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PAPER

# Using Digital Video Recordings in Class Activities for Enhancing Mathematics Pre-Service Teachers' Reflective Thinking

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**ABSTRACT**

Digital video recordings (DVRs) have become an effective tool in sustainable teacher education. In the current study, our aim was to investigate the impact of utilizing mobile applications for DVRs in classroom activities, designed to address misconceptions of mathematical concepts, on pre-service teachers' capacity of reflective thinking. Two groups of approximately 10 PSTs participated in an education program. The participants learned as third-year students in the Department of Mathematics Education. Interviews and digital video-recorded observations were used as data collection tools. Deductive and inductive content analysis would be used as data analysis tools. The study showed that the DVR environment constituted a sustainable educational environment that supported PSTs' development in writing reflections on their mathematics teaching. These results underscore the significance of using digital platforms for PSTs' education, particularly for promoting metacognitive thinking practices such as reflective thinking.

**KEYWORDS**

reflective thinking, pre-service teachers (PSTs), digital video recordings (DVRs), IRIS-connect

## 1 INTRODUCTION

Digital video recordings (DVR) have become an effective tool in mathematics education, especially in teacher education. These recordings could be used to help teachers address students' misconceptions when working with mathematical ideas and solving mathematical problems. These recordings could be used on different platforms, including those that populate mobile devices. In the present study, the mathematics pre-service teachers (PSTs) utilized the platform using their mobile phones. We aim to investigate how these recordings, when used by mathematics PSTs to address mathematical misconceptions, can motivate them to engage in reflective practice, thereby improving their reflective thinking.

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# 2 LITERATURE REVIEW

## 2.1 Reflective thinking

Reflective thinking for teachers is a process of self-evaluation and critical thinking about one's own teaching practices, beliefs, and experiences. Thus, this process of self-evaluation could be part of a sustainable teacher-education environment. It involves a deliberate and systematic examination of teaching methods, classroom management techniques, assessment strategies, and interactions with students, among other things [1]. As a result, teachers are able to uncover hidden beliefs and gain a deeper understanding of what they are teaching [2].

Reflective thinking enables teachers to identify moments of power and limitation in their instruction and to create plans of action to enhance their methods [3]. By reflecting on their practices, teachers can gain insight into their own biases, assumptions, and values and understand how these factors might influence their teaching practices. Educators can also gain a deeper understanding of their students' needs and demands, enabling them to adjust their teaching methods accordingly.

Reflective thinking for teachers can take many forms, including journaling, classroom observations, peer feedback, and discussions with colleagues. The process can be formal or informal and can be done individually or as part of a group. Ultimately, reflective thinking is an effective means for teachers to enhance their instruction and ensure successful outcomes for their students. The statement above highlights the importance of incorporating reflective thinking into teachers' educational interventions.

## 2.2 The role of reflective thinking in teachers' education

Reflective thinking is a tool for teacher educators to help teachers stay focused on the important aspects of education and to help them deliberate and thoughtfully analyze what they teach [4].

Choy et al. [5] found that PSTs' reflective thinking practices are context-related. Moreover, teaching awareness, which is the capability to recognize how teaching actions are affecting students, was significantly correlated with Malaysian PSTs but not with Australian pre-service teachers.

## 2.3 Measuring and analyzing reflective thinking

Reflective thinking comprises three categories: the cognitive category, the critical thinking category, and the narrative inquiry category [6]. The cognitive category addresses using reflection to cultivate knowledge for planning and making decisions. It comprises six elements: content knowledge, pedagogical knowledge, curriculum, learner characteristics, teaching contexts, and lifelong learning. The critical thinking category requires the teacher to analyze situations in the class and draw inferences to facilitate decision-making. The narrative inquiry category addresses how the teacher's voice can be heard. Choy et al. [7] suggest a reflective thinking framework for teachers that includes four categories: developing lifelong learning skills (making corrections and learning from mistakes and moving forward, whenever mistakes occur), the ability to self-assess (improving practice after reflection), beliefs about self-efficacy (looking for areas of connection between teaching and life experiences), and awareness of teachers (having a way of comfortable teaching).

