. (2015) Designed and Facilitated Cognitive Needs-Based Video Professional Development for Science Teaching (TSCD) project. Tekkumru-Kisa believes that facilitators of learner-centered teacher professional development face similar challenges as teachers who teach in the classroom. Analogous to the steps that teachers take to design instruction in the classroom, the researchers designed and mapped out a practical framework for video-based teacher professional development for teacher facilitators: setting the tone, "pre-determining" the response, sequencing the video, and organizing the professional development tasks around the video.

The choice of videos and the sequence of tasks play an important role in the acquisition of knowledge and the development of teachers' competence. Combined with the above case, the researcher did the following guidance in her facilitation activities. First, typical classroom videos were selected and sequenced based on cognitive theories so that teachers could make initial perceptions through comparison and eventually gain new knowledge. The selection and sequencing of videos was also intentionally considered in the video club environment designed by Barnhart & van Es (2020), where teachers participated

were asked to analyze and discuss around the published videos in the first three sessions, and in the last two sessions, the videos were replaced with teachers' own videos. The study found that by doing so, the design was able to promote more critical pedagogical conversations among the participant teachers. At the same time, focusing on the timing of teaching new knowledge to the teachers, the facilitator imparted the relevant knowledge of the professional concepts to the teachers only after they realized the problem, instead of indoctrinating them.

There is also a subset of researchers who have made separate provisions for video capture and collection, video quality control, what teachers pay attention to in video analysis, and how they analyze classroom interactions, and have designed and developed appropriate frameworks. As shown in **Table 3**, the frames for capturing and selecting video, curriculum analysis framework and framework of attention for the course in the research are summarized.

In addition, some scholars, represented by Kang & van Es (2019), have been influenced by socio-cultural theories that place more emphasis on the design of interactions around video. They argue that what teachers know and are able to do is shaped by their interactions with other people and material artifacts in different environmental communities, and therefore teachers' pedagogical learning depends on the type and nature of the interaction. And this interaction is built and coordinated by the system of activities embedded in the video, not the video itself. In other words, the video and the activities and materials that surround it have the potential to support the development of teachers' professional competence in ways that transcend their boundaries. Thus, they emphasize that video should be thought about and used from a systemic, holistic perspective and work to create a good atmosphere for teacher group workshops. To this end, scholars have proposed a number of heuristic design principles to provide some rules of thumb. For example, Blomberg et al. (2013) heuristic design of learning

Table 3. Capture and selection of videos, classroom attention, and classroom analysis frameworks.

Frames for capturing and selecting video	Three issues necessary to utilize selfie videos: camera position, how much video to take, and when to assign the task of taking, selecting, and using the video. (van Es et al., 2015) Select video clips that promote discussion of student thinking: windows: are there multiple entry points where students' thinking can be seen; depth: does the math work reflect depth and rigor? Clarity: is the student's thinking obvious or does it need to be understood by the viewer?
Curriculum analysis framework	Lesson Analysis Framework (Hiebert & Grouws, 2007) Learning to Notice Framework (Van Es & Sherin, 2002; 2008) Components of Effective Teaching (Seidel & Shavelson, 2007; Stürmer, Könings, & Seidel, 2013) Mathematical Quality of Instruction (Mitchell, Beisiegel, & Barmore, 2020) Task Analysis Guide in Science (Tekkumru-Kisa, Stein, & Schunn, 2015)
Framework of attention for the course	Algebraic thinking framework (Walkoe, 2015) Mathematical Opportunities in Student Thinking (Leatham et al., 2015) Rapid survey of student thinking (RSST) Algebraic thinking framework (ATF)

environments design centered on "learning objectives" and Kang & van Es (2019) Principled Use of video (PUV), a comprehensive framework for the use of video in video learning design.

