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Enhancing Nigerian Pre-Service Science Teachers' Technological Pedagogical Content Knowledge (TPACK) via a Video Self-Analysis Instructional Component Model (VSICM)

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Abstract

This study examined the effects of a Video Self-Analysis Instructional Component Model (VSICM) on the Technological Pedagogical Content Knowledge (TPACK) of pre-service science teachers. The VSICM integrates online video-based resources with classroom activities to promote reflective, teacher-centered learning. A pre-experimental design was employed, involving 67 pre-service science teachers in the 300- and 400-level classes of the Science and Technology Education Department at Olabisi Onabanjo University, Nigeria. Data were collected using questionnaires covering personal information, levels of technological knowledge, reasons for using technology, and the extent to which TPACK predicts technology use in teaching. Additional observational checklists and teaching practice assessment booklets were used. The data were analyzed using descriptive statistics, correlations, regression, and t-tests. Findings revealed that the VSICM significantly enhanced participants' TPACK, particularly in the technological, pedagogical knowledge (TPK) domain. Observational evidence further showed improvements in the integration of technology and mastery of science content during teaching. Results indicated that 41.8% of the pre-service teachers possessed a high level of technological knowledge, 34.3% had a moderate level, and 23.9% had a low level, attributed to limited exposure and nonchalant attitudes toward technology. The study concluded that pre-service teachers with strong TPACK are better positioned to deliver effective science instruction. Video-based tools proved valuable for assessing and strengthening teachers' usable knowledge for science teaching. It is recommended that teacher education institutions invest in technology resources to enhance the integration of the VSICM model in teacher education, while curriculum designers and policymakers use TPACK baseline data to support the design of an updated VSICM guide for teachers.

Keywords: *Technological pedagogical content knowledge, pre-service teachers, science teaching, video self-analysis, Nigerian teacher education.*

INTRODUCTION

Technological innovation continues to redefine how teaching and learning are conceived, implemented, and evaluated. The advent of digital technologies has expanded the possibilities of instruction, assessment, and professional development in higher education (Chapelle & Sauro, 2017; Okoye et al., 2023; Yao, 2025). As societies evolve, technology grows more sophisticated, offering tools that can transform learning environments and enhance the cognitive, social, and collaborative capacities of learners (Bourven, 2018; Yao, 2025). Education in the 21st century thus demands not only technical literacy but also the ability to integrate technology creatively and pedagogically to foster problem solving, flexibility, teamwork, and critical inquiry.

However, despite large-scale investment in digital infrastructure, research consistently shows that teachers and pre-service teachers often fail to integrate technology effectively into science teaching, thereby making the implementation process of technology integration in science education not realistic. Also, many teachers still struggle to develop integrated technological pedagogical expertise, resulting in low classroom transformation (Hew & Brush, 2007; Koehler et al., 2013). This challenge is particularly acute in contexts where teachers exhibit a nonchalant attitude toward technology use, have limited pedagogical understanding of digital tools, and rarely engage in reflective practice (Hew & Brush, 2007; Adebusuyi et al., 2020).

In many teacher education settings, in-service chemistry teachers have demonstrated moderate levels of TPACK. However, this knowledge often fails to translate into actual classroom practice, which negatively impacts students' scientific literacy and attitudes (Adebusuyi et al., 2020). In such environments, pre-service science teachers still show low performance in technology-supported lesson delivery, and limitations in adapting instructional approaches to individual learners, managing time, accessing resources, and reflecting on practice undermine their effectiveness. Additionally, another study noted that science teachers often have surface-level familiarity with digital tools and lack the integrated expertise (i.e., the technological pedagogical content knowledge or TPACK), required for meaningful classroom implementation (Fabian et al., 2024). This deficiency limits teachers' ability to connect technology use to specific pedagogical goals, resulting in instruction that fails to improve student understanding or engagement. If such trends persist, the cumulative effect will be a generation of science learners insufficiently prepared for tertiary-level scientific reasoning and problem-solving.

This gap has shifted the conversation from *technology-centric* to *techno-pedagogical* integration; an approach that emphasizes the seamless interconnection between technology, pedagogy, and content knowledge. This conceptual evolution has been captured in the Technological Pedagogical Content Knowledge (TPACK) framework (originally TPCK), first articulated by Koehler and Mishra (2005) and Mishra and Koehler (2006) as an extension of Shulman's (1987) *Pedagogical Content Knowledge* (PCK). The TPACK model conceptualizes teachers' ability to integrate digital tools in ways that are pedagogically sound and content-specific. Developing teachers' TPACK has become a central goal of 21st-century teacher education. Effective technology integration requires not only knowledge of tools but also pedagogical reasoning that aligns technology with specific learning goals and student needs. According to Adebusuyi et al. (2020), teachers' technological and pedagogical capabilities strongly influence their ability to implement learner-centered instruction in STEM disciplines. Literature shows that many teachers possess functional technological knowledge but often lack the pedagogical and content-related integration needed for meaningful application (Fabian et al., 2024; Kholid et al., 2023). As a response, teacher education programs worldwide have been reshaped to include TPACK-oriented coursework and practicum experiences that promote authentic, reflective technology use (Koh et al., 2014). These programs stress that teachers must not only know *how* to use technology but also *why* and *when* to employ it for deeper learning. The ultimate aim is to develop teachers who can use technologies to enhance students' conceptual understanding, critical thinking, and collaboration (Angeli & Valanides, 2020)

In this regard, structured video self-analysis instructional models have emerged as promising interventions for developing teachers' TPACK, reflective capacity, and classroom enactment skills (von Kotzebue, 2026). Video self-analysis allows pre-service teachers to record, observe, and analyze their own teaching with structured prompts and rubrics. It provides "objective records rather than uncertain recollections" (Kong et al., 2009, p. 546) and compels teachers to evaluate their instructional choices in relation to technology, pedagogy, and content (Sherin & van Es, 2009; Sewall, 2009; Snoeyink, 2010). Such reflective engagement enables them to recognize patterns in their practice, notice learner responses, and design more effective teaching strategies. Numerous empirical studies have affirmed the impact of structured video reflection on measurable TPACK gains and related competencies. For instance, Shayeb and Daher (2024) found significant improvements in all seven TPACK domains following a digital video recording self-analysis intervention among prospective teachers. Similarly, Karlsson and Nilsson (2023) demonstrated that combining self-video annotation with *Topic-Specific Content Representations (T-CoRe)* helped science pre-service teachers explicitly articulate how technology mediates pedagogical and conceptual understanding. Weber et al. (2018) further showed that structured video analysis promotes professional vision; teachers' ability to interpret classroom events in pedagogically meaningful ways, while Schlosser and Paetsch (2023) found that guided emotional reflection on recorded lessons enhanced teachers' technology-integration self-efficacy.