## 2.4 Noticing in the classroom

Noticing in the classroom refers to a teacher's ability to observe and pay attention to important details and events that occur during a lesson [8]. This includes noticing the different aspects of student learning: cognitive, affective, social, and behavioral.

Noticing is an essential aspect of effective teaching, as it allows teachers to make informed decisions about how to adjust their instruction to better meet the needs of their students [9]. For example, a teacher who notices a student struggling to understand a concept can modify their teaching methods or provide additional support to help the student better grasp the material.

König et al. [10] state that teachers' noticing is regarded as a component of their expertise, which develops through cognitive and reflective processes linked to their teaching practice and experiences.

Kaiser et al. [11] identified three situation-specific skills: (a) recognizing specific events in a classroom setting; (b) analyzing the conceived class activities; and (c) decision-making either in anticipation of a student's activity or by proposing an alternative instructional approach (p. 374). The mathematical knowledge of teachers, as well as their professional practices, are influenced by noticing [12]. Noticing helps the teacher select and design mathematical tasks, identify learners' mathematical thinking and evaluate it, and initiate and manage classroom interaction processes in the classroom.

Noticing in the classroom could be made easier with the help of video recording. Larison et al. [13] suggested engaging K-2 teachers with videos to support their observation of learners' mathematical thinking within the context of a professional development program. This highlights the benefits of video recordings for teachers and PSTs' attention.

## 2.5 Digital video recording as a tool in PSTs training

Videos have been utilized as a digital tool to reflect the teaching practices of teachers and PSTs during their training [14–15]. Studies have also shown that a blend of reflecting on practices and efficient use of video may enhance the professional development of teachers [16].

Using DVR among PSTs provides a long-term record of interaction events that occur in an educational setting, especially during lessons [17]. Video recording allows PSTs to observe their own teaching practices. The PST is also able to make decisions about their next teaching steps in the classroom by watching classroom interactions multiple times from different perspectives. This process of observing and reflecting on teaching practice in the classroom expands PST experiences [18–19]. The use of DVR helps PSTs foster the capability to recognize what is essential in the teaching process. In addition, it allows students to make links between classroom conclusions and their performance within the broader context of teaching and learning [20]. Several studies have investigated using video recordings and reflective thinking [21]. Moreover, using DVR among PSTs develops a community of learners by sharing videos among other PSTs to stimulate discussions about their teaching practices [20].

Using DVR in the teaching profession serves various purposes, including: (1) training PSTs [21]; (2) understanding teachers' thought processes [21]; (3) assisting teachers in reflecting on their classroom practices [22]; (4) analyzing and discussing teaching [23]; and (5) providing examples of good teaching practices and those that need improvement [24].

In recent years, the use of DVR has increased, opening up new possibilities for editing and sharing video recordings [25]. This means that the video analysis is conducted by entering argumentation texts directly into the video recording [26]. Recently, there has been a growing body of literature on the use of video annotation to enhance teachers' ability to be involved in discussing their teaching practices [25–27].

This study aims to show how watching and analyzing the DVR of PST activities can enhance their reflective thinking skills and offer concrete evidence of classroom events. This approach enables PSTs to revisit specific segments of a lesson to analyze a specific event closely.

### 2.6 Using digital video recordings-based events

Events in mathematics teacher education can be divided into a couple of themes, such as examples and problem situations [28]. Providing examples from real classrooms substantiates ideas about content and pedagogy by providing clear images of teachers in action. In contrast, a problem situation focuses on analyzing and resolving dilemmas presented by the complexity of teaching and performance, either mathematically or pedagogically. The events described may be real classroom events, which illustrate students' conceptions and misconceptions [29].

Using DVR-based events provides PSTs with rich examples of pedagogical dilemmas. Furthermore, these platforms enable PSTs to engage in reflective practices in their teaching and enhance their pedagogical content knowledge [30].

Some studies that investigated DVR event analysis showed that the video recording event analysis provided PSTs with a valuable developmental pattern that informs their teaching, promotes their learning, and fosters collaboration [31]. Teachers who participated in video recording analysis improved their explanations and developed their teaching and learning practices by engaging in critical discussions with colleagues [21].