What scholars agree on and emphasize is the role of the facilitator as a dialogue-guiding practice and atmosphere creator in the video-based instructional coaching process. For example, in Arya et al.'s (2014) study the facilitator creates an environment conducive to dialog in teachers' discussion of the videos, where sensitivity, responsibility, risk-taking, and trustworthiness of the teacher community are supported and encouraged, while different viewpoints are allowed to be freely expressed. Johnson & Cotterman (2015) set rules for pre-service teachers' video seminars, encouraging pre-service teachers to adopt an interpretive rather than an evaluative stance. Similar to Johnson's study, Coles (2019) also emphasized guiding teachers towards evidence-based interpretations, avoiding premature judgments or evaluations, and directing the focus of the discussion in some way during the discussion of video club. The view held by both researchers, Johnson and Coles, is that an interpretive stance focuses on the use of the evidence in the video clips to make sense of students' thinking and its relationship to teaching rather than explicitly criticizing the teacher. Barnhart et al. (2020), in order to foster critical discourse in the seminar, teachers were encouraged to adopt an inquiry stance to analyze practice, interpret student thinking based on the evidence and allow for a variety of possible interpretations, in addition to leading to problematizing the pedagogical challenges raised in the analysis. In Borko et al.'s (2008) study, the facilitator listens to and selects important ideas from group conversations to ensure that these important ideas are shared and fully discussed. As shown in **Table 4**, the discourse features that the researchers suggested should be developed in a video-based teacher professional workshop are summarized, and these discourse features provide a frame of reference for the facilitator to grasp and control the direction of the teacher workshop.

However, it has also been suggested that the facilitator role itself can be problematic as it can create hierarchies that can impede teacher learning (Carlone & Webb, 2006), and that a facilitator without the appropriate skills or support can stifle dialogue, and so it has been proposed that power be (at least partially) distributed amongst the group, and that there be a "leveling of the hierarchy" (Segal, Snell, & Lefstein, 2017), while at the same time. Mitchell also cautions that a facilitator with more expertise is not necessarily a good facilitator, i.e. skilled facilitation does not mean more or less expertise (Mitchell, Beisiegel, & Barmore, 2020).

In addition, a growing number of designers of teacher professional development recognize that if video-based facilitated instructional coaching is intended to achieve meaningful change in teacher practice, they must incorporate consideration of the multiple domains of teacher learning, cognitive, affective, and motivational (Kleinknecht & Schneider, 2013), that are relevant to socialized interactions in teacher group learning. Numerous studies have shown that mutual

Table 4. Characteristics of the discourse.

Discourse characteristics	Literature sources
1) Guide the group through the analysis task; 2) Maintaining a position of inquiry; 3) Stay on top of the video; 4) Support teamwork;	(van Es et al., 2014)
1) Cultivating Critical Discourse; 2) Encourage collaborative meaning making; 3) Support evidence-based discussions; 4) Remain open to multiple interpretations; 5) Problematize the pedagogical challenges raised in the analysis;	(Barnhart & van Es, 2020)
1) Teacher-led (primarily teacher-led conversations rather than outside experts); 2) Professional dialogues (discussions between teachers and researchers); 3) Focus (centered on the elements of the observation framework chosen by the teacher); 4) Evidence-based (using classroom videos to check teaching); 5) Directions (focusing on teachers' reflections and their implications for practice)	(Hollingsworth & Clarke, 2017)
1) Focus on issues related to classroom practice; 2) Involve pedagogical reasoning; 3) A rich manifestation based on practice; 4) Different viewpoints are presented and attended to; 5) Generative orientations toward students, learning, content, teaching, and practice issues; 6) Combined support and criticism	(Lefstein et al., 2020)

trust and equal inclusion is a favorable climate for teacher video learning and facilitates the production of generative discourse (Lefstein et al., 2020). However, on the one hand, the biggest threat to the creation of an atmosphere of trust and safety is the hierarchies in teacher groups, such as teacher power and status weighted by teaching experience, title, designation, age, etc. These hierarchies promote or impede inquiry-based learning and dialogue between novice and veteran teachers in teacher groups (Eshchar-Netz, Vedder-Weiss, & Lefstein, 2022). On the other hand, in order to maintain the seminar atmosphere, e.g., not to harm their own or their colleagues' public face, teachers engage in face work in seminars, which inhibits or mitigates the threat of face-saving, which, together with the public and collaborative nature of video-learning, makes face-saving unavoidable, and which facilitate or impede the generative pedagogical dialogues of teachers in teacher groups (Vedder-Weiss, Segal, & Lefstein, 2019).

