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Supporting pre-service life sciences teachers' development of pedagogical content knowledge using pre-recorded teaching videos

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Abstract

Positioning it within the Pedagogical Content Knowledge (PCK) construct, in this article I present a study based on developing pre-service Life Sciences teachers' PCK using pre-recorded videos. The pre-service teachers had to plan a first lesson on any sub-topic of population ecology. They were then given access to the teaching videos and had to produce individual reflections on them and then discuss them in groups. This was followed by whole-class discussions. The pre-service teachers planned a second lesson on the same topic. Data from the narratives, and from the group and whole-class discussions was analysed through narrative analysis and the analysis of narratives. Teaching videos and lesson plans were scored using adapted PCK rubrics. Findings indicate that the pre-service teachers' PCK scores related to the PCK components had improved by the time they had to plan the second lesson. Their knowledge of conceptual teaching strategies seems to have improved as a result of the whole-class discussions. I discuss these findings and offer recommendations regarding the use of pre-recorded videos to support the development of pre-service teachers' PCK.

Keywords: pre-recorded teaching videos, pedagogical content knowledge, pre-service life sciences teachers, lesson planning

Introduction

Initial science teacher education programmes are confronted with the need to develop pre-service science teachers (PSTs) who possess a strong knowledge base for teaching (Rollnick & Mavhunga, 2016). In science education, there is an agreement that this base is Pedagogical Content Knowledge (PCK), which helps teachers plan and teach science effectively (Mapulanga et al., 2024; Ndlovu et al., 2025). Science education research has been focusing on various ways to develop both pre-service and in-service science teachers' PCK using content representations (Forsler et al., 2024; Hume & Berry, 2013). Hamel & Viau-Guay

(2019) reported that another way in which teachers can develop their PCK is through watching videos of their own teaching. The argument is that when teachers watch and reflect on a video of their own teaching practice, PCK development is fostered. However, many studies have focused on in-service teachers. The assumption underlying this focus is that, unlike PSTs, in-service teachers have already developed some knowledge and skills that enable them to dissect their practice when they watch videos of their teaching, and thus build on their existing knowledge of teaching. Hamel and Viau-Guay (2019) found in their literature review that 49.5% of studies on video use in initial teacher training reported PSTs watching their own videos, 33% examined videos of PSTs and their peers, and 16.5% focused on videos of unknown teachers. Furthermore, many of these studies focused on supporting PSTs' reflection about their teaching praxis as opposed to the development of PCK. In this study, I take the view that reflection on watching videos leads to the development of PCK. This study was about the development of PCK in pre-service Life Sciences teachers after their exposure to videos of another teacher teaching specific Life Sciences topics. I sought to address the following research question:

- What role do pre-recorded teaching videos play in developing pre-service Life Sciences teachers' Pedagogical Content Knowledge?

Literature review

Reflection as a way of developing PCK during lesson planning

The notion of reflection comes from Schön (1983), who argued that teachers are reflective practitioners and it then gained popularity in teacher education in relation to how PSTs can be taught to reflect (Kulgemeyer et al., 2021). In his model of pedagogical reasoning and action, Shulman (1987) considered reflection as a key component of teacher development. In initial teacher education, reflection bridges the gap between theory and practice, thus helping PSTs gain professional knowledge necessary for teaching (Kulgemeyer et al., 2021). Teachers can reflect during lesson planning about how to transform the subject matter knowledge as they consider appropriate strategies that they can use along with possible misconceptions that can arise. Thus, Rusznyak and Walton (2011) designed lesson planning guidelines that allow PSTs to reflect and develop PCK. It can be seen, therefore, that reflection is foundational to developing PCK (Carlson et al., 2019).

Using teaching videos as reflection tools

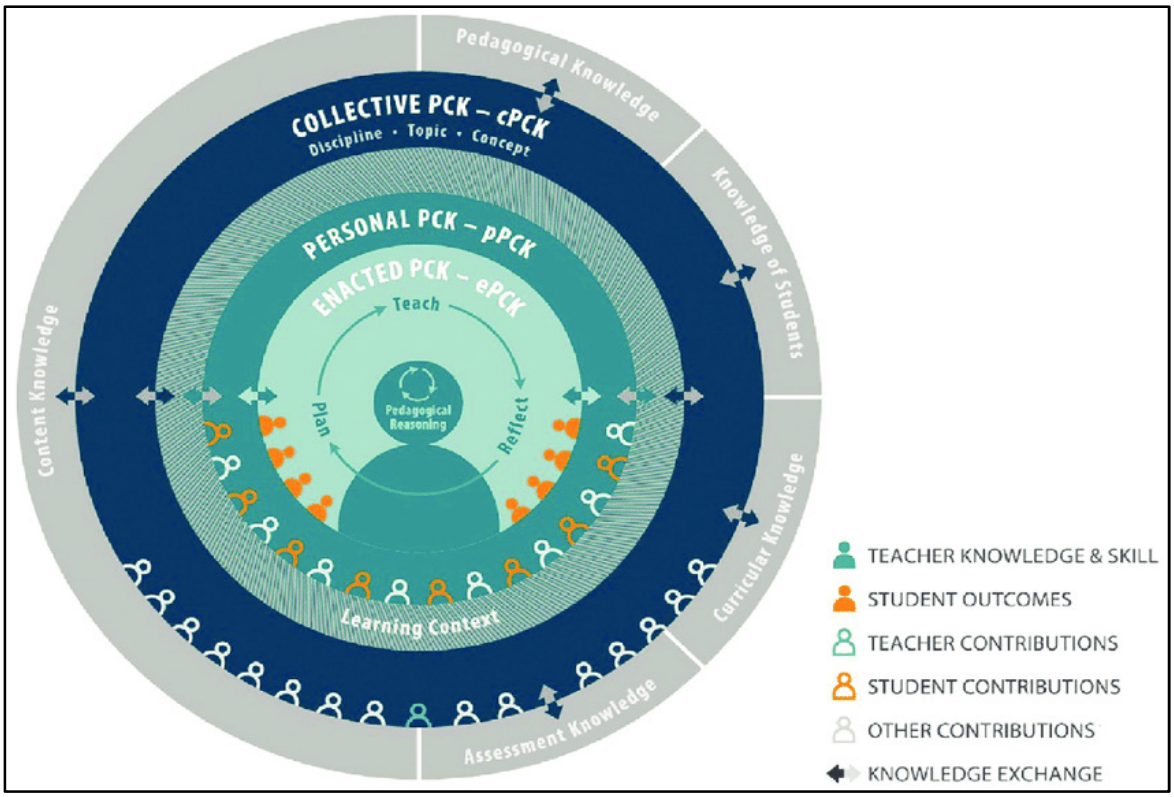
Research on using video-recorded lessons to enhance the professional development of PSTs has focused predominantly on recordings of their own teaching (see Allas et al., 2020). Such studies emphasise that such recordings help teachers reflect on specific elements of their practice, such as how they explain concepts. Although teachers can reflect on their own teaching videos, watching these videos with a mentor or colleague can also provide opportunities for feedback and collaborative reflection that could result in more insights. When teachers watch teaching videos, they observe aspects of teaching such as how