## 3 STUDY RATIONALE, GOALS, AND QUESTIONS

Several questions arise following the preparation processes of PSTs in educational institutions, especially the effect of these processes on their clinical training—whether and how are these processes implemented? How are they examined?—these are some of the crucial questions. Moreover, literature has largely emphasized the need to connect both the preparation processes of PSTs and their actual classroom practices, specifically through the use of video recordings of teaching events [30].

Digital video recordings have been reported as being beneficial for enhancing PSTs' reflective thinking skills. Therefore, we assume that using self-video recordings by the PST or colleagues (Selfie model), where the recording and analysis of the lesson practices are performed for reflective learning purposes, will provide the PSTs with pedagogical knowledge that can be implemented in their teaching. Following this assumption, we designed Selfie models (recording of classroom or field events) for recording purposes, presentation, reflection, discussion, analysis, and evaluation of classroom or field events by using a mobile digital recording tool that enables these actions either individually or collaboratively. 'Iris-Connect,' a digital tool we previously utilized in pilot research, serves these purposes. To implement the Selfie model, we utilized this tool for preservice teachers to record, reflect on, discuss, and analyze classroom teaching activities. This was done to enhance their reflective thinking during their clinical training.

Based on our pilot experiment, we identified various features of Iris-Connect that can ease the implementation of the selfie model. Moreover, we established different application methods for this implementation.

Mathematics PSTs at Al-Qasemi Academic College participate in the course 'Using Digital Tools' in their first academic year; students' study 'Mathematics Didactics' and 'Computerized Pedagogical Models in Teaching and Learning of Mathematics' in their second academic year. This provides them with several opportunities to integrate digital tools into designing and implementing technology-based activities in their mathematics teaching.

### 3.1 Research questions

1. How does the use of video-based reflection by PSTs advance their reflective thinking processes?
2. What is the contribution of video-based reflection to PSTs' preparation as mathematics teachers?

## 4 METHODOLOGY

### 4.1 Context of the study and participants

The context of the study focuses on an educational program for pre-service mathematics teachers in the academic year 2022–2023. Two groups of 10 PSTs each participated in the educational program. The participants were in their third academic year, majoring in teaching mathematics. They have already studied core courses in pure mathematics, basic courses in didactics, and how to use digital tools. The pedagogical supervisors accompanied the PSTs in their practical training in a couple of middle schools.

### 4.2 Study design

The PSTs worked in groups (2–3 in each). Each group designed a set of three-phase activities that focused on common mathematical misconceptions among students. The activity design was inspired by literature and educational resources on common mathematical misconceptions among students. Each group of PSTs conducted the activities with their students. All the activities in the second phase with students were video recorded. Below is a description of the three-phase activities.

First phase: In this phase, the PSTs chose a digital tool to present a quiz to students. It was based on mathematical problems inspired by common mathematical misconceptions. The students were required to read the problems and then choose the correct answer for each problem from the multiple-choice options provided. It included one correct answer and three other incorrect answers that were based on the literature. The PSTs scanned the quiz results and identified the types of mistakes in each problem.

Second phase: In this phase, the PSTs utilized appropriate digital tools that had been prepared beforehand to help students discover and address their mathematical mistakes and misconceptions after solving the quiz. This phase was digitally recorded for reflective purposes.

Third phase: In this phase, the PSTs considered the mathematical mistakes and misconceptions that emerged in the first phase. They proposed a follow-up quiz aimed at addressing the same. The PSTs carried out the activity with their students and compared their mistakes with the ones they made in the first quiz.

