DEVELOPING PRESERVICE SCIENCE TEACHERS' PEDAGOGICAL CONTENT KNOWLEDGE THROUGH REFLECTION ON LESSON PLANNING

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Abstract

Reflection is one of the subjects most discussed in teacher development. Despite its importance in improving teacher practices, reflection has been found to be contentious amongst teachers who battle with high workload and the need to complete the curriculum in time for examinations. Thus, said reflection can be viewed as a chore to most teachers particularly preservice teachers who not only need to master the pedagogical knowledge and subject matter knowledge but also classroom management techniques amongst other skills. The current paper reports on a study on how lesson planning was used as a tool to develop preservice teachers' pedagogical content knowledge through reflection. In a qualitative case study, 50 Bachelor of Education Life Sciences students in their final year of study were each tasked to identify their 'best' lesson plan and 'worst' lesson plan and critically reflect on why they considered the lesson plans that way. These lesson plans had been designed and taught in schools during schoolwork experience (herein referred to as work integrated learning (WIL) in the first half of the year. Data was obtained from each participant's submission of the two lesson plans and the reflection, which were then subjected to content analysis. The following aspects about lesson planning were considered: knowledge of the content to be taught, knowledge of the learners including classroom context, formulation of objectives, designing of teaching and learning strategies and activities, assessment opportunities, planning for technology use, and the student's ability to realise good and bad practices in lesson planning. Thereafter they were tasked to plan and teach in their last seven weeks of WIL. The findings showed how the preservice teachers were determined to improve their lesson planning as they included in their reflections how they could plan and teach the same lesson differently including the so-called best lesson plan. Preservice teachers used words such as deficit, unstructured, misaligned, unattainable, not well thought out, to critique their lesson plans. Creativity as an aspect of the teacher skills set was evident in the way these 21st century teachers conceptualised how science should be taught. There were however some who failed to identify obvious weaknesses or strengths in their lessons plans, which showed stagnancy in development. The findings provide implications for teacher professional development practices.

Keywords: *Lesson planning, pedagogical content knowledge, pre-service science teachers, reflection.*

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1. Introduction

The current study was aimed at improving pre-service life sciences (biology) teachers' personal pedagogical content knowledge (pPCK) through reflection on lesson planning. It was informed by the proposal by Alonzo, Berry, and Nilsson (2019) that transformation of pPCK into enacted pedagogical content knowledge (ePCK), and the reverse occurs throughout the plan-teach-reflect cycle. Planning lessons is viewed as a ubiquitous practice that produces important artefacts for effective teaching (Minken, Macalalag, Clarke, Marco-Bujosa, & Rulli, 2021). Minken et al. (2021) pointed out that the designed lesson plans are "windows into teachers' PCK" (p. 120). Hence analysis of lesson plans for evidence of PCK development can be done (Magnusson et al., 1999). In that respect teachers' well-developed PCK increases teachers' capabilities to improve students' learning (Bayram-Jacobs et al., 2019), and their instructional planning will reflect efforts to scaffold and support learners' conceptual understanding and development of skills. Well-designed lesson plans help teachers to reflect on the scaffolding strategies that help learners' conceptual understanding of science concepts. Consequently, the current study sought to answer the research question: How can lesson planning be used as a tool to develop preservice science teachers' pedagogical content knowledge through reflection?