discussions are facilitated (Luft et al., 2024). Noteworthy is a component of professional vision described as a set of skills that teachers possess to notice certain events professionally and decide on how to act on these events using professional knowledge (Yang et al., 2019). However, according to Leijen et al. (2014), many PSTs feel anxious when they have to be video-recorded even though watching the videos will be exclusive to them. Chan et al. (2018) also found that PSTs experienced more negative emotions when watching their own videos than when watching those of their peers. Given these difficulties, I aimed, in this study, to explore how watching videos of an experienced teacher delivering specific topics can enhance the PCK of PSTs.

Conceptual framework

This study is framed within a PCK construct that was first conceptualised by Shulman (1986). In science education, PCK is defined by the integration of various knowledge domains like student' knowledge, subject matter knowledge, pedagogical knowledge, and knowledge of context. In 2019, a refined consensus model (RCM) of PCK was suggested by Carlson et al., (2019) (see Figure 1).

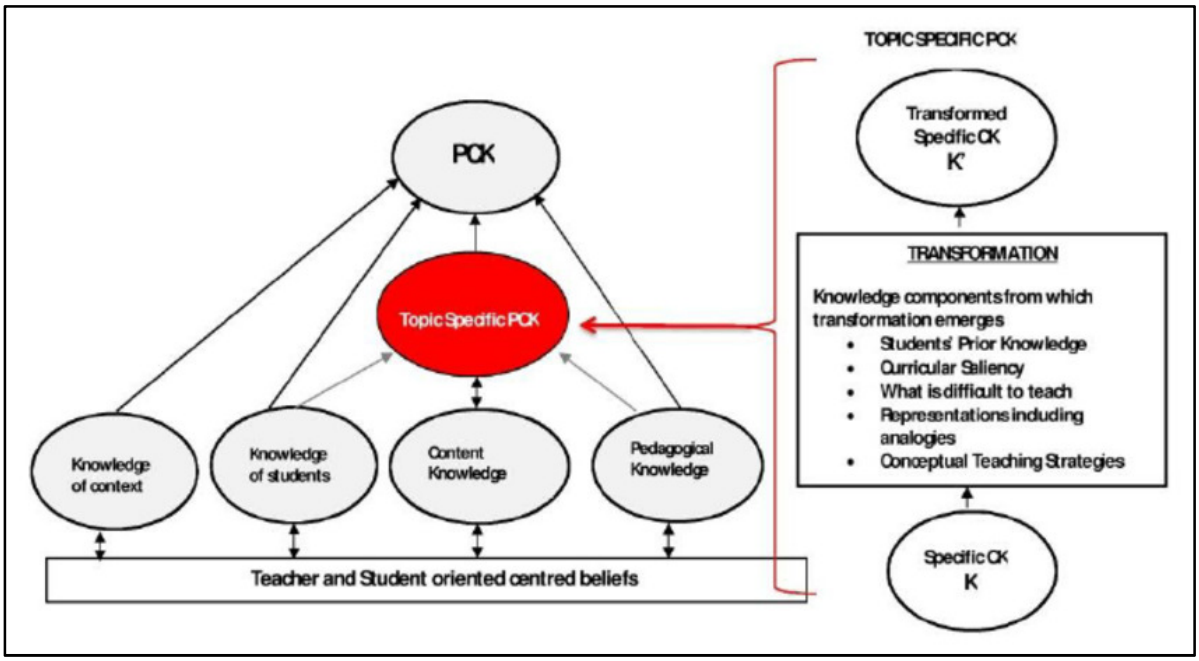
Figure 1
The Refined consensus model (RCM) of PCK (Carlson et al., 2019, p. 84)



From the outer edge inwards, the model shows five knowledge domains that are important for the development of teachers' PCK and that encompass content knowledge, pedagogical knowledge, student knowledge, curricular knowledge, and assessment knowledge (Carlson et al., 2019). This model shows three important aspects: realms of PCK; PCK grain sizes; and

the notion of pedagogical reasoning. The first realm is collective PCK (cPCK), which is gained through formal education. The second realm assumes that PCK can be personal (pPCK). This realm posits that PCK can be gained through experiences, thus making it tacit to an individual science teacher. The third realm is enacted PCK (ePCK), seen usually during the actual teaching. In this case, the ePCK was that of the experienced teacher. At the core of these realms is the assumption that pedagogical reasoning plays an important role as teachers plan, teach, and reflect on their practice, thus engaging in interplay between and among these realms. Pedagogical reasoning involves using knowledge of students' understanding of a particular concept in a specific context to inform decisions about teaching strategies (Shulman, 1987). In this study, I was interested in the second realm (pPCK) as I analysed the PSTs' lesson plans. The model also shows three-grain sizes of PCK. Grain sizes mean that PCK can exist at the discipline level, topic level, and concept level (Carlson et al., 2019). PCK at the topic level is explained by Mavhunga and Rollnick (2013). (See Figure 2.)