In summary, video is both a research tool and a teacher learning tool, and like any other tool used for teaching and teacher learning, video is only productive when it is used skillfully.

4. Implications for Teacher Video Learning

From the above analysis, it can be seen that the application of teacher video learning fully reflects the latest developments in video technology and teacher learning theory. Accordingly, there are important insights for further application

and research on teacher video learning.

4.1. Vision Guidance: "Lens" Layout and "Angle" Setting

A teacher's professional vision is the teacher's ability to observe and interpret what is happening in the classroom, which involves what the teacher "sees" and how he or she interprets what he or she "sees". The selection of videos limits the teacher's vision to its maximum range, so the video needs to present the most representative and typical classroom instruction based on the teacher's learning objectives or the pedagogical problem being solved. Focusing the video increases the chances that the teacher will "see" the most significant features of the classroom. It is also important to note the relationship between the teacher in the video and the observing teacher. Typically, videos of different subjects (including the teacher's own, colleagues', and published videos) are selected according to different teacher professional development goals (Kleinknecht & Schneider, 2013). Focused, multi-scenario, multi-granular video clip layouts provide teachers with "lenses" to see multiple dimensions of instructional practice and possible learning opportunities for students, while classroom observation and analysis tools and frameworks help to further narrow down the scope of the observations, helping teachers to focus on specific features of interest and to take multiple perspectives on what is being observed. And understand and analyze the observed content in a multi-faceted, multi-thematic, logical and structural manner (Brouwer et al., 2017). This is an important part of a teacher's professional vision. Therefore, scaffolding for teachers to observe and analyze videos needs to be provided at the right time in relation to professional development goals and the content of the videos selected. In short, the selection of "focus" videos and the identification of a structured, multi-dimensional framework for classroom observation and analysis lay out the lens and set the perspective for teachers' professional vision, allowing them to see the "big world of teaching and learning" from a "tiny place".

4.2. Practice Approximation: "Virtual" and "Simulated" Field Creation

As an education in practice, teacher preparation should be a practice-based teaching and as preparation for the professionalization of practice, teacher education is predicated on the development of the capacity to continually improve practice, to make it more effective and equitable and so what pre-service teachers need to learn needs to be integrated with practice. However, time and space constraints are currently two major challenges in practice-based teacher preparation programs in teacher education (Santagata, Yeh, & Mercado, 2018). With the evolution of technology and related learning theories, teacher educators can create "simulated" or "virtual" venues for pre-service teachers to prepare for the teaching profession in "safe" simulated learning environments. This requires teacher educators to work with computer science

experts to develop instructional simulation environments that effectively support pre-service teachers. Examples include mixed-reality simulation platforms, instructional simulation platforms, or scripted simulation videos. Such simulations become a substitute or approximation of practice while providing teachers with authentic teaching experiences and feelings. In addition, the fidelity of the instructional simulation environment is a key factor that needs to be further considered, i.e., whether the simulation platform, which is designed for specific pedagogical skills training, is effective in supporting the acquisition of teachers' knowledge and skills, as well as effective in enabling the transfer of learning so that what is learned can be truly applied to real classroom scenarios.

