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Pre-service teachers' action research: technology education lesson planning in a South African University

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ABSTRACT

Effective lesson planning promotes good teaching and the implementation of curriculum policy. Lesson planning enables teachers to determine appropriate lesson objectives, teaching and learning activities, and teaching methods. Effective lesson planning stimulates teachers to evaluate their instructional strategies and to reflect on how to improve their teaching. Action research was conducted in this study to improve the ways in which participating third-year pre-service teachers planned their lessons. Deficiencies were identified and corrected using the Kemmis Action Research model: plan, act, observe, and reflect. The study revealed that pre-service teachers find it difficult to grasp what influences them to select teaching methods and outline teaching and learning activities. It also emphasised that pre-service teachers should first comprehend the content to be taught prior to selecting the teaching and learning activities, as well as the instructional strategies to be used. As a result of the action research described here, the third-year pre-service students were able to prepare appropriate lesson plans.

Introduction

A lesson plan is an essential instrument that serves as a guide, a resource, and as a document that reflects the teaching philosophy, and most importantly, the learning objectives of a lesson (Jensen 2001; Nesari and Heidari 2014). A lesson plan reflects a teacher's beliefs, understanding of, and orientation towards the curriculum, the subject, the learners, pedagogy and so on (Li and Zou 2017; Shen et al. 2007). Amongst others, the purpose of lesson planning is to provide a framework for a specific subject (Gün 2014), to enable teachers to accomplish the lesson objectives (Nesari and Heidari 2014), to strengthen their confidence (Owen-Jackson 2012), to arrange suitable resources for teaching and learning, to manage time (Hall and Smith 2006), and to provide a sense of coherence (Jensen 2001). Furthermore, lesson planning produces a practical guide to the teaching and learning activities that take place in a specific lesson (Butt 2008).

The key to effective teaching, good class management, and sustained educational advancement depends on fruitful lesson planning (Butt 2008). Hall and Smith (2006) conducted research using pre-service teachers to determine the effectiveness of

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a planned lesson versus an unplanned lesson. Their results indicated that a planned lesson had a positive effect on some pre-service teachers' presentations and that this positive effect was transferred to the learning experience. Teaching a planned lesson enabled the pre-service teachers to be more efficient, and it resulted in learners paying greater attention to the activity at hand. Furthermore, the pre-service teachers who planned their lessons were able to provide the appropriate attention to learners during the activity and also to offer them consistent feedback. Butt (2008) argues that effective lesson planning requires a lot of time and a variety of skills that teachers need to grasp swiftly, particularly those who are inexperienced. However, many inexperienced teachers consider lesson planning difficult and excessively time-consuming. Mishra (2008) avers that many teachers do not even attempt to prepare lesson plans or make an effort to set the learning outcomes of their lessons. Experienced teachers seldom apply instructional design (a methodical process by which teaching materials are developed and presented) features in a well-structured format of lesson planning. As a result, teachers' records of lesson planning are often either sketchy or meaningless (Mutton, Hagger, and Burn 2011).

Studies have revealed that experienced teachers have a rich knowledge structure of teaching and are proficient in pedagogical tactics (Tsui 2009; Gün 2014). In addition, they possess an extensive repertoire of information which enables them to make swift decisions in the classroom. Butt (2008) asserts that experienced teachers who have developed a rapport with learners and are familiar with the relevant subject resources tend to give the impression that they can teach effectively without lesson planning. However, such teachers have the subject and pedagogical knowledge that novice or pre-service teachers often lack. Furthermore, experienced teachers who have taught effectively for many years have developed a collection of lesson activities from which they can select instantly according to the specific context (Butt 2008).

Mutton, Hagger, and Burn (2011) assert that pre-service teachers do not have highly contextualised knowledge or a detailed understanding of their learners, unlike experienced teachers who draw on this on a daily basis. Given this lack of knowledge and the belief that planning is 'visualisation', it can be difficult for them to predict the manner in which the lesson plan might unfold in the classroom. Practically every teacher preparation programme spends substantial time training pre-service teachers how to construct detailed lesson plans (John 2006; Rusznyak and Walton 2011), indeed, as one of the lecturers teaching methods for teaching, I myself teach pre-service teachers how to construct appropriate lesson plans. Pre-service teachers are taught to interpret the curriculum, to develop lesson objectives, to select suitable instructional strategies, and to outline the learning and teaching activities, including assessment strategies. However, when pre-service teachers are presented with the opportunity to construct their own lesson plans, they provide diverse responses (Rusznyak and Walton 2011). For some, lesson planning provides an opportunity to be creative, while others find it difficult. As numerous studies have revealed, many pre-service teachers struggle to construct productive lesson plans and, in particular, to select the lesson objectives, to match them with the assessment strategy, to identify appropriate teaching methods, to provide activities that stimulate cognitive skills, and to allow learners sufficient time to engage in the activities at hand (Rusznyak and Walton 2011; John 2006; Gülten 2013; Jones et al. 2011; Thompson 2007).

Table 1. School of education teaching practice lesson plan.

Grade:		Subject:	Phase:
Date:		Duration:	
Lesson topic			
Specific objectives			
Teaching and learning resources			
Teaching methods			
Activities	Time allocation	Teaching activities	Learning activities
Lesson Introduction			
Lesson Presentation			
Assessment Activities			
Lesson Conclusion			
Expanded opportunities			

Before teaching practice begins, pre-service teachers in South Africa are trained how to prepare a lesson plan using a set lesson plan template (see Table 1). Teaching practice then provides an authentic experience for pre-service teachers to implement a planned lesson. However, during teaching practice, South African teachers tend to recuse themselves from their usual duties once the pre-service teacher appears, thereby failing to provide mentorship or any form of support, particularly in relation to lesson planning.[1] Although Thi and Anh 2013) found that pre-service teachers frequently experience difficulties in transferring theory to practice, little research has been conducted to improve the way in which pre-service teachers prepare lesson plans, especially in South Africa.