Figure 2
Model of Topic Specific Pedagogical Content Knowledge (TSPCK) (Mavhunga & Rollnick, 2013)



In the TSPCK framework, there are five components that teachers can use to transform content knowledge. The first is learner prior knowledge (LPK), defined as the knowledge, skills, attitudes, and values that students bring to the lesson. The second component is curricular saliency (CS), described as the teacher's understanding of the sequencing of topics and the prior knowledge necessary for students to learn the topic at hand. This also includes understanding the concepts that are core and those that are peripheral, as well as sequencing concepts and teaching processes in a single lesson (Mavhunga & Rollnick, 2013). Consideration of CS during lesson planning is seen in how the teacher decides to sequence the teaching of specific concepts in a single lesson (Khoza, 2024). The third component, what is difficult to teach (WD), comprises the teacher's knowledge of gate-keeping concepts in a specific topic as well as awareness of misconceptions that perpetuate the difficulties. The

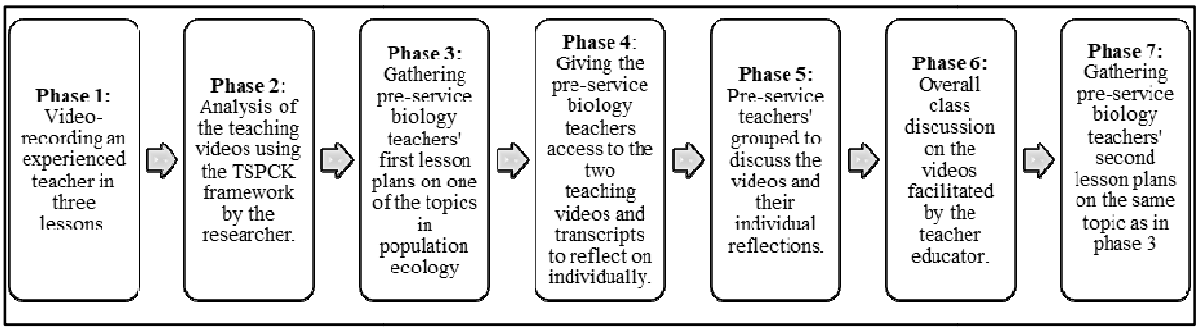
fourth component is representations (RP) encompassing the teacher's knowledge of appropriate analogies, models, and visual illustrations of a given concept that can be used to help students understand the topic and confront misconceptions that students may have (Mavhunga & Rollnick, 2013). The last component is conceptual teaching strategies (CTS), defined as techniques that are used to address specific learners' misconceptions and areas of difficulty. According to Mavhunga (2020), teachers' knowledge of this component emerges as a result of the interaction of the other four components. I adopted this conceptualisation in the sense that I analysed the CTS component by looking at the interaction of the other four components.

Methodology and design of the study

In this study I employed a qualitative case-study research approach guided by the interpretivist paradigm (Kivunja & Kuyini, 2017). This approach was applicable to describe the pre-service Life Sciences teachers' PCK. The participants consisted of one Life Sciences school teacher with 6+ years of teaching Life Sciences, one lecturer teaching a methodology module, and eight PSTs in that module. I conducted the study in a South African institution that follows a concurrent model where the PSTs complete both the content and methodology modules and graduate with a Bachelor of Education degree (see Khoza, 2022). Before this study, the PSTs completed a content module in which the topic of population ecology was dealt with. Therefore, it was assumed that the PSTs had the necessary subject matter knowledge on the topic.

I collected the data in a methodology module (following the content module described above) during the teaching of instructional design and lesson planning. The PSTs were exposed to the TSPCK framework as the knowledge base that should guide the transformation of the subject matter.[1] The study was designed to have seven phases (see Figure 3).

Figure 3
Phases of the study



In the first phase, three video recordings of an experienced teacher teaching population ecology to Grade 11 learners were collected. These teaching videos were then transcribed and analysed using the TSPCK framework in phase 2. In phase 3, the PSTs planned a lesson using the adopted RfLD guidelines on one of the topics in the two videos (Data Set 1). These

[1] The study was approved by the University of Pretoria, Faculty of Education Ethics Committee (Protocol Number: EDU029/21).

guidelines emphasise PSTs' pedagogical reasoning and are thus tools to evaluate teachers' PCK (Khoza, 2024). In phase 4, the teaching videos were given to the pre-service teachers together with the transcript to watch and reflect upon. The PSTs produced written reflections based on the question: "How did the teacher facilitate learning of the topics in each lesson?" (Data Set 2). In phase 5, the PSTs grouped themselves into three groups comprised of two or three individuals who were asked to discuss how the teacher facilitated learning in the three videos. These group discussions were audio-recorded and transcribed for analysis (Data Set 3). The discussions took 39 to 54 minutes. In phase 6, there was a whole class discussion on the videos facilitated by the lecturer. The whole class discussion took 1 hour and 48 minutes and was audio-recorded and transcribed for analysis (Data Set 4). In phase 7, the PSTs planned a second lesson considering what had transpired during phases 4, 5, and 6. Table 1 shows the PSTs' information.

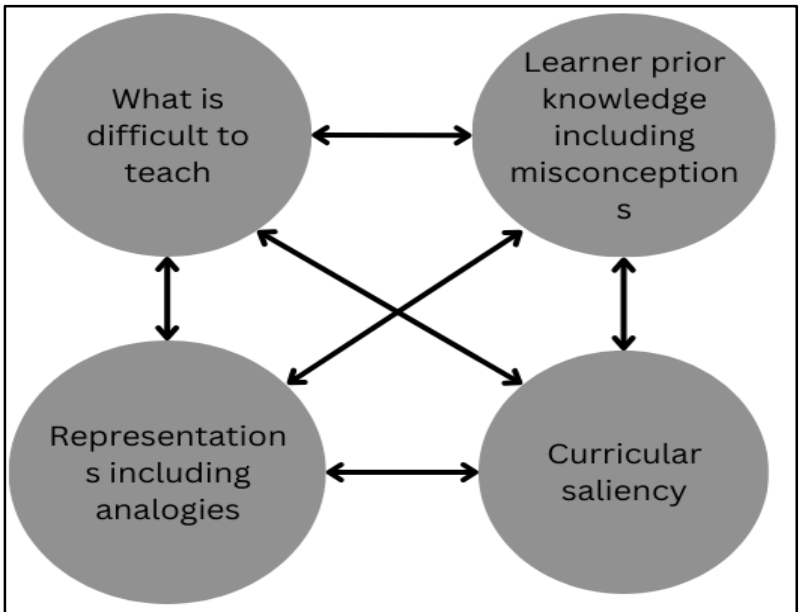
Table 1
Participating pre-service teachers' information

Pre-service teacher (Pseudonyms)	Gender	Lesson plan topic	Group
Tsibi	Male (He/his)	Predation and competition	A
Dodo	Female (she/her)	Geometric growth curve	
Meisie	Female (she/her)	Geometric and exponential growth curves	
Gregor	Male (he/his)	Predation and competition	B
Solanje	Female (she/her)	Calculating population sizes	
Peril	Female (she/her)	Predation and competition	
Anathi	Female (she/her)	Factors affecting population growth and population size	C
Dolly	Female (she/her)	Parasitism and mutualism	

The gender and pronouns of the PSTs are included since they were asked to thus identify themselves for reporting purposes.