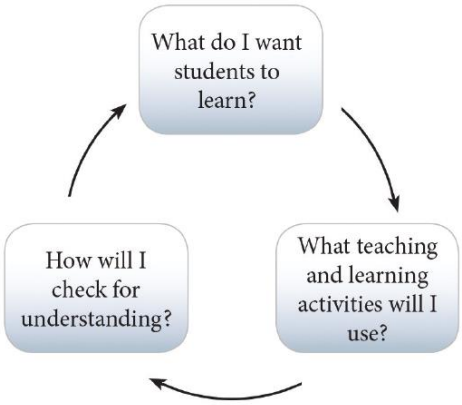
2. Literature review

The study was underpinned by the Refined Consensus Model (RCM) of PCK (Carlson & Daehler, 2019). In this model there is collective PCK (cPCK) which refers to the published and documented experiences of practitioners, in this case biology teachers, which informs the professional way of teaching the subject (Behling, Förtsch, & Neuhaus, 2022). These authors pointed out that when a teacher is confronted with cPCK during preservice teacher development, through engagement with content materials taught, interaction and communication with lecturers and colleagues, they integrate it internally into their own pPCK based on how they understand and experience. ePCK is developed through teachers' application of pPCK as they select teaching strategies, teaching materials and tasks to structure the learning process.

ePCK only occurs in action and is unique and cannot be repeated. As such, Alonzo, Berry and Nilsson (2019) differentiated between three steps of teaching which are: 1. A teacher plans own lesson and hence generate ePCK (Planning); 2. The teacher then teaches the learners in class using the lesson plan and ePCK (Teaching) is generated; and 3. The teacher reflects on the taught lesson and generate ePCK (Reflection). It is through this reflection that the teacher improves on the planning of the next lesson. This is called the Plan–Teach–Reflect Cycle of ePCK (Alonzo, Berry, & Nilsson, 2019). Because PCK influences learning and learning outcomes, examining developing teachers' PCK is pertinent and is an agenda for many education systems (Guerreiro, 2017).

Planning lessons "is an essential part of education and indicates the path teachers will follow throughout a lesson." (Contreras et al., 2020, p.1). Planning for effective teaching can be daunting for upcoming and novice teachers as it requires continued practice and deep critical reflection on how the teacher would conduct the lesson and how learners would respond. In the current study the author conceptualises reflection in line with Dewey's (1938) as a process of making meaning, and as an organised process where one engages in thinking due to interaction with others. Reflection plays a critical role in developing teachers' capabilities in active decision making as they identify and select appropriate instructional strategies (Borg, 2003). Reflection enables the teacher to gain insights based on experiences and learning from practice (Finlay, 2008). According to Finlay (2008) this happens when a teacher becomes self aware and critically evaluate own responses to practical situations. In the context of lesson planning, such a process is illustrated in Figure 1.

Figure 1. Key components of lesson plan design (Fink, 2005).



3. Methodology

The study followed a qualitative case study research design (Creswell, 2014). The design helped the participants to articulate their reflections based on their experiences and the context within the institution they were studying and the diverse nature of the schools they taught in during school experience herein referred to as work integrated learning.

3.1. Selection of participants

In a targeted purposive sampling technique (Patton, 2002), 50 preservice teachers enrolled for a bachelor's degree in education (BEd) specialising in Life Sciences (Biology) were selected. These students were in their final (fourth) year of study. It is in this fourth year when the focus is on methodology as they learn how they can transform the biology content knowledge when teaching in different classroom contexts to ensure learner understanding.

3.2. Data collection and analysis

In collecting data, the preservice Life Sciences teachers were each tasked to identify their 'best' lesson plan and 'worst' lesson plan and critically reflect on why they considered the lesson plans that way. These lesson plans had been designed and taught in schools during work integrated learning (WIL) in the first half of the year. Data was obtained from each participant's submission of the two lesson plans and the reflection made. A total of 100 lesson plans and 100 reflections became the source of data. The researcher wanted to check the authenticity of the participants' reflections; hence the participants were asked to submit their reflections together with their lesson plans.

The reflections were then subjected to content analysis (Bowen, 2009). The following aspects about lesson planning were considered: knowledge of the content to be taught, knowledge of the learners including classroom context, formulation of objectives, designing of teaching and learning strategies and activities, assessment opportunities, planning for technology use, and the student's ability to realise good and bad practices in lesson planning.