4.3. Facilitation: "Focus" Maintenance and "Atmosphere" Construction

Teacher group learning around videos allows individual teachers to develop their professional competence through group dynamics. However, simply bringing teachers together to watch a video does not ensure effective, ongoing professional development. It is important to carefully select video clips and their viewing perspectives based on teachers' professional development goals or actual teaching problems to be solved, and to embed sequential tasks and activities around the video to enable participant-centered discussions that help teachers to notice and reflect on important aspects of teaching and learning in the video (Zhang, Lundeberg, & Eberhardt, 2011). This emphasizes the facilitator's role of facilitating leadership in teachers' video learning. In order to facilitate teachers' video learning more effectively, facilitators need to shape the teacher group seminar discourse by using dialogic feedback such as maintaining a stance of inquiry, fostering critical discourse, supporting evidence-based discussion, maintaining a pedagogical focus on the video, avoiding evaluative dialogue, remaining open to multiple interpretations, and guiding generative orientations toward students, learning, content, teaching, and practice issues (Lefstein et al., 2020), to create a favorable atmosphere of the seminar.

5. Conclusion

In teacher education, videos are widely used to facilitate teachers' learning about teaching practices. After a long period of research and application, the application model of the types of video resources for teacher learning has matured. Under the dual spiral development of video technology and teacher learning theory, it is believed that the models of video learning for teachers will be expanded and extended, and more innovative and effective teacher learning models will be used to promote teachers' knowledge and skills, and to feed into classroom teaching practices. It is worth noting that teacher learning is a long-term cyclical process, and its effectiveness will ultimately need to be tested in practice. Teachers need to learn by doing, practice by learning, and reflect and

act in an iterative cycle. In addition, teacher educators should also realize that in teacher education, they should not just pursue the application of new technologies and blindly copy mature application models, but should flexibly design and plan a localized picture of teacher professional development according to local socio-cultural contexts, school policy contexts, teachers' learning goals, and technological conditions.

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Conflicts of Interest

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References

Ally, M. (2004). Foundations of Educational Theory for Online Learning. In T. Anderson (Ed.), *The Theory and Practice of Online Learning* (2nd ed., pp. 16-44). AU Press. https://doi.org/10.1108/09555340410561723

Arya, P., Christ, T., & Chiu, M. M. (2014). Facilitation and Teacher Behaviors: An Analysis of Literacy Teachers' Video-Case Discussions. *Journal of Teacher Education, 65,* 111-127. https://doi.org/10.1177/0022487113511644

Barnhart, T., & van Es, E. A. (2020). Develop a Critical Discourse about Teaching and Learning: The Case of a Secondary Science Video Club. *Journal of Science Teacher Education, 31,* 491-514. https://doi.org/10.1080/1046560X.2020.1725724

Bautista, N. U., & Boone, W. J. (2015). Exploring the Impact of TeachME™ Lab Virtual Classroom Teaching Simulation on Early Childhood Education Majors "Self-Efficacy Beliefs". *Journal of Science Teacher Education, 26,* 237-262. https://doi.org/10.1007/s10972-014-9418-8

Blomberg, G., Renkl, A., Gamoran Sherin, M., Borko, H., & Seidel, T. (2013). Five Research-Based Heuristics for Using Video in Pre-Service Teacher Education. *Journal for Educational Research Online, 5,* 90-114.

Borko, H., Jacobs, J., Eiteljorg, E. et al. (2008). Video as a Tool for Fostering Productive Discussions in Mathematics Professional Development. *Teaching and Teacher Education, 24,* 417-436. https://doi.org/10.1016/j.tate.2006.11.012

Brouwer, N., Besselink, E., & Oosterheert, I. (2017). The Power of Video Feedback with Structured Viewing Guides. *Teaching and Teacher Education, 66,* 60-73. https://doi.org/10.1016/j.tate.2017.03.013

Carlone, H. B., & Webb, S. M. (2006). On (Not) Overcoming Our History of Hierarchy: Complexities of University/School Collaboration. *Science Education, 90,* 544-568. https://doi.org/10.1002/sce.20123

Chini, J. J., Straub, C. L., & Thomas, K. H. (2016). Learning from Avatars: Learning Assistants Practice Physics Pedagogy in a Classroom Simulator. *Physical Review Physics Education Research, 12,* Article ID: 010117.