The teaching videos were analysed to understand the ePCK of the experienced teacher. A rubric was adapted from Mazibe et al. (2020) to score the teacher's ePCK when teaching specific concepts (see Appendix A for the rubric). The results of this analysis are shown in Table 2. Before scoring the PSTs' knowledge of CTS, the other four components were mapped to understand their interactions. The mapping was informed by the approach of Mapulanga et al. (2024) in relation to analysing the nature of interactions among TSPCK components. Unlike Mapulanga et al. (2024), who looked at the interactions of the five components, I looked at the four components as illustrated in Figure 4. This is because, as argued in the TSPCK framework, the knowledge of CTS emerges from the interaction of the other four components (Mavhunga, 2020).

Figure 4
Possible interactions amongst TSPCK components to produce a conceptual teaching strategy



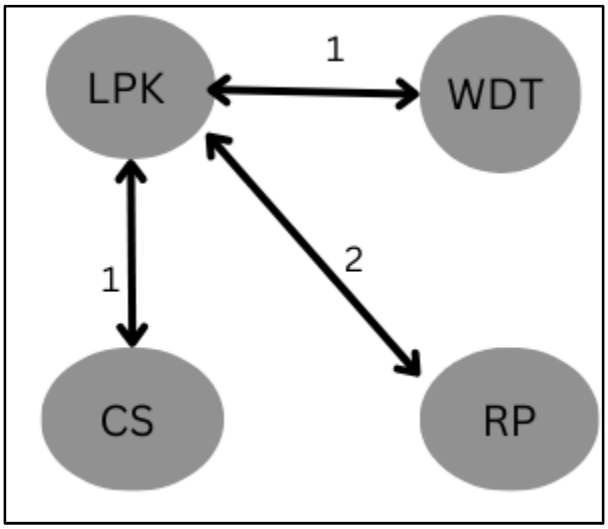
As can be seen in Figure 4, there are six possible interactions among the four TSPCK components. This was used as a basis for developing the criteria for conceptual teaching strategy in the two rubrics (see Appendices A and B).

Table 2
The experienced teachers' ePCK as revealed in the three videos

Teaching video	LPK	CS	WDT	RP	CTS	Proxy Score
1. Introduction to population ecology	3	3	4	4	3	*4*
2. Exponential and logistic growth models	4	4	3	4	3	*4*
3. Social interactions in the environment	4	3	3	4	4	*4*
Component proxy score	***4***	***3***	***3***	***4***	***3***	

As can be seen in Table 2, the average score in the last column and row shows the calculated scores of each component to stand as a proxy for the quality of each TSPCK component and individual lessons. In the first lesson, an analysis of the video shows that the teacher sought LPK, identified gate-keeping concepts, and used CTS revealing a proxy score of 4 (exemplary PCK). The same finding was observed in the second and third lessons during which the teacher used various representations while drawing from LPK and RP. Figure 5 shows an example from the second teaching video.

Figure 5
Components' interactions in the teacher's second lesson



The figure on the arrows shows the number of interactions observed between the two components. There were two unique interactions during which the interaction between LPK and RP was repeated twice. The teacher sought LPK by asking them the question, "What do you know when they say something is growing exponentially?" As learners responded, the teacher then went on to show the two graphs of population growth as well as their formulae, numbers, and symbols on the axes (revealing the use of a diagram and symbols as representations). However, the teacher also noted that learners do not need to know the formulae at their level. During the whole-class discussion, the teacher asked questions about possible examples for each model and then displayed a simulation with examples to show how these models happen in real life.

To analyse the PSTs' lesson plans, I adapted a rubric from Khoza (2024) for assessing teachers' PCK shown in Appendix B. Similar to the teaching videos, to score the lesson plans for conceptual teaching strategies, I used the PCK mapping approach. To analyse the PSTs' written narratives, group discussions, and whole class discussions, I employed both narrative analysis and analysis of narratives (Stephens & Breheny, 2013). Narrative analysis involves telling the story of the participants. In this study, these stories were about their reflections on the teaching videos and how this influenced their lesson planning. During an analysis of narratives, they are transformed in light of theoretical perspectives in relation to patterns. Both approaches were used to analyse, interpret, and reveal the kind of knowledge (in terms of PCK) that the teachers gained from the teaching videos.

Findings

Below, I show the PSTs' pPCK scores before and after being exposed to the teaching video.

Table 3
PCK scores from the pre-service teachers' first and second lesson plans

Pre-service teacher	**PCK scores in lesson plans 1 and 2**					
	LPK	**CS**	**WDT**	**RP**	**CTS**	***Proxy Score***
Tsibi	2	1	2	2	1	*1*
	4	3	3	4	3	*3*
Dodo	2	2	2	3	3	*2*
	4	2	3	3	4	*3*
Meisie	1	2	1	2	1	*1*
	3	3	2	3	2	*3*
Gregor	2	2	1	1	1	*1*
	3	3	2	3	3	*2*
Solanje	3	1	2	3	2	*2*
	4	3	3	3	3	*3*
Peril	2	2	2	3	3	*2*
	3	3	2	3	3	*3*
Anathi	3	2	2	2	2	*2*
	4	3	3	3	3	*3*
Dolly	2	2	2	3	2	*2*
	4	3	3	4	3	*3*
Component Proxy score	***2***	***2***	***2***	***2***	***2***	***2***
	3	***3***	***3***	***3***	***3***	***3***

As can be seen in Table 3, there is a variation in terms of scores for each component in the PSTs' lesson plans before and after exposure to the teaching videos. The main noticeable difference is that none of the PSTs revealed exemplary PCK in any of the components. In terms of LPK, the average proxy score improved from 2 (resembling a basic knowledge of LPK) in the first lesson plans to 3 (resembling developing LPK) in the second lesson plans. Anathi and Dolly moved from basic knowledge of this component to exemplary. Meisie had not considered LPK in her first lesson but showed developing PCK in terms of this component. Regarding CS, Tsibi and Solanje scored 1 and then 3 in their second lesson plans after watching the teaching videos. Other PSTs like Peril and Gregor moved from a score of 2 to 3 revealing that they gained knowledge of CS after engaging with the videos. Regarding the consideration of WDT, the PSTs showed basic and limited knowledge. All the PSTs showed some knowledge of RP except Gregor. This is noticeable from their scores of 2 or 3.