Video reflection models, such as video clubs and peer-annotated video sessions, also foster social learning and professional dialogue. Adebusuyi et al. (2020) reported that targeted professional development focusing on TPACK dimensions improved science teachers' capacity to integrate digital resources effectively. Moreover, in-service teachers with limited TPACK had a statistically significant effect on students' attitudes toward science and their scientific literacy, underscoring the urgent need for pre-service interventions. Accordingly, some studies (e.g., Prilop et al., 2020; Shayeb & Daher, 2024) show that video-based microteaching can enhance pre-service teachers' planning, reflection, and confidence in using digital media during teaching practice. These studies, though limited in number, confirm that structured video reflection is feasible and impactful in African teacher education contexts. Meta-analytic and design-based recent studies suggest that effective video self-analysis interventions share certain design features: (a) the use of teachers' own recorded lessons, (b) scaffolded prompts that explicitly target TPACK dimensions, (c) iterative analysis–feedback–redesign cycles, and (d) social moderation through peer or mentor discussion (Schlosser & Paetsch, 2023; Shayeb & Daher, 2024). These design elements turn video analysis from a passive viewing exercise into a reflective inquiry process that enables teachers to notice, reason about, and improve their pedagogical decisions.

Nevertheless, significant gaps persist. Evidence remains limited on how structured video self-analysis models can be effectively adapted for Nigerian pre-service science teachers, many of whom face resource constraints and have limited access to mentoring support. In addition, a considerable number of pre-service teachers still demonstrate reluctance toward technology use, engage minimally in reflective practice, and struggle to adapt instruction to learners' cognitive diversity. As a result, technology integration in pre-service science education remains largely ineffective, hindered by low levels of reflection, weak pedagogical alignment, and inadequate implementation of learner-centered technological approaches. Without targeted intervention, these limitations in technological and reflective competence will continue to undermine the quality of science teaching and learners' achievement across educational levels. Addressing these challenges requires innovative, context-sensitive pedagogical models that integrate video reflection, structured self-assessment, and iterative feedback within teacher preparation programs (von Kotzebue, 2026). Hence, this study investigates the use of a video self-analysis instructional component model to enhance pre-service science teachers' TPACK, reflective capacity, and technology-integration efficacy. By testing this model in teacher education contexts, the study aims to contribute both locally relevant evidence and globally comparable insights into how structured video reflection can transform teacher learning and practice.

The findings of this study will assist students in acquiring essential scientific skills, improving their performance, and enhancing their academic achievement. The study will also prepare students for future opportunities in science-related fields, enabling them to compete more effectively in the labour market and contribute meaningfully to societal development. Furthermore, it would empower students to appreciate the need for developing creative thinking, manipulative skills, and the curiosity required for practical scientific work.

OBJECTIVES OF THE STUDY

The primary objective of this study is to examine the impact of a video self-analysis instructional component model on pre-service Science teachers' technological pedagogical content knowledge. This objective is further elaborated in the following aims for the study, namely to examine the level of pre-service science teachers' (PSTs) technological knowledge and to observe how the video self-analysis instructional component predicts teachers' TPACK. The following research questions were raised and answered in the study:

1) What is the level of pre-service science teachers' (PSTs) technological knowledge?
2) Does the use of a video self-analysis instructional component predict teachers' TPACK?

The following null hypotheses are formulated and tested at 0.05 level of significance.

H_{01}: There is no statistically significant relationship between pre-service science teachers' VSICM instructional practice scores and their TPACK scores.

H_{02}: There is no statistically significant difference between pre-service science teachers' pre-intervention and post-intervention TPACK scores following participation in the guided VSICM intervention.

LITERATURE REVIEW

TPACK and Technology Integration in Teacher Education

Technological Pedagogical Content Knowledge (TPACK) builds on Shulman's (1987) Pedagogical Content Knowledge (PCK), which emphasizes the interactive learning of content and pedagogy in teacher education. Koehler and Mishra (2005) expanded this concept by integrating technology, highlighting that effective teaching in the 21st century requires the simultaneous mastery of content, pedagogy, and technology. TPACK reflects the complex interplay among these knowledge domains, guiding teachers in designing learning experiences that integrate digital tools meaningfully.

Technology knowledge ranges from traditional tools such as pencils and paper to digital technologies, including interactive whiteboards, software, and multimedia resources (Koehler et al., 2013). Integrating technology into teaching can enhance cooperative learning, diversify instructional strategies, improve communication, and support global learning. Recent TPACK research increasingly incorporates lesson plans and recorded lessons as performance indicators evaluated via TPACK rubrics (e.g., Angeli & Valanides, 2005; Archambault, 2016; Ocak & Baran, 2019; Valtonen et al., 2020). However, links between these performance metrics and self-reported TPACK remain underexplored. Some studies report weak correlations between teachers' self-perceived TPACK and actual classroom technology use (Backfisch et al., 2020). This gap highlights the need for instructional interventions that bridge perception and practice, enabling teachers to translate TPACK into effective lesson design and technology integration. Self-report surveys have shown positive associations with the perceived frequency, type, or quality of technology use (Habib et al., 2019), yet objective measures of implementation show less consistency. Beyond individual knowledge, contextual and institutional factors — such as access to technology, administrative support, and classroom resources — also play a substantial role in shaping whether teachers' TPACK translates into actual technology integration (Blackwell et al., 2016). Effective TPACK implementation requires teachers to use technologies appropriately, select suitable tools for instructional goals, and support students' learning with digital resources (Starkey, 2019). Most TPACK studies focus on pre-service teachers (Mouza, 2016), with limited research on in-service teachers (Chen et al., 2020), raising questions about adaptability and professional growth, particularly in emergent contexts such as remote teaching during the COVID-19 pandemic (Baroudi & Shaya, 2022).

Video Self-Analysis in Teacher Education

Video self-analysis has often been described as an instructional approach in teacher education that enables teachers to examine their own instructional practices and identify areas for improvement. Through the process, teachers watch recordings of their teaching, identify and prioritize evidence from classroom practice (Sewall, 2009; Sherin & van Es, 2009; Snoeyink, 2010). The teacher then analyzes the activities watched in the video recording and consequently makes self-directed adjustments to improve subsequent instruction. In this study, it is referred to as the Video Self-Analysis Instructional Component Model (VSICM)**.** This model provides teachers with an objective record of their classroom practices that can support purposeful reflection and professional growth. By allowing teachers to see aspects of their instruction that may be overlooked during live teaching, video self-analysis can promote deeper reflection, strengthen pedagogical decision-making, and support the development of Technological Pedagogical Content Knowledge (TPACK) (Horak et al., 2023; Tripp & Rich, 2012; von Kotzebue, 2026). Empirical research demonstrates that video-supported reflection improves the depth and quality of teacher noticing of students' learning, instructional strategies, and classroom management; thus cultivating professional vision (Blomberg et al., 2011; Gaudin & Chaliès, 2022; Kleinknecht & Schneider, 2013; Santagata, 2014; Seidel et al., 2011; Sherin & van Es, 2009).