https://doi.org/10.1103/PhysRevPhysEducRes.12.010117

Codreanu, E., Sommerhoff, D., Huber, S. et al. (2020). Between Authenticity and Cognitive Demand: Finding a Balance in Designing a Video-Based Simulation in the Context of Mathematics Teacher Education. *Teaching and Teacher Education, 95,* Article ID: 103146. https://doi.org/10.1016/j.tate.2020.103146

Coles, A. (2019). Facilitating the Use of Video with Teachers of Mathematics: Learning from Staying with the Detail. *International Journal of STEM Education, 6,* Article No. 5. https://doi.org/10.1186/s40594-018-0155-y

Colestock, A., & Sherin, M. G. (2009). Teachers' Sense-Making Strategies While Watching Video of Mathematics Instruction. *Journal of Technology and Teacher Education, 17,* 7-29.

Dalinger, T., Thomas, K. B., Stansberry, S. et al. (2020). A Mixed Reality Simulation Offers Strategic Practice for Pre-Service Teachers. *Computers & Education, 144,* Article ID: 103696. https://doi.org/10.1016/j.compedu.2019.103696

Damewood, A. M. (2016). Current Trends in Higher Education Technology: Simulation. *TechTrends, 60,* 268-271. https://doi.org/10.1007/s11528-016-0048-1

Dieker, L. A., Hynes, M. C., Hughes, C. E. et al. (2015). TLE TeachLivE™: Using Technology to Provide Quality Professional Development in Rural Schools. *Rural Special Education Quarterly, 34,* 11-16. https://doi.org/10.1177/875687051503400303

Dieker, L. A., Lane, H. B., Allsopp, D. H. et al. (2009). Evaluating Video Models of Evidence-Based Instructional Practices to Enhance Teacher Learning. *Teacher Education and Special Education, 32,* 180-196. https://doi.org/10.1177/0888406409334202

Dieker, L. A., Rodriguez, J. A., Lignugaris/Kraft, B. et al. (2014). The Potential of Simulated Environments in Teacher Education: Current and Future Possibilities. *Teacher Education and Special Education, 37,* 21-33. https://doi.org/10.1177/0888406413512683

Dieker, L. A., Straub, C. L., Hughes, C. E. et al. (2014). Learning from Virtual Students. *Educational Leadership, 71,* 54-58.

Eshchar-Netz, L., Vedder-Weiss, D., & Lefstein, A. (2022). Status and Inquiry in Teacher Communities. *Teaching and Teacher Education, 109,* Article ID: 103524. https://doi.org/10.1016/j.tate.2021.103524

Ferguson, K. (2017). Using a Simulation to Teach Reading Assessment to Preservice Teachers. *The Reading Teacher, 70,* 561-569. https://doi.org/10.1002/trtr.1561

Gallego, M. D., Bueno, S., & Noyes, J. (2016). Second Life Adoption in Education: A Motivational Model Based on Uses and Gratifications Theory. *Computers & Education, 100,* 81-93. https://doi.org/10.1016/j.compedu.2016.05.001

Gaudin, C., & Chaliès, S. (2015). Video Viewing in Teacher Education and Professional Development: A Literature Review. *Educational Research Review, 16,* 41-67. https://doi.org/10.1016/j.edurev.2015.06.001

Goeze, A., Zottmann, J. M., Vogel, F. et al. (2014). Getting Immersed in Teacher and Student Perspectives? Facilitating Analytical Competence Using Video Cases in Teacher Education. *Instructional Science, 42,* 91-114. https://doi.org/10.1007/s11251-013-9304-3

Herbst, P., Chazan, D., Chen, C. L. et al. (2011). Using Comics-Based Representations of Teaching, and Technology, to Bring Practice to Teacher Education Courses. *ZDM, 43,* 91-103. https://doi.org/10.1007/s11858-010-0290-5

Hiebert, J., & Grouws, D. A. (2007). The Effects of Classroom Mathematics Teaching on Students' Learning. *Second Handbook of Research on Mathematics Teaching and Learning,*

1, 371-404.