### 4.3 Reflective process

The second phase was followed by a reflection process, which aimed to discuss and reflect on insightful aspects. For this purpose, we utilized the IRIS-connect tool to conduct and analyze the reflection process. The students utilized the tool using their mobile phones. The IRIS-connect allows two modes of reflection: personal and collective. During the personal reflective session, each participant or group individually reflected on their experiences and insights gained from the activity they conducted with their students. This reflection was available for all PSTs. During the collective reflection, the pedagogical supervisors discussed the learning process and mathematical activities that have been implemented with the students. For example, the following questions and issues were discussed during the reflection phase: (1) PSTs' feelings and responses towards their experiences or specific situations they notice. (2) Questions and hesitations during the activity or in specific situations they notice. (3) Strengths and weaknesses observed during the activity. (4) How do the PSTs cope with the problems and challenges that arise during the activity? What are the suggested solutions to the problems and challenges they faced? (5) What are the possible reasons for the problems faced, and what are the possible solutions or alternatives? To what extent was the role of the teacher or digital tool effective? (6) How would the PSTs react in similar situations next time? How would they cope with similar situations next time? (7) Whether and how do the activities contribute to overcoming students' misconceptions?

### 4.4 Data collection and analysis

The tool for the study was based on the use of the Selfie model, which involves recording teaching processes in the mathematics classroom. The IRIS-connect tool was used as a data resource, which included all activity recordings with students and reflection processes of the PSTs. The IRIS-connect system allowed the PSTs to watch the video recordings, choose, focus, analyze, and reflect on specific excerpts based on pedagogical and didactical aspects.

The PSTs' reflections on the mathematical activities, along with discussions with the pedagogical supervisors, served as the raw data for analyzing the development of PSTs' reflective thinking as they implemented activities to cope with mathematical misconceptions. Moreover, we interviewed the participating PSTs regarding their observations while watching the video recordings. We explored how this process assisted them in reflecting on their practices in the mathematics classroom as well as on their students' misconceptions. Examples of interview questions include: What are the advantages of using video recordings in your reflective thinking? Can you provide a specific example of how the video recording helped you notice a student's misconception? Can you provide an example of how watching the video recording helped you notice a behavior that you would like to change? How did your reflection help you pay attention to the different aspects of your training practice?

Data were analyzed qualitatively following the reflection process in the second phase of PSTs' activities. Then, characterize the PSTs' reflective thinking and, if possible, identify indications (statements, utterances, etc.) that demonstrate any reflective development of PSTs. This was done by considering the reflective thinking aspects (cognitive, critical thinking, and narrative inquiry) and using Hamilton's [32] framework for analyzing reflective thinking elements. Table 1 outlines the categories and themes of reflective thinking, along with an example for each theme.

**Table 1.** Categories and themes of reflective thinking according to Hamilton [32]

| Category and Themes of Reflection | Introductory | Intermediate | Advanced |
|---|---|---|---|
| **Ability to self-assess** | | | |
| – Watches one's doing.<br>– Uses feedback and evidence.<br>– Looking for patterns.<br>– Judges actions. | – Judges globally with verification.<br>– Considers performance as similar to assignment.<br>– Repeats evaluators' judgments.<br>– Considers feedback as confirmation process.<br>– Narrates processes.<br>– Watches rather than reckons. | – Applies disciplinary acts.<br>– Displays understanding of meaning.<br>– Utilizes feedback in increasing knowledge.<br>– Identifies relationships.<br>– Makes inferences. | – Watches processes of change.<br>– Examines own work.<br>– Uses interdisciplinary frameworks for understanding.<br>– Makes connections to move forward. |
| **Awareness of how one learns** | | | |
| – How one conceives or misconceives.<br>– Knowledge Construction.<br>– Metacognition. | – Restricts development of learning to assignments.<br>– Sees feedback as out of analysis.<br>– Sees knowledge construction in assignments.<br>– Utilizes personal theories without explanation | – Sees feedback as means for conceiving concepts.<br>– Connects between present and future implementation.<br>– Observes changes in own actions.<br>– Sees knowledge building as connecting between known and new knowledge.<br>– Applies theoretical frameworks to analyze the conceiving of new knowledge | – Uses feedback to plan learning.<br>– Uses awareness of knowledge constructs to picture forthcoming learning processes.<br>– Understands own strategies as a learner and transports them to new contexts |
| **Developing lifelong learning skills** | | | |
| – Develops learner identity.<br>– Transfers learning to new contexts.<br>– Considers learning as a lifelong process. | – Confuses performance and feedback with identity.<br>– Uses generalized notions of success to reflect.<br>– Neglects links between performance and reflecting on it. | – Identifies as a learner who constructs meaning from experience.<br>– Questions personal assumptions to recognize different perspectives.<br>– Uses self-assessment to demonstrate a positive attitude and improve | – Sees own identify as internalizing construction of efficiency.<br>– Questions assumptions to be part of commitment that engages in multiple viewpoints.<br>– Situates personal narrative in larger contexts. |