For example, Rosaen et al. (2008) found that pre-service teachers who reflected using video recordings identified more instructional details, focused more on student engagement (Horak et al., 2023), and improved lesson-specific behaviors compared to those reflecting from memory alone. Video analysis also allows teachers to pause, replay, and examine moments in depth, supporting iterative learning and reducing cognitive overload. The Modern Classroom Project (MCP), founded in 2018, operationalizes video-based instructional strategies through a self-paced, mastery-based learning model. MCP emphasizes blended learning, differentiated instruction, and social-emotional development, providing teachers with tools to adapt lessons to diverse student needs. Its video self-analysis instructional component model (VSICM) specifically aids teachers in clarifying lesson directions, breaking down complex content into manageable steps, and offering multiple modes of engagement, consistent with Universal Design for Learning (UDL) principles. Teachers can create short videos for each instructional step, allowing students to revisit content asynchronously and engage in learning flexibly.

Video Self-Analysis and TPACK Development

Video self-analysis has gained increasing attention in teacher education as an instructional approach for connecting pre-service teachers' technological, pedagogical, and content knowledge (TPACK) with actual teaching practice. By reviewing recordings of their own teaching, pre-service teachers can identify knowledge gaps, critically examine instructional decisions, and make informed adjustments to their teaching. Karlsson and Nilsson (2023) reported that combining self-recorded videos, video annotations, reflective writing, and the T-CoRe tool helped 87 secondary science student teachers make aspects of their TPACK visible. Shayeb and Daher (2024) further found that digital video recordings significantly improved prospective teachers' overall TPACK and its seven domains. Similarly, Mouza et al. (2021) found in a longitudinal study that sustained engagement with video-based reflection supported measurable growth in pre-service teachers' TPACK over time. In addition, Horak et al. (2023) showed that video self-analysis supported teachers' reflective practice, changes in pedagogical beliefs, and instructional development. Recently, von Kotzebue (2026) demonstrated that performance-assessed TPACK, rather than self-reported TPACK, was positively associated with the quality of technology-supported lesson plans among pre-service biology teachers, highlighting the importance of authentic performance-based approaches to TPACK development.

These studies provide evidence for the potential of video self-analysis to support TPACK development in teachers by making instructional practice visible, identifying knowledge gaps, promoting reflection, and encouraging pedagogical decision-making. However, limited research has examined structured models that systematically guide pre-service science teachers from watching their teaching, identifying priority evidence, analyzing that evidence, and making self-directed instructional adjustments**.** The Video Self-Analysis Instructional Component Model (VSICM) addresses this gap by conceptualizing video self-analysis as an iterative process for developing and applying TPACK in science teacher education.

METHODOLOGY

Research Design

The pre-experimental research design was used for this study to examine the effect of video self-analysis on teachers' instructional practices and/or TPACK. This design was adopted because a single group of teachers (N = 67) was used as participants in the video self-analysis intervention, with no separate control group to compare the impact of the VSICM. It was used only to examine changes in participants' outcomes following their exposure to the video self-analysis intervention. However, because the study did not include a control group and participants were not randomly assigned to different treatment conditions, the design does not provide the same level of causal inference as a true experimental or quasi-experimental design. The schematic design of the study is illustrated in Figure 1 below:

$$O_1 \qquad\qquad X \qquad\qquad O_2$$

where O_1 is the pretest, X is the intervention (VSICM), and O_2 is the posttest.

Research Participants

The study sampled 67 pre-service teachers in the 3rd and final years of the teacher education program at a public university in southwest Nigeria from various science education disciplines. Table 1 summarizes the respondents' demographics, including gender, age, and course of study, level, and subjects taught. The sample comprised more females (70.1%) than males (29.9%). Most respondents were aged 20–24 years (68.7%) and identified as Christian (67.2%). Biology was the most common course of study (80.6%), with the majority at the 400 level (85.1%). Regarding subjects taught, most participants taught biology (67.2%).

Table 1
Demographic Characteristics of the Respondents (N = 67)

Variable		**Frequency**	**Percentage**
Gender	Male	20	29.9
	Female	47	70.1
Age	15-19 years	19	28.4
	20-24 years	46	68.7
	Above 25 years	2	2.9
Specialization	Integrated Science	2	2.9
	Chemistry	4	5.9
	Biology	54	80.6
	Physics	3	4.5
	Mathematics	4	5.9
Level	300	10	14.9
	400	57	85.1

Research Instrument

Three instruments were employed in this study, namely (1) The Pre-Service Science Teacher Teaching Practice Assessment Scale (PST-TPAS); (2) The Pre-Service Science Teachers' Technological Pedagogical Knowledge Questionnaire (PST-TPKQ), and (3) a video self-analysis rubric.

(1) PST-TPAS

This instrument was used to evaluate pre-service teachers' instructional competencies during teaching practice. This supervisor-rated observation form assessed lesson planning, classroom teaching, teacher-student interactions, instructional resource use, evaluation, classroom management, and teacher personality and effectiveness. It comprises six sections: (1) Lesson Preparation Plan; (2) Classroom Teaching (Teacher and Student Activities); (3) Instructional Resources; (4) Evaluation; (5) Classroom Management; and (6) Teacher Personality and Effectiveness, with items rated from 0 ("Not Observed") to 5 ("Excellent"), providing the quantitative data on teaching performance. Science educators ensured the instrument's content validity through expert review, and reliability was adjudged with a Cronbach's alpha of 0.87 and confirmed to be acceptable.

(2) PST-TPKQ

This instrument measured participants' self-reported technological knowledge, motivation for technology use, and TPACK application in teaching. Adapted from Schmid et al. (2021) and Chai et al. (2013), it includes socio-demographic items and three TPACK-related subscales: (1) Technological Knowledge; (2) Motivation for Technology Use; and (3) TPACK Application in Teaching. All items were rated on a four-point Likert scale from 1 ("Strongly Disagree") to 4 ("Strongly Agree"). The PST-TPKQ demonstrated strong content validity through expert review and high internal consistency reliability (Cronbach's alpha = 0.91). Together, these instruments enabled the study to examine both observed teaching performance and self-reported TPACK, allowing for analysis of the relationship between technological pedagogical content knowledge and classroom practice.

(3) Video Analysis Rubric

A Video Self-Analysis Reflection Rubric was developed to guide the participants through a structured reflection process while reviewing recordings of their own teaching. It consists of ten reflective questions, each paired with specific evidence to look for in the video and a corresponding planned adjustment for the next lesson. The questions address content accuracy, technology integration, questioning strategies, student engagement, and assessment of student understanding. A full version of the rubric is attached as Appendix A.