4. Findings

The findings showed how the preservice teachers were determined to improve their lesson planning as they included in their reflections how they could plan and teach the same lesson differently including the so-called best lesson plan. Preservice teachers used words such as deficit, unstructured, misaligned, unattainable, not well thought out, to critique their lesson plans. Creativity as an aspect of the teacher skills set was evident in the way these 21st century teachers conceptualised how science should be taught. There were, however, some who failed to identify obvious weaknesses or strengths in their lessons plans, which showed stagnancy in PCK development. This also applied to some partcipants who failed to articulate their reflections for example one would just say, "The lesson was not well planned" instead of indicating why it was considered that way for instance where the mistake was, was it the poorly formulated objectives, the inappropriate teaching strategies, activities, or assessment tasks selected etc.The following three sections present the details of the preservice teachers' reflections under strengths, weakness, and lessons learned for future lesson planning.

4.1. Strengths

Some of the strengths preservice teachers mentioned included a deliberate effort to design appropriate open-ended questions which helped in eliciting learners' prior knowledge which not only helped as a smooth introduction to the concepts taught but also motivated learners to wanting to know what they were going to learn. As such, these short introductory interactive sessions captured learners' attention. They mentioned the importance of formulating objectives which deliberately intended to develop learners in terms of what knowledge, skills and attitudes required for that topic. This included designing activities that provided learners with opportunities to develop manipulative, cognitive and relevant attitudinal skills that not only make them be able to answer questions in tests and examinations, but also ensure the utility value of the knowledge learned in their lives, communities, and workplaces. To this one participant wrote, "The applicability of knowledge or skills learnt should be made apparent in the classroom." On that note the other said,

> *I do not want to fall into the same trap that I went through when I learned Life Sciences concepts through memorising and only ask myself later after writing the test what it was about because I quickly forgot it.*

An important reflection made with regards to the curriculum was the need to interpret the curriculum properly which the preservice teachers indicated as an important issue if the teacher has to teach learners the appropriate content. One participant indicated how he would go out of his way to go through the content in the curriculum and also comparing the scope with the related content taught in the previous grade and to be taught in the following grade. On that note another participant indicated, "Failure to interpret the curriculum correctly results in teaching irrelevant concepts either by including concepts not needed or repeating concepts already learned from previous grades." Another said,

> *I consult with experienced teachers to check whether the content I am planning is the right one, including asking their opinions about the activities, resources and assessment tasks I plan.*

Some of the participants indicated how much they had improved in terms of lesson design from the first time they went to schools to teach at the beginning of the year. This one participant said, "When I inspect the lesson plans that I have designed during the third section of WIL, I can see a huge improvement."

4.2. Weaknesses

Some of the participants reflected on their failure to plan adequate content to be taught in a lesson as they either planned less content or too much content for the time allocated for the lesson. In the case of too much content, these participants indicated that their learners became overwhelmed, and it was difficult for learners to comprehend the concepts. Those who planned less content reflected on how they struggled to manage classroom discipline as learners were not engaged completely leaving room for misdemeanors.

An aspect that many participants mentioned was their failure (for some) and recklessness (for others) to formulate well thought out lesson objectives. Some identified their mistakes as follows:

Participant 1: The verbs I used for psychomotor domain did not advocate for hands-on application of skills, rather they leaned towards the cognitive domain.

Participant 2: Designing objectives for higher order thinking skills was problemmatic for me particularly analysis, evaluation, and creativity. I took the lectures on these for granted.

Many participants mentioned that they struggled to formulate proper objectives that addressed the life sciences curriculum specific aim which states that learners should be involved in, "Appreciating and understanding the history, importance and applications of life sciences in society" (Department of Basic Education, 2011, p. 17). A lack of such planning meant that these preservice teachers' lessons did not develop learners appropriately. Learners would not be able to answer higher order questions asked in the tests and examinations.

Most of the participants mentioned how they failed to plan for the questions that they would ask learners to ensure meaningful engagement with the content. One participant reminisced, "I kept on failing to ask questions to elicit my learners' thinking which would have helped me to create links between prior knowledge and the new knowledge." Others indicated how this failure to ask important questions resulted in learners remaining with misconceptions which they only detected in the way learners answered questions in the assessment activities. Some participants attributed most of their errors to the following: that they had no time to know their learners' backgrounds and abilities; failure by the mentor to guide them appropriately when planning; the mentor interfering with how the preservice teachers planned and taught the lessons; and their efforts to cover as much content as possible which the mentor had allocated them for quite limited time.