The validity and reliability of the study were ensured by the saturation of categories and themes emerging in the analysis process. Analyzing the reflection texts of the preservice teachers showed that the trajectories of advancement are similar, which indicated saturation of the results [33].

## 5 RESULTS

The PSTs differed in their advancement to the reflection phases, where this difference was represented in the number of lessons needed to be taught and reflected upon till the PST advanced towards the next reflection phase. Following, we give an

example of the advancement of one PST, named Suad, who advanced to the intermediate phase in her reflection on the fourth lesson and to the advanced phase in her reflection on the seventh lesson. Analyzing the reflective texts of the rest of the preservice teachers, we arrived at similar trajectories of advancement. Afterward, we describe the PSTs' perceptions of the contribution of mobile video recordings to their professional development as teachers.

## 5.1 Advancement in reflection on classroom lessons

A) **Reflection on the first lesson:** The text in Transcript 1 is Suad's reflection on the first lesson.

1T1: At first, I was nervous and scared when the students were quiet because of the filming. But when I told them that no one would see the video, they behaved as usual.
1T2: I did not expect that some of the students did not remember the rules; in addition to that, some of them did not remember the concept either.
1T3: There was an unusual student in the lesson; He was too talkative and too moving, and that was shocking to me.
1T4: In one of the clips, I felt somewhat nervous because there was a student who was not convinced of the answer to the question and was insisting on his answer even though it was wrong!

Transcript 1: Suad's reflection on the first lesson

In 1T1, Suad describes her emotions while watching the video of the first lesson. The students' quietness bothered her, but she managed to make them return to normal. The text belongs to the theme 'Ability to self-assess: Using feedback and evidence,' where she assesses her emotions in addition to her ability to make the students return to normal. The level of reflection is 'Introductory: Global judgments without evidence,' as she assessed her global and the students' global states.

In 1T2, Suad expresses her on-the-spot evaluation of the students' knowledge at the beginning of the lesson, where she did not expect that some of the students would not remember neither the rules nor the concepts of the previous topic. The text belongs to the theme 'Ability to self-assess: Observing students' performance,' where her evaluation resulted from observing the students' remembrance of the previous topic. The level of reflection here is introductory, as it is related to the 'Narrates process (did this; did that).' The type and level of reflection in 1T3 are similar to those in 1T2, where Suad describes her observation of one talkative student who kept moving. In addition, she describes herself as being shocked as a result of her observation, where this reflection is similar to that in 1T1, so its type and level are similar to those in 1T1.

In 1T4, Suad expresses being nervous as a result of a student not being convinced of the answer to a question, besides insisting on the correctness of his answer, even though it was wrong. The text belongs to the theme 'Awareness of how the students learn: Concepts and misconceptions,' as Suad observes that it is difficult for some students to be convinced of the mathematical facts or solutions, so they stay at their current knowledge level without wanting or being able to advance. The level of reflection here is introductory, as it is related to 'Seeing knowledge construction only within terms of the assignment.' Here, the assignment is the solution to a mathematical problem.

**B) Reflection on the fourth lesson:** Suad advanced to the intermediate reflection phase when she came to reflect on her fourth lesson. The text in Transcript 2 is Suad's reflection on the second lesson.