Intervention

The Video Self-Analysis Instructional Component Model (VSICM) intervention was implemented over a six-week teaching practice period during the 2025/2026 academic session. The intervention was designed to provide pre-service science teachers (PSTs) with a structured process for examining their own technology-integrated teaching, receiving feedback, and making informed adjustments to subsequent lessons. The intervention followed an iterative cycle of video recording, self-analysis, peer feedback, mentor feedback (the researchers played the role of mentors in this study), instructional adjustment, and subsequent teaching. Before the commencement of the intervention, the researchers introduced the PSTs to the purpose and procedures of the VSICM. The participants were oriented on the principles of TPACK, video self-analysis, reflective practice, and technology integration in science teaching. They were also introduced to a structured video self-analysis rubric developed with reference to the reflective approach reported by Karlsson and Nilsson (2023). The details of the rubric used were explicitly stated in the data collection procedure. The rubric (Apendix A) guided participants in examining their use of technology, alignment between technology and learning objectives, science content accuracy, student engagement, questioning, classroom interaction, assessment of learning, and their ability to identify specific areas for improvement.

DATA COLLECTION PROCEDURE

Data collection was conducted in three major stages: pre-intervention, intervention, and post-intervention. Before data collection commenced, ethical approval was obtained from the appropriate Head of Department of Science and Technology Education (STED) of the institution, and all participants provided informed consent after receiving information about the purpose and procedures of the study. Participants were informed that their participation was voluntary and that they could withdraw from the study at any time without penalty. The self-reported questionnaire also stated the confidentiality and anonymity of their responses and that video recordings would be maintained throughout the research process.

Phase 1: Pre-Intervention

At the beginning of the six-week teaching practice, all 67 PSTs completed the Pre-Service Science Teachers' Technological Pedagogical Knowledge Questionnaire (PST-TPKQ) to establish their baseline self-reported technological knowledge and TPACK-related characteristics. The Pre-Service Science Teacher Teaching Practice Assessment Scale (PST-TPAS) was also used to assess their observed instructional performance.

Phase 2: Intervention

Participants were oriented to the process of video self-analysis and trained to critically examine their teaching by identifying critical incidents or priority evidence, reflecting on the significance of observed events, evaluating how technology supported or hindered learning, and considering possible instructional improvements. They were also guided on ethical and practical procedures for recording classroom lessons, including obtaining permission, appropriately positioning recording devices, and maintaining confidentiality. Each participant then recorded approximately 10 minutes of a science lesson during the second week of the teaching practice period using a smartphone or other digital device, after which they independently reviewed the recording and completed the VSICM reflection rubric by identifying specific evidence from the video and reflecting on their teaching practices.

1) What happened during the selected classroom episode?
2) What was effective or ineffective about the instructional practice?
3) How effectively was technology integrated with the science content and pedagogy?
4) How did students respond to the instructional strategy and technology?
5) What difficulties or misconceptions did students demonstrate?
6) What could you have done differently?
7) What specific adjustment should be made in the next lesson?

Following individual self-analysis, participants shared their selected video clips with their peers and mentors in the WhatsApp group created for the purpose of the study for collaborative review. This collaborative structure reflects research showing that video annotation can effectively support shared, peer-based reflection in teacher education (Näykki et al., 2022). The 67 PSTs were organized into small peer-review groups of five members to facilitate manageable and focused feedback. Each participant reviewed selected videos from peers and provided constructive feedback using the same VSICM reflection criteria. This collaborative structure aligns with research showing that peer- and technology-supported collaborative processes can strengthen pre-service teachers' instructional design capacities (Chai et al., 2021).Also, the researchers (mentor) reviewed the participants' selected video recordings and their reflections. Feedback was provided through a dedicated WhatsApp group created for the intervention. The WhatsApp platform was used for asynchronous communication, sharing of reflections and feedback, and continued discussion among participants and the researcher. The mentor's feedback focused on helping participants connect their instructional decisions to the principles of TPACK and effective technology integration in science teaching. Participants were encouraged to consider whether the technology used was appropriate for the learning objectives, whether it supported students' understanding of the science concept, and whether alternative technologies or teaching strategies could have been more effective.

Throughout the six-week intervention, PSTs participated in weekly reflective mentoring sessions in which they discussed teaching challenges, reviewed evidence from their video recordings, received feedback, and explored strategies for improving student engagement, participation, learning difficulties, and meaningful technology integration. Following self-analysis and feedback from peers and the researcher, each PST identified specific instructional adjustments, incorporated them into subsequent lesson planning and teaching, and recorded a second approximately 10-minute science lesson to assess the implementation and effectiveness of these changes. Participants reviewed and compared their teaching episodes using the VSICM rubric to identify improvements and areas requiring further development. This iterative cycle of video recording, self-analysis, feedback, instructional adjustment, and subsequent application continued throughout the intervention, supported by weekly mentoring sessions and asynchronous discussions through the WhatsApp.Platform.

Phase 3: Post-Intervention

At the end of the six-week intervention, the PSTs completed the PST-TPKQ again, and their teaching performance was reassessed using the PST-TPAS. These posttest scores were compared with the pretest scores to determine whether there were changes in the participants' technological knowledge, TPACK-related outcomes, and observed instructional performance following participation in the VSICM intervention.

DATA ANALYSIS TECHNIQUES

The analysis involved three statistical procedures: descriptive statistics, linear regression, and a paired-sample t-test, each of which is explained below.

Descriptive Statistics for Technological Knowledge

Participants' responses to the Technological Knowledge subscale of the PST-TPKQ were summarized using descriptive statistics, including frequency, percentage, mean, and standard deviation.

Linear Regression: Does VSICM Predict TPACK?

A linear regression analysis was conducted to determine whether pre-service science teachers' instructional practice scores on the video self-analysis instructional component (VSICM) predicted their TPACK scores. The VSICM instructional practice score, computed from participants' video self-analysis performance across the intervention period, served as the predictor variable, and the TPACK score served as the criterion variable. The analysis examined the strength and direction of the relationship between the two variables and the extent to which VSICM scores predicted variation in TPACK scores. The relationship was tested for statistical significance at the 0.05 level.

Paired-Samples t-Test: Did TPACK Change from Pretest to Posttest?

To examine whether pre-service science teachers' TPACK differed significantly before and after participation in the guided video self-analysis instructional model, a paired-samples t-test was conducted comparing participants' pretest and posttest TPACK scores. Cohen's *d* (effect size) was calculated using the pooled standard deviation of the pretest and posttest scores, $d = (M_2 - M_1) / \sqrt{[(SD_1^2 + SD_2^2) / 2]}$ (Cohen, 1988), rather than the paired-difference formula (dz), to allow comparison with studies reporting between-group-style effect sizes. Effect sizes were interpreted using Sawilowsky's (2009) extended guidelines: 0.01 as a very small effect, 0.2 as small, 0.5 as medium, 0.8 as large, 1.2 as very large, and 2.0 as a huge effect.