However, this improved in their second lesson plans with scores of 3 and 4. Since CTS is dependent on the other four components, all the PSTs scored 1 or 2 except Dodo and Peril who scored 3 in their first lesson plans. As with the other components, their knowledge of this component improved in the second lesson plan (see Table 3). Below, I describe how the pre-recorded videos helped the pre-service teachers improve their knowledge of the TSPCK components using data from their lesson plans, group discussions, and whole-class discussions.

During the group discussions, the groups leveraged teacher-learner interactions to notice and reflect on the possible LPK and WDT. The following discussion transpired during the Group A discussion.

> **Tsibi**: Did you guys notice something about the teacher interacting with the learners?
>
> **Dodo**: Like how? *Mina ngithe* (I said) the teacher entertains learners' answers for the questions he asks . . . there was a lot of interaction [Referring to her individual reflection].
>
> **Meisie**: Yes, it was a way of correcting their misconceptions like when one learner said we a population can increase forever . . .
>
> **Tsibi**: Yes. . .I think it was in the second video and the teacher seemed surprised.
>
> **Meisie**: Is that a misconception though because the way he looked at those learners. . . but he clarified this.

In this excerpt, the three PSTs discussed how they were able to realise a possible misconception from teacher-learner interactions. The discussion led Tsibi to note this possible misconception and other aspects of LPK. In his second lesson, Tsibi identified the misconception that "a lot of people think that the population can increase without any consequences." This was also supported by his utterances during the whole class discussion where he said, "In the second video, I saw the teacher asking learners a question of what will happen if a population continues to increase and many of the learners said nothing will happen . . . this is a misconception." This showed how the video helped him to identify the main misconception that could impact his teaching of competition. He further stated, "I think competition can be seen by learners as an interaction that emerges without prior factors like lack of shelter and food." In her first lesson plan, Meisie did not outline any possible misconceptions regarding the topic of models of population growth. However, in her second lesson, she noted, "Learners might think because some organisms reproduce quickly, their population increase will continue increasing exponentially." During the whole class discussion, she stated, "The teacher did not deal with the uncertainty of why populations that grow exponentially crash . . ." Meisie here critiqued the teacher, and this led her to thinking about LPK in planning her lesson. This was supported by Anathi (who showed developing PCK in terms of LPK) by stating that "the teacher could have used an example to show

learners examples of what they see in real life instead of using just an example of bacteria." In this way, Anathi was able to notice that the abstract nature of an example of bacteria may have been difficult for learners to grasp and understand why populations do not increase indefinitely.

Not only were the PSTs able to gain LPK but also aspects of WDT. Gaining this knowledge was seen during the whole class discussion.

> **Lecturer:** I want us to reflect on the third video. What do you think of how the teacher taught?
>
> **Gregor:** I saw the teacher continuously emphasizing the difference between how it is important to view social interactions holistically.
>
> **Lecturer:** And what is your take on that observation?
>
> **Dolly:** Can I say something here? Is it not that maybe he was deliberate? I mean when he started, he said the topic is easy but a bit challenging . . .
>
> **Gregor:** If I was a learner, I would study these interactions one by one . . .
>
> **Solanje:** I also noticed that . . . I wrote it here . . . in the second lesson that the teacher in the video said to learners they need to understand the basic shapes of the graphs before.
>
> **Lecturer:** So, how is that important for us as we plan our lessons?
>
> **Gregor:** Do we need to emphasise such to our learners when we teach?
>
> **Meisie:** It also seems like the teacher thought about these before going to teach and this goes back to the issue of lesson planning.

In the extract above, the lecturer facilitated the PSTs' reflections on the videos by posing an open-ended question. Gregor outlined what he noticed from one of the videos with the support from his fellows like Solanje who noted another incident in the teacher's second lesson. The lecturer also facilitated the PSTs' noticing in the sense that they were able to translate this into their practice of lesson planning while considering the knowledge of WDT. The results of this are seen in Gregor's PCK scores from 1 to 2 in terms of this component. Meanwhile, in his second lesson plan, Gregor wrote, "I will first ask learners the relationship between predation and competition." He further noted that learners may see predation and competition as two separate concepts. He was, therefore, able to show some knowledge of WDT. Solanje also improved her lesson plan after noting a possible challenge of learners making sense of the graphs as models.

The PSTs relied on the nature of learning activities as well as the teacher's explanations in the teaching videos to develop their knowledge of CS. An example of this is seen in Group C's discussion.

Anathi: This teacher knows his story . . . the teaching was coherent . . . from one concept to the other.

Dolly: Yeah, I agree with you . . . you can see how he moved from one topic to the next and also used what he covered in the previous lesson . . .

Anathi: . . .each activity was based on one concept in that topic . . . he would teach about density and then give learners an activity

Dolly: I think that is what sir wants us to do in the lesson plan . . .

Anathi: Yes, also when you have to decide what you teach first. . .like the sub-topic of this lesson and the one after . . . I thought you just get that from the curriculum.

Dolly: . . . you can use the curriculum to get the content then decide how you teach that and what follows what.

What is observable in the above extract is that Anathi and Dolly noticed the coherence not only of topics but also of the activities versus concepts in a single lesson. In addition to Anathi's and Dolly's gaining the knowledge of CS through reframing what they noticed during individual reflections, Dodo also showed that she had developed this knowledge from the whole class discussion. She indicated that she would teach competition and predation before the models of population growth in the first lesson plan. However, in her second lesson plan, she changed to teaching the models of population growth before predation and competition. In her narratives, she said, "I realised that the teacher used the concepts of carrying capacity and environmental resistance when teaching competition . . ." in her arguing that the concepts of carrying capacity need to be taught first since this has implications for learners' understanding of some phases of the geometric growth pattern. Meanwhile, in the teaching videos, when teaching models of population growth, the teacher said to learners, "Carrying capacity will make more sense when we do social interactions." It can be said, therefore, that Dodo leveraged this to think of the sequencing of topics.