2T1: In all the lesson's events, the feeling of tension and pressure was visible on me and affected the way I taught, but when it was over, I felt relief and accomplishment, and at that time, I remembered the F saying that never leaves me, "There is nothing called impossible."
2T2: It would have been better if we divided the class into groups and distributed figures that include two squares of different sizes and two identical rectangles, through which we can build a larger square.
2T3: I would have guided the students to the steps they will take by presenting the idea gradually to them so that they discuss it, and it becomes their own.
2T4: This idea is similar to what was presented in class, but it is in an embodiment that allows the student to better understand the subject.

Transcript 2: Suad's reflection on the fourth lesson

In 2T1, Suad expressed her observation of the tension and pressure that were not only visible to her but also affected the way she taught. When she succeeded in overcoming that feeling, she felt victorious. During the reflection, she remembered the saying that there is nothing impossible. The previous reflection text belongs to the theme 'Developing lifelong learning skills: Developing identity as a learner,' where Suad's identity was affected by reflecting on the lesson, which convinced her that nothing is impossible in learning to teach. The level of the reflection here is intermediate, as it is related to 'Self-identifying as a learner constructing meaning within experience, now and in the future.'

In 2T2, Suad started reflecting on alternative actions during the teaching of the lesson. Specifically, she reflected on the grouping of the students, expressing her preference for the students working in groups and not individually. The reflection text belongs to the theme 'Awareness of how one teaches: metacognition' or to the theme 'Awareness of how students learn: knowledge construction,' where the level of the reflection is intermediate as it addresses 'Seeing feedback as a means for understanding links between current and future performance.'

In 2T3, Suad continued reflecting on alternative actions that would have been taken during the teaching of the lesson. These actions were related, as in 2T2, to the teacher's instruction as well as to the student's learning. Thus, here we have the same themes and level of reflection that we saw in 2T2. In 2T4, Suad evaluated her idea in 2T3 of an alternative teaching strategy, but with a different teaching technique. The theme of the reflection text in 2T4 is 'Developing lifelong learning skills: Transferring learning to other contexts,' as this text evaluates the different teaching strategies, which helps decide on strategies to use in different educational contexts.

**C) Reflection on the seventh lesson:** Suad advanced to the advanced reflection phase when she wrote the reflection on her seventh taught lesson. The text in Transcript 3 is Suad's reflection on the second lesson.

3T1: We could have used GeoGebra, so the students can manipulate the functions related to the algebraic equations on the sides of the equation, and by observing the change in the graphs, they can better understand the subject of equivalence of equations.

3T2: I need to familiarize myself with more technological tools, as these tools are now those used in the mathematics classroom. They could be effective for students' learning.

3T3: Using video recordings through "Iris-Connect", enabled us to write reflections on our lessons. We did not use "Iris-Connect" as a platform for reflection. I will use it in the future to share videos and reflection on them with the schoolteachers.

Transcript 3: Suad's reflection on the seventh lesson

In 3T1, Suad expressed her reflection on the teaching method during the seventh lesson, where she considered that an alternative teaching method, that of technology-based learning, would have enabled the students to manipulate the functions on the sides of the equation so that the change in the graphs could make them better understand the concept of equivalence of equations. Here, the reflection text addresses the 'Awareness of how one learns: knowledge construction,' where the level is 'Advanced,' as the text expresses the 'Use of growing awareness of knowledge structures to envision future learning.'

In 3T2, Suad expressed the need to familiarize herself with the technological tools used in the mathematics classroom. Here, the reflection resulted from her belief that those tools were effective for students' learning. Here, the theme of the reflection text is 'Developing lifelong learning skills: Developing identity as a teacher', where its level is the advanced level because Suad seems to see her identity as a teacher by employing an internalized construction of effectiveness. Here, the internalized construction resulted from her constructed belief regarding the utility of technological tools.

In 3T3, Suad reflected on students' use of the technological tool 'Iris-Connect', evaluating its positive impact on their writing reflections on their lessons. She also negatively evaluated their use of this tool as a platform for reflection. These evaluations made her express the intent to share the mathematical lessons' videos with the other schoolteachers through the 'Iris-Connect' platform, so that they reflect on them using the same platform. The reflection text belongs to the theme 'Developing lifelong learning skills: Understanding learning as a lifelong process,' where Suad talks about her future use of the technological tool. This reflection text is at the advanced level, as it 'situates personal narrative in larger intellectual and professional frameworks, transferring learning to new situations,' where the new situation occurs in the future school in which the PST will work as a mathematics teacher.