RESULTS OF THE STUDY

Descriptive Analysis

To determine the respondents’ level of technological knowledge, descriptive statistics using percentages, means, and standard deviations were computed in Table 2.

Table 2

Level of Pre-Service Science Teachers’ Technological Knowledge (N = 67)

TPACK Level	Range of Scores	Frequency (n)	Percentage (%)
Low	9-15	16	23.9
Moderate	16-20	23	34.3
High	21-25	28	41.8

The mean of the Pre-Service Teachers' (PSTs) post-test scores on the PST-TPAS was used to categorize participants into low, moderate, and high levels of technological knowledge. Participants who scored between 9–15 were rated as low, those who scored between 16–20 were categorized as moderate, and those who scored between 21–25 were categorized as high. Table 2 shows that 23.9% of participants demonstrated low technological knowledge, 34.3% demonstrated moderate knowledge, and 41.8% demonstrated high technological knowledge. Overall, the results indicate that technological knowledge was fairly distributed across the three levels, with slightly more PSTs falling into the high category than the moderate or low categories.

Linear Regression Analysis

A regression model was estimated to examine whether video self-analysis predicted teachers' TPACK in the classroom. The results are presented in Table 3.

Table 3

Regression Results for Video Self-Analysis Predicting TPACK

Predictive Variable	B	SE B	β	t	*p* value
Constant	10.711	2.036	—	5.262	.001
Video Self-Analysis Score	0.077	0.019	.452	4.085	.001

Model Summary:
$R = .452$, $R^2 = .204$,
$F(1, 65) = 16.685$, $p < .001$

Results from the regression analysis indicate that video self-analysis scores significantly predicted PSTs' TPACK scores. As shown in Table 3, the regression model was statistically significant, $F(1, 65) = 16.685$, $p < .001$, with the model accounting for 20.9% of the variance in TPACK scores ($R^2 = .209$). The standardized regression coefficient ($\beta = .458$, $p < .001$) indicates a positive predictive relationship between video self-analysis and TPACK, such that higher video self-analysis scores were associated with higher TPACK scores among the PSTs.

Hypothesis Testing

Correlation analyses were conducted to examine the association between PSTs' instructional practice scores and their TPACK. The results are indicated in Table 4.

Table 4
Relationship Between Teachers' Instructional Practice and TPACK (N = 67)

Variable	Score 1	Score 2	PSTs' TPACK
Score 1	—		
Score 2	.217	—	
PSTs' TPACK	.407**	.139	—

Table 4 presents the correlation matrix examining the relationship between teachers' instructional practice scores (Score 1 and Score 2) and their Technological Pedagogical Content Knowledge (TPACK). The results indicate a moderate positive correlation between Score 1 and TPACK (r = .407, p = .001), suggesting that teachers who demonstrated stronger performance in instructional practice; as captured by Score 1tended to exhibit higher levels of TPACK. This moderate correlation implies that effective lesson delivery, student engagement strategies, and classroom decision-making may be meaningfully associated with teachers' technological–pedagogical integration skills. Furthermore, Score 2 showed a small, positive but non-significant correlation with TPACK (r = .139, p = .268), indicating that the aspects of instructional practice captured by Score 2 do not strongly relate to pre-service teachers' TPACK levels in this sample. The correlation between Score 1 and Score 2 (r = .217, p = .078) was also non-significant, suggesting that the two instructional practice indicators measure related but distinct dimensions of teaching performance.

To test the second hypothesis, a paired-sample *t*-test was used to compare TPACK scores before and after the guided video self-analysis instructional model, as shown in Table 5.

Table 5
Paired-sample t-test Results (N = 67)

Variables	Mean	SD	df	*t*	*p*
BVSAIM Score	41.01	12.73	66	26.37	< .001
AVSAIM Score	64.04	9.21			

Note. BVSAIM = Before Video Self-Analysis Instructional Model; AVSAIM = After Video Self-Analysis Instructional Model.

As shown in Table 5, the paired-samples t-test results revealed that teachers' TPACK scores increased significantly from the pretest (BVSAIM) (M = 41.01, SD = 12.73) to the post-test (AVSAIM) (M = 64.04, SD = 9.21), t(66) = 26.37, $p < .001$, with a huge effect size (Cohen's $d = 2.07$). This suggests that the guided video self-analysis instructional model had a substantial practical impact on PSTs' TPACK development. However, given the one-group pre-experimental design, this increase should be interpreted cautiously, as it cannot rule out alternative explanations such as maturation, testing effects, or history.

DISCUSSION

The findings of the study showed that pre-service science teachers (PSTs) demonstrated varying levels of technological knowledge (TK), with 23.9% classified as having low TK, 34.3% as having moderate TK, and 41.8% as having high TK. Thus, although the largest proportion of PSTs fell within the high technological knowledge category, a substantial proportion demonstrated moderate levels of TK. This finding suggests that while many PSTs possessed a relatively strong foundation in technological knowledge, technological competence was not uniform across the participants. The finding is relevant to the integration of technology within the broader TPACK framework because technological knowledge represents one of the foundational domains required for teachers to consider how digital technologies can be meaningfully connected with content and pedagogy. The result can be considered in relation to earlier research by Bon and Koem (2025), which reported challenges among pre-service teachers in applying technology to represent science concepts. Differences between the present findings and earlier reports may reflect variations in teacher education contexts, participants' prior exposure to digital technologies, and the increasing availability of technology-supported learning environments.

The findings also provide support for the relevance of video self-analysis as an approach for examining and developing technology-related teacher knowledge. Video self-analysis has gained increasing attention in teacher education as an instructional approach for connecting pre-service teachers' technological, pedagogical, and content knowledge with authentic teaching practice. By reviewing recordings of their own teaching, pre-service teachers can make aspects of their instructional practice visible, identify areas requiring attention, and critically examine their instructional decisions. Karlsson and Nilsson (2023) reported that the combination of self-recorded videos, video annotations, reflective writing, and the T-CoRe tool helped secondary science student teachers make aspects of their TPACK visible. Shayeb and Daher (2024) also reported improvements in prospective teachers' overall TPACK and its constituent domains following engagement with digital video recordings. In addition, Horak et al. (2023) demonstrated the potential of video self-analysis to support reflective practice, changes in pedagogical beliefs, and instructional development. More recently, von Kotzebue (2026) highlighted the importance of performance-based approaches to TPACK development by demonstrating an association between performance-assessed TPACK and the quality of technology-supported lesson plans among pre-service biology teachers. Collectively, these studies suggest that video-based reflection can provide opportunities for teachers to examine authentic instructional practice and connect technological knowledge with pedagogical and content considerations.