Throughout the videos, the teacher used a variety of RP (see Table 2). PSTs used what they observed in the videos to think of possible RP for their lessons. This was a result of the lecturer's facilitation during the whole class discussion.

Lecturer: I want us to focus on the representations that the teacher used . . .

Anathi: For me, I was able to see a lot of representations . . . I think the teacher did well here.

Peril: I agree. I got some pointers on what I can use . . . the teacher used the graph of the predator-prey relationship which worked nicely because learners could see the fluctuation of the two animals.

Lecturer: Did it work in helping learners understand the relationship?

Tsibi: I think it worked . . . but what happens when you are teaching in a school that does not have a projector to show slides?

Lecturer: Why are you asking that question?

Tsibi: I might teach in a rural school and they might not have a projector.

Lecturer: Yes . . . so what would you do?

Tsibi: . . . that's difficult with examples maybe draw a similar graph on the board? Or I can give them a table with the changing numbers of predator and prey over time and ask them to draw the graph . . .

Dolly: Yeah . . . I like that. Also, learners will be involved in the lesson.

As can be seen in the extract above, the lecturer focused the PSTs' attention on the teacher's use of RP. This led to Peril's sharing of what he noticed in the videos in terms of the kinds of representations used by the teacher. The lecturer's question sparked the PSTs to reflect on their future context (the case of Tsibi). In this way, the PSTs were able to envision their future teaching contexts in terms of the representations they would use. Meanwhile, Tsibi had identified his approach to using RP in his second plan. In the discussion, Anathi said that he planned to use concept maps to help learners see the connections between concepts. However, this was different from what the teacher used in the videos. The teacher used mind maps. Anathi wrote, "Mind map[s] helped the learners to grasp the content, but I would use concept maps to show them links . . ." This is an indication that Anathi got some ideas on possible RP that can be used to teach about factors affecting population growth.

Although the teacher showed developing knowledge of CTS, a notable finding in group discussions is that the PSTs talked about various teaching strategies that the teacher used instead of noticing how these strategies were used while drawing from the other components. An example of this discussion comes from Group B.

Peril: What I liked about the second video is that the teacher questioned learners a lot . . . At some point, I thought he was wasting time but I later saw that he was driving learners to discover certain things.

Gregor: I also noticed that in the second lesson where he kept on questioning a group of learners.

Peril: Guys . . . did you see the third lesson? It was more learner-centred.

Solanje: Yah . . . I would say it was an inquiry-based lesson . . . but he was also explaining some concepts.

Peril: He also gave learners an activity . . . I liked that because learners take ownership of their learning.

Gregor: I think he also had a worksheet that learners did after introducing a concept . . . that was cool.

Solanje: For me, that is a good strategy because learners do most of the work when you, as a teacher, become a facilitator.

Peril: His slides had a lot of diagrams instead of a lot of text . . . I think learners enjoyed this.

In the extract above, the PSTs seem to have noticed various teaching strategies like explaining, questioning, and demonstrating using diagrams. However, what they did not notice, even in their reflections, was how the teacher showed evidence of drawing from the other TSPCK components. Through the lecturer facilitating whole-class discussion, the PSTs started to look for the *hidden* instances where the teacher drew from the other four components to explain a concept while involving learners. The following excerpt reveals what transpired during the whole class discussion.

Lecturer: I saw a lot of questioning in the videos. Can we reflect a bit on that?

Peril: Yes, we talked about in our group how the teacher facilitated learning by asking a lot of questions.

Lecturer: Can you give us an example?

Peril: Like in the first lesson, he would give learners a picture and ask them to say something about the picture . . .

Lecturer: Anything else that he did following up on that question?

Silence

So, maybe let us look at the transcript of the third lesson. I want you to outline what the teacher said or did besides asking the question.

Dolly: Sir, what I see here is that with some questions, especially at the beginning, it seems like he was trying to get what learners know already.

Lecturer: Yes, that is a good observation . . . and how did he do that?

Dolly: He also showed them a graph of the geometric curve . . .

Peril: If you are referring to the second transcript, there was a point where he said "I want you to look closely at this graph and compare it to this other one" (referring to the exponential model).

Tsibi: And a learner asked a question and he did not answer . . .

Lecturer: Okay . . .why do you think he did not answer? What did he say?

Tsibi: The question was about carrying capacity, and he said to learners "You will see how carrying capacity is important to understand especially when we will talk about competition" . . . To me, it seemed like he did not want to talk about competition because it was the focus of the coming lesson.

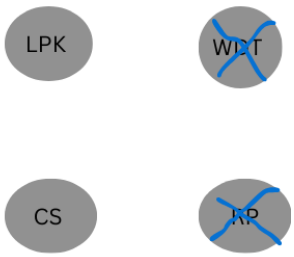
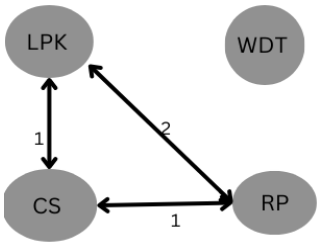
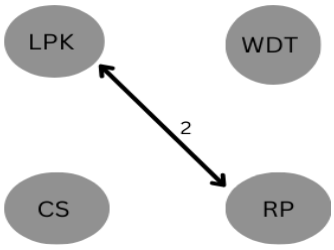
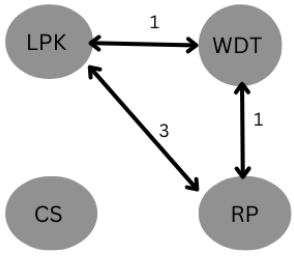
Lecturer: Remember the conceptual teaching strategy?

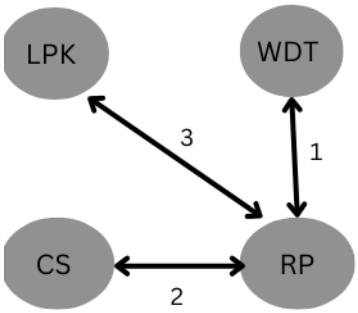
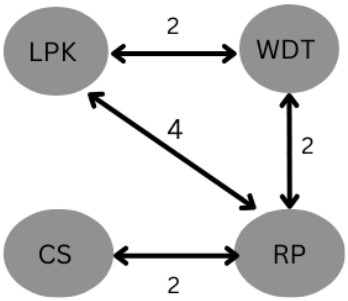
Dodo: . . . it makes sense now . . . but it would be difficult to anticipate the questions that learners would ask.