## 5.2 The reflection's contribution to pre-service teachers' professional development

Upon interviewing Suad and five other students who participated in the study regarding the contribution of the video-based reflection to their professional development, they mentioned five contributions described below.

A) **Accuracy of mathematical terms and relations:** Salam described how the video-based reflection helped her look at her classroom language, especially those related to mathematical terms and relations. She said, "The reflection helped me look at my language during my teaching. This made my use of mathematical terms more accurate. For example, I used the term 'perimeter' instead of 'size.'

I knew that the term was 'size,' but for some reason, I used the term 'perimeter.' Reflecting on my teaching when watching the video made me pay attention to this inaccurate use. The same happened with the statements of mathematical relations. I kept comparing these statements to those in the book, which made these statements more formal."

B) **Awareness of the students' learning difficulties:** Suad described how the video-based reflection helped her look at her students' difficulties in learning mathematics. Suad said, "The reflection helped me look at students' difficulties solving mathematical problems. I noticed that when watching the video, the students had difficulties solving word problems because they did not understand the formulation of the problems. This encouraged me to verify this understanding before the students engage in solving the word problems."

C) **Pre-working on students' errors:** Amina described how the video-based reflection helped her look for students' errors in the mathematical topic before teaching this topic. She said, "Making the video-based reflection, I noticed that the students had different errors and misconceptions. Some of which I had not expected. So, I made it a rule for me to look for the expected students' errors in a specific subject matter."

D) **Fetching and building tools that specifically fit the mathematical topic:** Amira stressed that the video-based reflection helped her decide to use more specific technological tools to teach the mathematical topic. She said, "Watching the video and reflecting on my teaching, I say that sometimes the GeoGebra applet led to misconceptions among the students. So, I decided to choose an applet that best fits my goals and the specific relations in the mathematical topic."

Suad talked about appropriating tools to her goals, "Reflecting on the tools used in my lessons, I came to a decision that involved appropriating the GeoGebra tool to fit more with the specific goal of my lesson. This approach lessened my students' misconceptions. This happened, for example, when I taught the height of the triangle. The applet that I chose only showed the interior heights. I appropriated the applet to address exterior heights as well."

E) **Becoming more confident in her teaching ability:** Noura mentioned that, as a result of reflection on her teaching, she became more confident in her teaching ability. She said, "Reflecting on my teaching, I became more confident in my teaching, the accuracy of the terms and relations that I state, and the tools that I use in the classroom."

## 6 DISCUSSION

Reflection in educational settings is attracting the attention of researchers [34–35]. The present study aimed to investigate the advancement of middle school mathematics PSTs by reflecting on the lessons taught. They performed this reflection on their mobile phones. To do that, we followed one PST advancement in writing reflective texts on her teaching. The study results indicate that, during the introductory phase, the PST was concerned with self-assessment of her own learning and that of her students. The reflection served to calm the atmosphere by assuring the students about the filming conditions, and gave rise to the use of feedback as proof of the classroom climate. The concern was also directed towards observing students' performance, specifically their ability to recall the rules and concepts related to the mathematical topic being studied. The reflection of the PST was also focused on how students learn concepts and their misconceptions. The PST reflected on her

astonishment that one student was not convinced of the answer to a question. He insisted that his answer was correct, even though it was wrong.

Educational researchers emphasize the importance of self-assessment, particularly in teaching and learning for teachers. Bailey [36] mentions seven steps that help the teacher with self-assessment. The PST used two of them in the first phase of reflection. First, she utilized the theme of 'Identifying basic teaching behaviors,' which includes creating a safe classroom environment for students [37]. This demonstrates the effectiveness of using video recordings to educate PSTs. Second, the PST used 'Planning Instructional Behaviors,' Here, this planning is necessary as the PST observed a lack of retention of previous knowledge among the students.