The regression findings further showed a statistically significant positive predictive relationship between video self-analysis scores and PSTs' TPACK scores. The regression model was statistically significant, $F(1, 65) = 16.685$, $p < .001$, with video self-analysis scores significantly predicting TPACK scores ($\beta = .452$, $p < .001$). The model accounted for 20.4% of the variance in TPACK scores ($R^2 = .204$). This finding indicates that higher scores on the video self-analysis measure were associated with higher TPACK scores among the PSTs in the study. However, given the one-group pre-experimental design, this result should be interpreted as evidence of a significant predictive relationship rather than proof that video self-analysis caused an increase in TPACK. Other factors not examined in the model may also have contributed to differences in participants' TPACK scores. Nevertheless, the finding provides empirical support for the potential relevance of structured video self-analysis to TPACK development and is consistent with previous studies emphasizing the value of making teachers' instructional knowledge and practice visible through video-supported reflection (Karlsson & Nilsson, 2023; Horak et al., 2023; Shayeb & Daher, 2024). Findings from the study also provide further insight into the relationship between instructional practice and TPACK. A moderate correlation indicates that participants with higher scores on Score 1 tended to have higher TPACK scores. In contrast, the relationship between Score 2 and TPACK was positive but not statistically significant ($r = .139$, $p = .268$). The significant association between Score 1 and TPACK is nevertheless consistent with the conceptualization of TPACK as an integrated form of teacher knowledge that becomes relevant when teachers make instructional decisions involving technology, pedagogy, and content. The TPACK framework emphasizes that effective technology integration requires teachers to consider the relationship between what is being taught, how it is taught, and which technological tools are appropriate for supporting learning (Koehler et al., 2013). The present finding is also consistent with research suggesting that reflective engagement with real classroom teaching realities can help teachers examine the connections among content, pedagogy, and technology (Karlsson & Nilsson, 2023).

Another finding from the study indicates that participants' scores increased significantly from the pre-intervention to the post-intervention assessment. The result provides evidence of a significant change in the measured outcome following participants' engagement with the Video Self-Analysis Instructional Component Model (VSICM). Thus, the result supports the potential effectiveness of the intervention but may not, by itself, establish a causal effect. The significant pre-post difference is consistent with the literature emphasizing the value of video-supported reflection in teacher education. Karlsson and Nilsson (2023) similarly demonstrated that combining self-recorded videos with structured annotation and reflection could make aspects of pre-service science teachers' TPACK visible. Shayeb and Daher (2024) also reported positive changes in prospective teachers' TPACK following engagement with digital video recordings, while Horak et al. (2023) identified video self-analysis as a potentially useful approach for supporting reflective practice and instructional development. These findings provide a plausible basis for interpreting the present pre-post improvement as evidence that structured opportunities to examine one's own teaching are associated with changes in teachers' knowledge and reflective engagement. Nevertheless, the present study extends this literature by examining a structured video self-analysis model that guides PSTs through a cycle of recording their teaching, analyzing instructional decisions, receiving feedback, and making adjustments to subsequent teaching.

An important contribution of the present study is the conceptualization of video self-analysis as an iterative rather than a one-time reflective activity. The VSICM moves beyond simply asking PSTs to watch recordings of their teaching by guiding them to identify specific evidence from classroom practice, interpret the significance of that evidence—considering the role of technology in supporting or constraining learning—and implement instructional adjustments in subsequent teaching episodes. This iterative process has the potential to improve their TPACK. This approach is consistent with research emphasizing the potential of video-based reflection to make otherwise difficult-to-observe aspects of teaching visible and to support teachers in developing a more analytical understanding of classroom practice (Horak et al., 2023; Karlsson & Nilsson, 2023). It also aligns with the argument that performance-based approaches can complement self-reported measures of TPACK by providing opportunities to examine how teacher knowledge is connected to actual instructional practice (von Kotzebue, 2026). However, future studies employing randomized or quasi-experimental designs with comparison groups could provide stronger evidence regarding the causal effects of structured video self-analysis on PSTs' TPACK and classroom instructional practice.

CONCLUSION

The study highlights the potential value of structured video self-analysis in pre-service science teacher education. By enabling PSTs to observe their own teaching, identify priority evidence, reflect on instructional decisions, receive feedback, and make adjustments to subsequent teaching, the VSICM provides a structured mechanism for connecting theoretical knowledge with authentic classroom practice. The findings suggest that incorporating structured video self-analysis into science teacher education and teaching practicum programmes may provide opportunities for PSTs to develop greater awareness of their technological, pedagogical, and content knowledge and its application in instructional contexts. However, further research using quasi-experimental or randomized designs with appropriate comparison groups is needed to establish more conclusively whether structured video self-analysis causes improvements in TPACK and instructional practice.

RECOMMENDATIONS

Based on the findings of this study, the following recommendations are made for improving teacher education and training involving the use of video self-analysis:

1) Teacher education institutions should incorporate structured video self-analysis into microteaching and teaching practicum programmes. Pre-service science teachers should be guided to record their teaching, identify areas needed for adjustments, encourage reflection on their instructional practices and the role of technology in teaching and learning, and make appropriate adjustments to subsequent lessons.
2) Teacher educators should provide structured mentoring and feedback alongside video self-analysis activities. They should also help pre-service science teachers connect technological, pedagogical, and content knowledge with classroom practice.
3) Teacher education institutions should provide PSTs with repeated opportunities to apply and reflect on technology-supported instructional practices in science teaching contexts. These opportunities should go beyond basic exposure to hardware and software and focus on developing PSTs' ability to make informed decisions about when, why, and how digital technologies can be meaningfully integrated with specific science content and pedagogical strategies.
4) Universities and education stakeholders should provide adequate digital infrastructure, instructional technologies, and technical support for teacher education programmes. Such investment should be accompanied by appropriate pedagogical training to ensure that PSTs develop the technological knowledge and practical experience required to integrate digital technologies meaningfully into science teaching and learning.