Tsibi: I think the important thing here is he asked questions to get their prior knowledge but still made them aware of concepts that will follow . . .

The excerpt from the whole class discussion above reveals the PSTs engagement with some of what the teacher did. The engagement was opened by the lecturer with a question that sparked Peril to remember that they talked about questioning in their group discussion. This then resulted in other PSTs joining the discussion where the lecturer helped them to see more features of the extract they were talking about. This discussion led to the PSTs improving their knowledge of CTS in their second lesson plans. Table 4 shows an example of two PSTs' knowledge of CTS in the first and second lesson plans.

Table 4
Improvement of pre-service teachers' knowledge of CTS

Pre-service teacher	Lesson plan 1	Lesson plan 2
Gregor		
Dolly		

Pre-service teacher	Lesson plan 1	Lesson plan 2
Dodo		

Initially, Gregor had planned to seek LPK by asking them the question "Why do you think animals would compete?" However, he did not state what else he would do. In the second lesson plan, he stated, "I will show learners a diagram of two animals 'fighting' and ask learners the question 'Why do you think the animals are fighting' and then outline the difference between intra- and interspecific competition." Here, Gregor drew from LPK, CS, and RP. In the lesson steps, he wrote, "Learners think that competition of organisms in a population does not end . . . I will use a simulation to show how it affects population size." In this case, LPK and the use of a representation different from the first one were considered, thus producing a CTS to explain the concept of competition. According to Gregor, how the teacher drew from representations that were used in the second video gave him ideas about how he can integrate them when seeking LPK. Dolly, however, had only considered one aspect of learner prior knowledge (that learners might know the term mutual relationship) and planned to use an example from their everyday lives (RP). In her second lesson plan, she drew from various aspects of LPK like a misconception that parasitism is bad for the environment (LPK). Furthermore, she considered the concepts of harm and gain as difficult to teach and suggested drawing from a diagram of interdependence in ecosystems (RP) to explain how parasitism is important for maintaining equilibrium in the ecosystem. This was made possible from watching the videos. As she said, "I saw how the teacher drew from what learners have done in the lower grades on ecosystems . . ." Dodo improved her knowledge of CTS as seen in Table 4. Her score improved from 3 to 4 as a result of showing more integration of different TSPCK components.

Discussion

The PSTs' knowledge of LPK and WDT improved from the first to the second lesson plans. This improvement is attributed to their ability to notice (Luft et al., 2024) and individually reflect on how these knowledge components were enacted in the teaching videos. In a study conducted by Sonmez and Hakverdi-Can (2012), beginner teachers put little or no emphasis on the students, their behaviour, or on interactions between them and teachers. However, the current study revealed that it was through looking closely at the interactions between the teacher and his learners that they were able to notice how the teacher worked with LPK. Although this is the case, previous literature on the use of pre-recorded videos has advocated

for watching one's own teaching to foster noticing and professional knowledge for teaching (Allas et al., 2020; Luft et al., 2024). This is because, when teachers watch their own teaching videos, they can reframe their understanding of what effective teaching entails, thus questioning their beliefs and actions. In this study, I argue that this can still be done when PSTs watch teaching videos of other experienced teachers. The current study has shown that when the PSTs were reflecting individually, they were able to put themselves in the shoes of the teacher and began to think about how the teacher's practices translated into their understanding of science teaching, thus, their development of pPCK.

Although literature advocates that PSTs have to watch their own teaching videos, other scholars have argued that they may not have developed a sense of looking at practice with a critical eye because they experienced discomfort (Lepp et al., 2023) unlike experienced teachers who can use their pPCK gained through experience (Yang et al., 2019). However, Seidel et al. (2011) found that teachers who watched their own teaching videos activated professional vision as a result of immersion, resonance, and motivation. The PSTs in this study showed the capability of noticing because videos of someone else's teaching provided a standpoint to question the already perceived knowledge of what science teaching entails. The resonance and motivation can still be fostered by PSTs observing the teaching of others. This immersion might have been a result of the PSTs having no fear of judging themselves or of being judged. A mere observation of a video from the lesson may not necessarily lead to desirable results and improved practice accountability. However, in this study, the video observation helped PSTs notice specific events that were important to the lesson, even if they had not been instructed to focus on particular events.

Through discussions in groups based on individual reflections on the teaching videos, the PSTs began to notice other things that they did not notice before, thus developing their pPCK as can be seen in the second lesson plans. Lepp et al. (2023) suggested providing PSTs with the experience of video reflection using a more supportive pathway. In this study, this supportive pathway was attained by group discussions as well as whole-class discussions with the lecturer. Although the teacher's enacted PCK was classified as developing and exemplary in the three lessons, there was room for improvement as PSTs reflected on the videos. This was evident in the PSTs' reasoning for the selection of representations and strategies for teaching population ecology. The teaching videos were prompts for PSTs to "envisage possible future teaching contexts," thus improving their pPCK from the first to second lesson plans especially with the selection and use of suitable representations which are significant in science teaching (Mavhunga & Rollnick, 2013). Furthermore, the group discussions prompted the PSTs to revisit the videos and transcript and begin to consider aspects of practice from different perspectives.

What was interesting in this study is that during individual and group reflections, the PSTs noticed only how the teacher used various generic teaching strategies. They were not able to recognise how the teacher drew from other TSPCK components to reveal the use of CTS. Knowledge of CTS is one of the knowledge components that is difficult to attain (Khoza, 2024; Ndlovu et al., 2025). Data from whole class discussions revealed that noticing was

fostered leading the PSTs to reframe their perceptions about teaching regarding the use of CTS. In their second lesson plans, the PSTs' knowledge of CTS improved as a result of seeing how the teacher drew from various components of TSPCK. Although the PSTs did not show exemplary knowledge of CTS, the scores moved from limited/basic to basic/developing. An important observation here is the role of the lecturer who facilitated the discussion to focus the pre-service teachers' attention on significant events in the videos.