Hollingsworth, H., & Clarke, D. (2017). Video as a Tool for Focusing Teacher Self-Reflection: Supporting and Provoking Teacher Learning. *Journal of Mathematics Teacher Education, 20,* 457-475. https://doi.org/10.1007/s10857-017-9380-4

Johnson, H. J., & Cotterman, M. E. (2015). Developing Preservice Teachers' Knowledge of Science Teaching through Video Clubs. *Journal of Science Teacher Education, 26,* 393-417. https://doi.org/10.1007/s10972-015-9429-0

Johnson, H. J., & Mawyer, K. K. N. (2019). Teacher Candidate Tool-Supported Video Analysis of Students' Science Thinking. *Journal of Science Teacher Education, 30,* 528-547. https://doi.org/10.1080/1046560X.2019.1588630

Kang, H., & van Es, E. A. (2019). Articulating Design Principles for Productive Use of Video in Preservice Education. *Journal of Teacher Education, 70,* 237-250. https://doi.org/10.1177/0022487118778549

Kaufman, D., & Ireland, A. (2016). Enhancing Teacher Education with Simulations. *TechTrends, 60,* 260-267. https://doi.org/10.1007/s11528-016-0049-0

Kim, D., & Blankenship, R. J. (2013). Using Second Life as a Virtual Collaborative Tool for Preservice Teachers Seeking English for Speakers of Other Languages Endorsement. *Journal of Educational Computing Research, 48,* 19-43. https://doi.org/10.2190/EC.48.1.b

Kleinknecht, M., & Gröschner, A. (2016). Fostering Preservice Teachers' Noticing with Structured Video Feedback: Results of an Online- and Video-Based Intervention Study. *Teaching and Teacher Education, 59,* 45-56. https://doi.org/10.1016/j.tate.2016.05.020

Kleinknecht, M., & Schneider, J. (2013). What Do Teachers Think and Feel When Analyzing Videos of Themselves and Other Teachers Teaching? *Teaching and Teacher Education, 33,* 13-23. https://doi.org/10.1016/j.tate.2013.02.002

Knutzen, B., & Kennedy, D. (2012). The Global Classroom Project: Learning a Second Language in a Virtual Environment. *The Electronic Journal of e-Learning, 10,* 90-106.

Kolb, D. A. (1984). *Experience as the Source of Learning and Development* (pp. 31-61). Prentice-Hall.

Leatham, K. R., Peterson, B. E., Stockero, S. L., & Van Zoest, L. R. (2015). Conceptualizing Mathematically Significant Pedagogical Opportunities to Build on Student Thinking. *Journal for Research in Mathematics Education, 46,* 88-124. https://doi.org/10.5951/jresematheduc.46.1.0088

Lee, M. Y. (2021). Improving Preservice Teachers' Noticing Skills through Technology-Aided Interventions in Mathematics Pedagogy Courses. *Teaching and Teacher Education, 101,* Article ID: 103301. https://doi.org/10.1016/j.tate.2021.103301

Lefstein, A., Louie, N., Segal, A. et al. (2020). Taking Stock of Research on Teacher Collaborative Discourse: Theory and Method in a Nascent Field. *Teaching and Teacher Education, 88,* Article ID: 102954. https://doi.org/10.1016/j.tate.2019.102954

Lindgren, R., Tscholl, M., Wang, S. et al. (2016). Enhancing Learning and Engagement through Embodied Interaction within a Mixed Reality Simulation. *Computers & Education, 95,* 174-187. https://doi.org/10.1016/j.compedu.2016.01.001

Ling, S. C., & Leonard, T. (2021). Examining Online Video-Based Professional Development for Music Teachers. *Music Education Research, 23,* 580-593. https://doi.org/10.1080/14613808.2021.1977786

Masats, D., & Dooly, M. (2011). Rethinking the Use of Video in Teacher Education: A Holistic Approach. *Teaching and Teacher Education, 27,* 1151-1162. https://doi.org/10.1016/j.tate.2011.04.004