REFERENCES

Adebusuyi, O. F., Bamidele, E. F., & Adebusuyi, A. S. (2020). Effects of in-service chemistry teachers' technological pedagogical content knowledge on students' scientific attitude and literacy in Southwestern Nigerian secondary schools. *European Journal of Interactive Multimedia and Education*, *1*(2), e02009. https://doi.org/10.30935/ejimed/9306

Angeli, C., & Valanides, N. (2005). Preservice teachers as ICT designers: An instructional design model based on an expanded view of pedagogical content knowledge. *Journal of Computer Assisted Learning*, *21*(4), 292–302. https://doi.org/10.1111/j.1365-2729.2005.00135.x

Angeli, C., & Valanides, N. (2020). Developing and assessing pre-service teachers' technological pedagogical content knowledge (TPACK). *Australasian Journal of Educational Technology*, *36*(6), 89–110. https://doi.org/10.14742/ajet.6370

Archambault, L. (2016). Exploring the use of qualitative data to enrich understandings of TPACK. *Journal of Research on Technology in Education*, *48*(1), 16–29. https://doi.org/10.4324/9781315771328

Backfisch, I., Lachner, A., Hische, C., Loose, F., & Scheiter, K. (2020). Professional knowledge or motivation? Investigating the role of teachers' TPACK on technology integration in the classroom. *Journal of Computer Assisted Learning*, *36*(4), 1–13. https://doi.org/10.1016/j.learninstruc.2019.101300

Baroudi, S., & Shaya, N. (2022). Exploring predictors of teachers' self-efficacy for online teaching in the Arab world amid COVID-19. *Education and Information Technologies*, *27*, 8093–8110. https://doi.org/10.1007/s10639-022-10946-4

Blackwell, C. K., Lauricella, A. R., & Wartella, E. (2016). The influence of TPACK contextual factors on early childhood educators' technology integration. *Computers & Education*, *98*, 57–69. https://doi.org/10.1016/j.compedu.2016.02.010

Blomberg, G., Renkl, A., Sherin, M. G., Borko, H., Seidel, T., & Stürmer, K. (2011). Five research-based heuristics for using video in pre-service teacher education. *Journal for Educational Research Online*, *3*(1), 12–33. https://doi.org/10.1016/j.tate.2013.03.004

Bon, S., & Koem, V. (2025). STEM education: Pre-Service teachers' knowledge, attitude, practice intention, and possible challenges. *International Journal of Technology in Education and Science*, *9*(2), 270–284. https://doi.org/10.46328/ijtes.617

Bourven, T. (2018). Digital technology and cognitive learning: The 21st-century learning paradigm. *European Journal of Educational Research*, *7*(3), 417–428. https://doi.org/10.12973/eu-jer.7.3.417

Chai, C. S., Koh, J. H. L., & Tsai, C. C. (2013). A review of technological pedagogical content knowledge. *Educational Technology & Society*, *16*(2), 31–51.

Chai, C. S., Tan, L., Deng, F., & Koh, J. H. L. (2021). Examining pre-service teachers' design capacities through collaborative lesson design supported by online tools. *Teaching and Teacher Education*, *97*, 103244. https://doi.org/10.1016/j.tate.2020.103244

Chapelle, C. A., & Sauro, S. (Eds.). (2017). *The handbook of technology and second language teaching and learning*. Wiley-Blackwell.

Chen, C. H., Zhang, K., & Jang, S. J. (2020). Supervising student teachers with video feedback: Exploring the effects on teaching performance and self-efficacy. *Computers & Education*, *146*, 103758. https://doi.org/10.1016/j.compedu.2019.103758

Cohen, J. (1988). *Statistical power analysis for the behavioral sciences* (2nd ed.). Lawrence Erlbaum Associates.

Fabian, A., Backfisch, I., Kirchner, K., & Lachner, A. (2024). A systematic review and meta-analysis on TPACK-based interventions from a perspective of knowledge integration. *Computers and Education Open*, *7*, 100200. https://doi.org/10.1016/j.caeo.2024.100200

Gaudin, C., & Chaliès, S. (2022). Video viewing in teacher education and professional development: A systematic review (2000–2020). *Educational Research Review*, *36*, 100450. https://doi.org/10.1016/j.edurev.2022.100450

Habib, M., Yusop, F. D., & Razak, R. A. (2019). The influence of technology integration on teachers' TPACK and students' achievement in Malaysian schools. *Education and Information Technologies*, *24*(2), 1233–1249. https://doi.org/10.1007/s10639-018-9818-8

Hew, K. F., & Brush, T. (2007). Integrating technology into K–12 teaching and learning: Current knowledge gaps and recommendations for future research. *Educational Technology Research and Development*, *55*(3), 223–252. https://doi.org/10.1007/s11423-006-9022-5

Horak, A. K., Marotta, J., Brusseau, R., & Daly, K. (2023). Supporting PBL instruction with teacher video self-analysis and reflection. *Teacher Development*, *27*(1), 36–54. https://doi.org/10.1080/13664530.2022.2153909

Karlsson, G., & Nilsson, P. (2023). Capturing student teachers' TPACK by using T-CoRe and video-annotation as self-reflective tools for flexible learning in teacher education. *Technology, Pedagogy and Education*, *32*(2), 223–237. https://doi.org/10.1080/1475939X.2023.2170455

Kholid, M. N., Hendriyanto, A., Sahara, S., Muhaimin, L. H., Juandi, D., Sujadi, I., Kuncoro, K. S., & Adnan, M. (2023). A systematic literature review of Technological, Pedagogical and Content Knowledge (TPACK) in mathematics education: Future challenges for educational practice and research. *Cogent Education*, *10*(2), Article 2269047. https://doi.org/10.1080/2331186X.2023.2269047

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

Koehler, M. J., & Mishra, P. (2005). What happens when teachers design educational technology? The development of technological pedagogical content knowledge. *Journal of Educational Computing*, *32*(2), 131–152. https://edtechbooks.org/-RAo

Koehler, M. J., Mishra, P., & Cain, W. (2013). What is technological pedagogical content knowledge (TPACK)? *Journal of Education*, *193*(3), 13–19. https://doi.org/10.1177/002205741319300303

Koh, J. H. L., Chai, C. S., & Tsai, C.-C. (2014). Demographic factors, TPACK constructs, and teachers' perceptions of constructivist-oriented TPACK. *Educational Technology & Society*, *17*(1), 185–196.

Kong, S. C., Shroff, R. H., & Hung, H. K. (2009). A web enabled video system for self reflection by student teachers using a guiding framework. *Australasian Journal of Educational Technology*, *25*(4). https://doi.org/10.14742/ajet.1128

Mishra, P., & Koehler, M. J. (2006). Technological pedagogical content knowledge: A framework for teacher knowledge. *Teachers College Record*, *108*(6), 1017–1054. https://doi.org/10.1111/j.1467-9620.2006.00684.x

Mouza, C. (2016). Learning with technology: A review of the literature. In *Teacher Learning and Technology Integration* (pp. 11–30). Springer. https://doi.org/10.1007/978-3-319-25446-5_2

Mouza, C., Nandakumar, R., Yilmaz Ozden, S., & Karchmer-Klein, R. (2021). A longitudinal study of pre-service teachers' TPACK development through video-based reflection. *Teaching and Teacher Education*, *101*, 103423. https://doi.org/10.1016/j.tate.2021.103423

Näykki, P., Isohätälä, J., & Kallio, S. (2022). Fostering collaborative reflection with video annotations in teacher education. *Frontiers in Education*, *7*, 835237. https://doi.org/10.3389/feduc.2022.835237