Conclusions, limitations, and recommendations

I have demonstrated an approach to using pre-recorded teaching videos to develop pre-service teachers' PCK outlined in the steps below.

- Step 1: Providing the PSTs with the teaching videos (including transcripts) to go over on their own. This provides the PSTs with an opportunity to question their beliefs and assumptions using the little professional knowledge they have.
- Step 2: Grouping the PSTs then allows them to share their observations of the videos. This allows them to reframe what they have noticed individually in light of their peers' observations, thus questioning their knowledge collectively.
- Step 3: Discussing the videos with the PSTs during the whole class discussion further allows the PSTs to reframe what they notice about what they plan to teach. The exchange of ideas in an argumentative manner provides the PSTs with an opportunity to begin seeing their future context. Furthermore, the more knowledgeable other (the teacher educator) plays a major role in facilitating this reframing process.

This study contributes to the existing literature on the development of PSTs' PCK using pre-recorded videos in two ways. First, when using the videos of an unknown teacher, PSTs seem to be able to dissect the practices, question their assumptions, and reframe their understanding. Second, this study demonstrates that beyond individual PSTs' reflections on the video, further development of their PCK can be attained by engaging in collaborative discussions that foster intersubjectivity. Therefore, showing PSTs' videos of real-time teaching should be embraced in initial teacher education programmes such that they can start to envisage their future teaching context as well as gain the knowledge for teaching. One of the limitations of this study is that the pre-recorded teaching videos came from an experienced teacher who showed strong ePCK on all the topics they taught. This might have skewed the results in the sense that the PSTs might have focused on good teaching practices. PSTs might be given teaching videos where the teacher shows basic PCK to understand what they notice and how this leads to an improvement in their PCK. Second, data on the teacher's pedagogical reasoning regarding the decisions taken was not generated. Given this limitation, I, therefore, ask about the role of the teacher's pedagogical reasoning on the PSTs' development of PCK.

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Appendix A

Rubric for scoring the quality of ePCK in teaching videos

TSPCK component	Limited	Basic	Developing	Exemplary
Learner prior knowledge	No facilitation of discussions that expose learners' misconceptions. Learners are spoon-fed with the necessary prior knowledge.	Facilitates discussions that expose learners' misconceptions. Confronts some of them by providing standardised definitions.	Facilitates discussions that expose learners' misconceptions. Confronts most of them by expanding and rephrasing further.	Exposed learners' misconceptions through discussions Confronts all of them by expanding and rephrasing further. Confirms learners' understanding.
Curricular saliency	Explains irrelevant concepts. Leaves out important concepts in the topic. Sequencing of all key ideas is illogical. The interconnections between concepts are not explained.	Relevant key ideas are discussed but not given attention equally. Sequencing has illogical placing of most of the key ideas. Explains the interconnection between some concepts.	Relevant concepts are explained and given enough attention. Most of the key ideas are sequenced logically. The interconnection between most concepts is also logical.	Explains concepts giving them the attention they deserve. All concepts are sequenced logically, in the order of importance. Also explains the interconnections between all concepts.
What is difficult to teach?	No evidence of ideas that are difficult to teach. Identified difficult concepts are not confronted or are confronted incorrectly	Facilitation of discussions that reveal difficulties. No expansion of explanations of the difficult concepts.	Facilitation of discussions that reveal difficulties. Teacher expands on the explanation of difficult concepts.	Facilitation of discussions that reveal difficulties. Confrontation starts from gatekeeping concepts and concepts are expanded. Teacher confirms learners' understanding.
Representations including analogies	There is no use of representations. The teacher only relies on the verbal talk when teaching.	Uses one relevant representation. The representation is used in passing without learners engaging learners in scientific ideas.	Uses at least two relevant representations and engages learners when using these representations	Uses three or more relevant representations and engages learners when using these representations.
Conceptual teaching strategies	No evidence of interactions among the four individual TSPCK components.	Evidence of at least 2 interactions between the four TSPCK components.	Evidence of at least 3 interactions among the four TSPCK components.	Evidence of at least 4 interactions among the four TSPCK components.

Appendix B

Rubric for scoring the quality of pPCK in lesson plans

TSPCK component	Limited	Basic	Developing	Exemplary
Learner prior knowledge	No identification/ acknowledgement of learners' prior knowledge and/or misconceptions.	Identified possible learner prior knowledge, one major misconception, and other minor misconceptions.	Identified possible prior knowledge, two major misconceptions, and other minor misconceptions.	Identified possible prior knowledge, three or more major misconceptions, and other minor misconceptions. Reasons for relevance of prior knowledge are compelling.
Curricular saliency	Identified irrelevant sub-topics. Illogical sequencing of concepts and/or teaching and learning activities.	Identified relevant sub-topics. The reasoning of the interrelatedness between sub-topics, concepts, and teaching and learning activities is clumsy. The teaching and learning activities are not scaffolded.	Identified relevant sub-topics sequenced logically. Reasoning for the interrelatedness between concepts is evident in the teaching and learning activities and includes scaffolding.	Identified relevant sub-topics logically. Concepts and teaching and learning activities are sequenced logically. The indication of the interrelatedness among concepts is adequate.
What is difficult to teach?	No indication of concepts/ ideas that are difficult to teach. Reasons for the difficulty or gate-keeping concepts are not specified.	Identified broad concepts as difficult. Reasons for the difficulties are provided but not specific to the key ideas.	Identified specific concepts as difficult. Outlined reasons related to learners' common difficulties.	Evidence of activities to expose learners' misconceptions and difficulties. Confrontations of difficulties and misconceptions evident. Indication of how some key ideas will be explained and interrelated. Representations identified to explain concepts in general. There is evidence of learner involvement.
Representations including analogies	Representations not identified.	Identified a relevant representation. No reasoning regarding how the representation works and which concepts it supports.	Identified at least two relevant representations. Reasoned how the representation supports the explanations of concepts.	Identified a variety of relevant representations with reasons on how the representations support the confrontation of misconceptions and difficult concepts.
Conceptual teaching strategies	No evidence of interactions among the four individual TSPCK components.	Evidence of at least 2 interactions between the four TSPCK components.	Evidence of at least 3 interactions among the four TSPCK components.	Evidence of at least 4 interactions among the four TSPCK components.