Mitchell, R., Beisiegel, M., & Barmore, J. (2020). How Much Does Facilitation Matter? Comparing Externally and Participant-Facilitated, MQI-Based Video Clubs. *Mathematics Education Research Journal, 34,* 369-392. https://doi.org/10.1007/s13394-020-00348-5

Peterson-Ahmad, M. (2018). Enhancing Pre-Service Special Educator Preparation through Combined Use of Virtual Simulation and Instructional Coaching. *Education Sciences, 8,* Article No. 10. https://doi.org/10.3390/educsci8010010

Pinter, E. B., East, A., & Thrush, N. (2015). Effects of a Video-Feedback Intervention on Teachers' Use of Praise. *Education and Treatment of Children, 38,* 451-472. https://doi.org/10.1353/etc.2015.0028

Prilop, C. N. (2021). *Fostering and Assessing Preservice Teacher's Professional Competence with Digital Reflection and Feedback Environments.*

Sancar, R., Atal, D., & Deryakulu, D. (2021). A New Framework for Teachers' Professional Development. *Teaching and Teacher Education, 101,* Article ID: 103305. https://doi.org/10.1016/j.tate.2021.103305

Sander, S. A. (2014). *Exploring Preservice Science Teachers' Interpretations of Curricular Experiences While Learning to Teach in an Inquiry-Oriented Way. A Phenomenology.* Miami University.

Santagata, R., & Bray, W. (2016). Professional Development Processes That Promote Teacher Change: The Case of a Video-Based Program Focused on Leveraging Students' Mathematical Errors. *Professional Development in Education, 42,* 547-568. https://doi.org/10.1080/19415257.2015.1082076

Santagata, R., Yeh, C., & Mercado, J. (2018). Preparing Elementary School Teachers to Learn from Teaching: A Comparison of Two Approaches to Mathematics Methods Instruction. *Journal of the Learning Sciences, 27,* 474-516. https://doi.org/10.1080/10508406.2018.1441030

Segal, A., Snell, J., & Lefstein, A. (2017). Dialogic Teaching to the High-Stakes Standardized Test? *Research Papers in Education, 32,* 596-610. https://doi.org/10.1080/02671522.2016.1225803

Seidel, T., & Shavelson, R. J. (2007). Teaching Effectiveness Research in the Past Decade: The Role of Theory and Research Design in Disentangling Meta-Analysis Results. *Review of Educational Research, 77,* 454-499. https://doi.org/10.3102/0034654307310317

Shan, Z. (2021). Behaviorism Reinforcement Learning and Its Application in Mathematics Teaching in Primary and Middle Schools. *Frontiers in Educational Research, 4,* 93-98. https://doi.org/10.25236/FER.2021.040419

Shapiro, B. R., & Garner, B. (2021). Classroom Interaction Geography: Visualizing Space & Time in Classroom Interaction. *Journal of Research on Technology in Education, 54,* 769-783. https://doi.org/10.1080/15391523.2021.1927265

Sherin, M. G. (2003). New Perspectives on the Role of Video in Teacher Education. In J. Brophy (Ed.), *Using Video in Teacher Education* (pp. 1-27). Emerald Group Publishing Limited. https://doi.org/10.1016/S1479-3687(03)10001-6

Sherin, M. G., & Han, S. Y. (2004). Teacher Learning in the Context of a Video Club. *Teaching and Teacher Education, 20,* 163-183. https://doi.org/10.1016/j.tate.2003.08.001

Sherin, M. G., Linsenmeier, K. A., & Van Es, E. A. (2009). Issues in the Design of Video Clubs: Selecting Video Clips for Teacher Learning. *Journal of Teacher Education, 60,* 213-230. https://doi.org/10.1177/0022487109336967

Stürmer, K., Könings, K. D., & Seidel, T. (2013). Declarative Knowledge and Professional