An important reflection made by several participants was their poor content knowledge to be taught. They indicated that they took for granted topics such as evolution and those involving ecology. A participant indicated how she struggled to explain some of the concepts she assumed she knew hence did not prepare the content. Another preservice teacher mentioned how he failed to respond to questions paused by some learners in one of the top classes. This is what he said,

> *At first I thought the learners were being naughty and wanted to me to prove myself that I was worthy to stand in front of the class as their teacher since I looked almost of their age. I only realised in the following lesson that I was in the wrong as I did not prepare the content.*

There were some whose reflections mostly focused on how they planned for the use of resources and technology to engage learners in meaningful activities. The most identified error was the use of videos which when used at the beginning in the introduction, they said it tended to be too long; when used during the lesson, videos kind of replaced the teacher. One such reflection was,

> *When teaching the lesson, I felt the video was taking my place because it took learners through all the concepts that I needed to teach; I felt so embarrassed as it was a lesson that my mentor chose to observe me teaching.*

Though some participants indicated their efforts in identifying suitable teaching approaches, they bemoaned the way they used the strategies. One participant said, "I was not flexible in creating a fun and interesting environment for the learners." Others indicated that the resources they used were very traditional, very limiting, especially regarding the context of the schools which they considered as under resourced.

Designing appropriate assessment tasks was one of the areas that preservice teachers mentioned as pertinent when planning for teaching. They indicated that the failure to design specific assessment activities for the lessons resulted in poor teaching as one would not be able to know whether learners understood the concepts taught. This also applied to the quality of test items which they mentioned should cover all the stages of revised Bloom's Taxonomy. One preservice teacher mentioned how his failure to set rigorous test items resulted in most learners getting full marks.

4.3. Lessons learnt for future planning

Lesson plans act as guides to a lesson and assist a teacher in setting up an appropriate atmosphere for teaching and learning. One participant indicated that lesson planning helps the teacher to conceptualise the implementation of what, why and how to teach including the resources, activities, and assessment to make Life Sciences concepts more meaningful and relevant to the learners. A teacher should plan for effective time management during the lesson by keeping discussions brief without abruptly cutting learners short or lengthening activities unnecessarily. Preservice teachers suggested that when planning the lesson, each aspect should be allocated a specific time. In the words of one participant, "Nothing should be left to chance unless one is destined to failure."

The preservice teachers pointed out that there are sometimes unforeseen circumstances that cannot be planned, for example, learner behaviour or participation in a lesson, unplanned load-shedding, emergencies and more. However, these issues may be corrected through reflection, practice, and experience.

5. Discussion, recommendations and conclusions

Some preservice teachers blamed their mentors for all the mistakes they made which shows lack of accountability. The chances of such preservice teachers to change for the better are slim considering that pPCK requires one to deliberately plan, teach and reflect (Alonzo, Berry & Nilsson, 2019). If one does not take accountability, it means there is no meaningful reflection as Finlay (2008) pointed out that reflection enables the teacher to gain insights based on experiences and learning from practice. There were preservice teachers who showed evidence of PCK development as indicated by Finlay (2008) that development happens when a teacher becomes self-aware and critically evaluates own responses to practical situations.

From the findings it shows that though the preservice teachers were in their last (fourth) year of studying for their teaching qualification, they still struggled to design 'perfect' lesson plans which shows that one needs to be a life long learner. An important aspect derived from the findings was that though most preservice teachers' reflection indicated failures in important aspects such as formulation of lesson objectives, preparation of content knowledge, poor questioning technique, and poor designing of assessment items, they reflected on their mistakes and how they intend to rectify their mistakes.

The findings have important implications for not only preservice teacher professional development but also continuous inservice teacher professional development.

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