Reflecting on the fourth lesson, Suad proceeded to the intermediate reflection phase. At this phase, the reflection texts are associated with a couple of reflection categories: 'Awareness of how one teaches or how students learn' and 'Developing lifelong learning skills'. Reflecting on how one teaches, the PST was concerned with metacognition. Reflecting on students' learning, the PST was concerned with knowledge construction. Moreover, reflecting on lifelong learning, the PST was concerned with developing identity as a learner and transferring learning to other contexts. Educational experts emphasize that metacognition is critical to both teaching and learning [38–43]. Therefore, they highlight the importance of developing PSTs' metacognitive skills as both learners [44] and teachers [45]. The DVR context supported the metacognitive behaviors of the participating PSTs. So, this context is suitable for the metacognitive preparation of PSTs.

In addition to the above, it is interesting that the PST addressed issues related to lifelong learning in the intermediate phase of reflection. This issue is not only important to the learner but also to the teacher. Researchers recommend encouraging teachers' lifelong learning through various methods [46]. Here, the DVR helped facilitate this learning process. In addition, teacher identity is an issue that needs to be at the center of teacher education. Again, this issue could be addressed through DVR practices.

Reflecting on the seventh lesson, Suad proceeded to the advanced reflection phase. At this phase, the reflection texts are associated with the same couple of reflection categories mentioned in the intermediate reflection phase: awareness of how one learns and develops lifelong learning skills. Reflecting on how one learns, the PST was concerned with knowledge construction, while reflecting on developing lifelong learning skills, the PST was concerned with 'Developing identity as a teacher' and 'Understanding learning as a lifelong process.' The issue of lifelong learning, especially the identity of the teacher and learning as a continuous process, captured the attention of the PSTs. This could be explained by Suad's experience as a PST, where identity issues occupy new teachers. We are aware that the new teacher's identity may undergo changes and fluctuations [47–48]. Nevertheless, it appears that the DVR environment assisted the PSTs in focusing on issues of the teacher's identity, particularly those related to lifelong learning.

Moreover, during the interview, the PSTs emphasized the significance of video-based reflection, which significantly contributed to their professional development. This contribution was not only related to their content knowledge (precision in formulating terms and relations) but also to their pedagogical knowledge (understanding how students learn), pedagogical content knowledge (students' errors), and TPACK knowledge (assessing the suitability of an applet for specific teaching objectives). The previous results indicate that video-based reflection could contribute to teachers' knowledge and their professional development [49].

In addition to the above, Puentedura [50] introduced the SAMR model, which studies changes in education due to the use of digital tools. These changes focus on the evolving role of digital tools in teaching. These roles of technology are substitution, augmentation, modification, and redefinition. The video-based reflection led to the advancement of teaching mathematics through the role of technology. Through the video-based reflection, the PST learned to adapt to the digital tools to align with the intricacies of the mathematical topic. This happened when they learned to select specific tools for the mathematical topics. Afterwards, they learned to redefine the role of technological tools by incorporating digital components into them. So, in addition to enriching the various types of knowledge of PSTs, the video-based reflection also advanced their use of technological tools in teaching mathematics.

## 7 CONCLUSIONS

Pre-service teachers' preparation to utilize digital environments and tools has been reported to positively impact their use of tools in teaching and their intention to continue using them [ex., 51]. The present study used this preparation as a study context. Videos in education are reported as an effective tool in electronic learning [52–53]. The present study examined the contribution of video-based reflection to PSTs' teaching as well as their advancement in using this video-based reflection to enrich their teaching practices.

The results of the study indicate that using the DVR context provides PSTs with rich examples of pedagogical situations of performance. Such platforms enable PSTs to adopt reflective practices in their teaching, which could develop pedagogical content knowledge [21]. Moreover, it enabled PSTs to enhance their reflective thinking. In addition, this DVR context enhanced the PSTs' knowledge and constituted a context for their professional growth. Thus, the DVR context could be utilized for the professional development of PSTs as well as in-service teachers. Moreover, the present study results indicate that a couple of tools—videos and reflection—could be part of a sustainable educational environment for pre-service and in-service teachers.

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