Vision in Teacher Education: Effect of Courses in Teaching and Learning. *British Journal of Educational Psychology, 83,* 467-483. https://doi.org/10.1111/j.2044-8279.2012.02075.x

Tekkumru-Kisa, M., & Stein, M. K. (2017). A Framework for Planning and Facilitating Video-Based Professional Development. *International Journal of STEM Education, 4,* Article No. 28. https://doi.org/10.1186/s40594-017-0086-z

Tekkumru-Kisa, M., Stein, M. K., & Schunn, C. (2015). A Framework for Analyzing Cognitive Demand and Content-Practices Integration. Task Analysis Guide in Science. *Journal of Research in Science Teaching, 52,* 659-685. https://doi.org/10.1002/tea.21208

Van Es, E. A., & Sherin, M. G. (2002). Learning to Notice: Scaffolding New Teachers' Interpretations of Classroom Interactions. *Journal of Technology and Teacher Education, 10,* 571-596.

Van Es, E. A., & Sherin, M. G. (2008). Mathematics Teachers' "Learning to Notice" in the Context of a Video Club. *Teaching and Teacher Education, 24,* 244-276. https://doi.org/10.1016/j.tate.2006.11.005

van Es, E. A., Stockero, S. L., Sherin, M. G., Van Zoest, L. R., & Dyer, E. (2015). Making the Most of Teacher Self-Captured Video. *Mathematics Teacher Educator, 4,* 6-19. https://doi.org/10.5951/mathteaceduc.4.1.0006

Van Es, E. A., Tunney, J., Goldsmith, L. T., & Seago, N. (2014). A Framework for the Facilitation of Teachers' Analysis of Video. *Journal of Teacher Education, 65,* 340-356. https://doi.org/10.1177/0022487114534266

Vedder-Weiss, D., Segal, A., & Lefstein, A. (2019). Teacher Face-Work in Discussions of Video-Recorded Classroom Practice: Constraining or Catalyzing Opportunities to Learn? *Journal of Teacher Education, 70,* 538-551. https://doi.org/10.1177/0022487119841895

Vince Garland, K. M., Holden, K., & Garland, D. P. (2016). Individualized Clinical Coaching in the TLE TeachLivE Lab: Enhancing the Fidelity of Implementation of the System of Least Prompts among Novice Teachers of Students with Autism. *Teacher Education and Special Education, 39,* 47-59. https://doi.org/10.1177/0888406415600769

Walkoe, J. (2015). Exploring Teacher Noticing of Student Algebraic Thinking in a Video Club. *Journal of Mathematics Teacher Education, 18,* 523-550. https://doi.org/10.1007/s10857-014-9289-0

Walkoe, J., Wilkerson, M., & Elby, A. (2017). *Technology-Mediated Teacher Noticing: A Goal for Classroom Practice, Tool Design, and Professional Development*. International Society of the Learning Sciences.

Walshe, N., & Driver, P. (2019). Developing Reflective Trainee Teacher Practice with 360-Degree Video. *Teaching and Teacher Education, 78,* 97-105. https://doi.org/10.1016/j.tate.2018.11.009

Wolff, C. E., Jarodzka, H., & Boshuizen, H. P. (2017). See and Tell: Differences between Expert and Novice Teachers' Interpretations of Problematic Classroom Management Events. *Teaching and Teacher Education, 66,* 295-308. https://doi.org/10.1016/j.tate.2017.04.015

Yeh, C., & Santagata, R. (2015). Preservice Teachers' Learning to Generate Evidence-Based Hypotheses about the Impact of Mathematics Teaching on Learning. *Journal of Teacher Education, 66,* 21-34. https://doi.org/10.1177/0022487114549470

Zhang, M., Lundeberg, M., & Eberhardt, J. (2011). Strategic Facilitation of Problem-Based Discussion for Teacher Professional Development. *Journal of the Learning Sciences, 20,* 342-394. Https://Doi.Org/10.1080/10508406.2011.553258