Ocak, C., & Baran, E. (2019). Observing the indicators of technological pedagogical content knowledge in science classrooms: Video-based research. *Journal of Research on Technology in Education*, *51*(1), 43–62. https://doi.org/10.1080/15391523.2018.1550627

Okoye, K., Hussein, H., Arrona-Palacios, A., et al. (2023). Impact of digital technologies upon teaching and learning in higher education in Latin America: An outlook on the reach, barriers, and bottlenecks. *Education and Information Technologies*, *28*, 2291–2360. https://doi.org/10.1007/s10639-022-11214-1

Prilop, C. N., Weber, K. E., & Kleinknecht, M. (2020). Effects of digital video-based feedback environments on pre-service teachers' feedback competence. *Computers in Human Behavior*, *102*, 120–131. https://doi.org/10.1016/j.chb.2019.08.011

Rosaen, C. L., Lundeberg, M. A., Cooper, M., Fritzen, A., & Terpstra, M. (2008). Noticing noticing: How does investigation of video records change how teachers reflect on their experiences? *Journal of Teacher Education*, *59*(4), 347–360. https://doi.org/10.1177/0022487108322128

Santagata, R. (2014). Towards ambitious teaching: Using video to support future teachers reasoning about evidence of student learning. *Recherche & Formation*, *75*, 95–110. https://doi.org/10.4000/rechercheformation.2180

Schlosser, C., & Paetsch, J. (2023). Reflective video analysis and pre-service teachers' self-efficacy: Emotional engagement in focus. *Frontiers in Psychology*, *14*, 1162313. https://doi.org/10.3389/fpsyg.2023.1162313

Schmid, M., Brianza, E., & Petko, D. (2021). Self-reported technological pedagogical content knowledge (TPACK) of pre-service teachers in relation to digital technology use in lesson plans. *Computers in Human Behavior*, *115*, 106586. https://doi.org/10.1016/j.chb.2020.106586

Seidel, T., Stürmer, K., Blomberg, G., Kobarg, M., & Schwindt, K. (2011). Teacher learning from analysis of videotaped classroom situations: Does it make a difference whether teachers observe their own teaching or that of others? *Teaching and Teacher Education*, *27*(2), 259–267. https://doi.org/10.1016/j.tate.2010.08.009

Sewall, M. (2009). Transforming supervision: Using video elicitation to support preservice teacher-directed reflective conversations. *Issues in Teacher Education*, *18*(2), 11–30.

Shayeb, A., & Daher, W. (2024). The impact of digital video recordings on pre-service teachers' technological pedagogical content knowledge. *European Journal of Investigation in Health, Psychology and Education*, *14*(10), 311–328. https://doi.org/10.3390/ejihpe14100311

Sherin, M. G., & van Es, E. A. (2009). Effects of video club participation on teachers' professional vision. *Journal of Teacher Education*, *60*(1), 20–37. https://doi.org/10.1177/0022487108328155

Shulman, L. (1987). Knowledge and teaching: Foundations of the new reform. *Harvard Educational Review*, *57*(1), 1–23. https://edtechbooks.org/-Jbm

Snoeyink, R. (2010). Using video self-analysis to improve the "withitness" of student teachers. *Journal of Digital Learning in Teacher Education*, *26*(3), 101–110.

Starkey, L. (2019). A review of research exploring teacher preparation for the digital age. *Cambridge Journal of Education*, *49*(1), 37–56. https://doi.org/10.1080/0305764X.2018.1554475

Tripp, T., & Rich, P. J. (2012). Using video to analyze one's own teaching. *British Journal of Educational Technology*, *43*(4), 678–704. https://doi.org/10.1111/j.1467-8535.2011.01234.x

Valtonen, T., Sointu, E., Kukkonen, J., Mäkitalo, K., Hoang, N., Häkkinen, P., & Järvelä, S. (2020). Examining pre-service teachers' TPACK in lesson design. *Computers & Education*, *146*, 103905. https://doi.org/10.1016/j.compedu.2020.103905

von Kotzebue, L. (2026). Linking performance-based TPACK to the quality of lesson plans and explanatory videos in teacher education. *Frontiers in Education*, *11*. https://doi.org/10.3389/feduc.2026.1857501

Weber, J., Gold, B., Prilop, C. N., & Kleinknecht, M. (2018). Promoting pre-service teachers' professional vision of classroom management through video-based course design. *Teaching and Teacher Education*, *76*, 21–34. https://doi.org/10.1016/j.tate.2018.01.002

Yao, Z. (2025). Exploring the impact of interactive digital tools on learning outcomes in higher education. *International Journal of Inclusive Education*, 1–34. https://doi.org/10.1080/13603116.2025.2540821

APPENDIX A

Video Self-Analysis Reflection Rubric for Science Pre-service Teachers

S/N.	Reflective Question for Video Analysis	Evidence to Look for in the Video	Planned Adjustment for the Next Lesson	Notes for Adjustment
1	Did I explain the science concept accurately and clearly?	Identify any scientific errors, misconceptions, unclear explanations, or inappropriate examples.	How will I improve or clarify my explanation of the concept?	
2	Did the technology I used genuinely support the intended science learning objective?	Examine whether the digital tool helped students understand the target concept or was merely used for presentation.	What will I change about my choice or use of technology?	
3	How effectively did I integrate technology into my teaching strategy?	Observe whether technology supported inquiry, visualization, experimentation, collaboration, or problem-solving.	How will I use the technology more effectively in the next lesson?	
4	How did students respond to and interact with the lesson and technology?	Look for students' attention, participation, questions, collaboration, and active use of digital tools.	What will I do to increase active student participation?	
5	Did I identify and respond effectively to students' alternative conceptions or difficulties?	Note students' incorrect responses, questions, confusion, or difficulties with the science concept.	What specific strategy or digital resource will I use to address these difficulties?	
6	Did my questions promote higher-order thinking and scientific reasoning?	Identify questions that require students to explain, predict, analyze, justify, or investigate.	What questions will I modify or introduce to promote deeper scientific thinking?	
7	Did the digital tools or representations make the science	Examine the use of simulations, animations, videos, models, graphs,	Which digital representation should I	

	concept more understandable?	visualizations, or other digital resources.	retain, modify, replace, or introduce?	
8	Did I effectively facilitate students' learning while using technology?	Observe teacher talk, student talk, feedback, classroom management, and transitions between activities.	How will I improve my facilitation and balance teacher- and student-centered interaction?	
9	Did I obtain sufficient evidence that students understood the science concept?	Look for formative assessment, questioning, student explanations, digital quizzes, demonstrations, or feedback.	What assessment strategy will I use to better identify students' understanding?	
10	What is the most important change I should make in my next lesson?	Identify one critical incident or moment that had a significant impact on students' learning.	State one or more specific, measurable changes to implement in the next lesson.	