Research conducted by Potgieter (2013) on lessons in South Africa revealed that both pre-service and established teachers experience difficulties when developing learning and assessment activities in Technology Education. A study conducted by Mapotse (2015) on an emancipation framework for Technology Education teachers found that in-service teachers in South Africa experience challenges in teaching technology. As part of that study, action research was conducted in the selected schools to support in-service technology teachers to implement the curriculum. These developments prompted this researcher to undertake participatory action research to support a number of pre-service teachers in developing effective lesson plans.

This study intended to identify and then address the deficiencies that pre-service teachers experienced when preparing lesson plans, and subsequently to help them improve their lesson planning skills. This is particularly important as the ability to plan an effective lesson shows that a teacher is able to interpret and implement the curriculum. It set out to answer the following questions:

Research questions

- How do pre-service teachers select teaching methods, and teaching and learning activities?
- What happens to the third-year pre-service teachers when they have been taught how to develop a productive lesson plan?

Lesson planning process

Figure 1 represents the process to be followed when planning an appropriate technology lesson, particularly in South Africa. The model was influenced by key aspects of teaching technology, namely, curriculum policy, knowledge base, teaching and learning activities, lesson objectives, assessment strategy, resources, and reflection. The Department of Basic Education's (DBE) curriculum (Curriculum Assessment and Policy Statement, CAPS) stipulates that the technology curriculum aims to produce learners that are able to identify and solve problems, make decisions using critical and creative thinking, and work effectively as individuals and with others as a team (DBE 2011, 5). The purpose of Technology Education is to stimulate learners to be innovative and develop creative and critical thinking skills (DBE 2011, 8). In addition, the specific aims of Technology Education are to contribute to learners' technological literacy by providing them with the opportunities to, amongst others (a) Develop and apply specific design skills to solve technological problems, and (b) Understand the concepts and knowledge used in Technology Education and use them responsibly and purposefully. Thus, lesson objectives are central to lesson planning. De Jager (2014) clarifies that learning objectives are short-term,
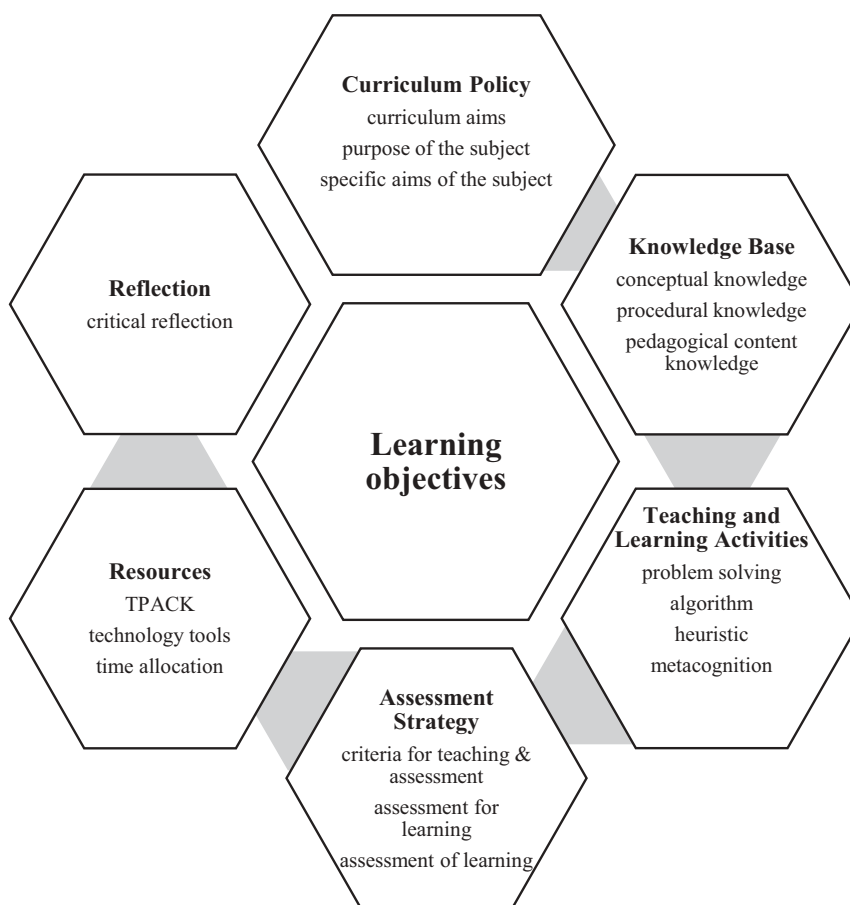

Figure 1. Lesson planning process.

purposeful targets that are constructed for a particular activity. When planning the lesson, pre-service teachers should consider the purpose and the specific aims of Technology Education.

In terms of knowledge base, Technology Education emphasises conceptual and procedural knowledge. However, Pedagogical Content Knowledge (PCK) is very important in order to teach technology. Conceptual knowledge refers to system concepts (McCormick 2004). Procedural knowledge represents such things as design, problem solving, planning, systems analysis (or systems approach), optimisation, modelling, and strategic thinking (heuristic, algorithms and metacognition). PCK denotes the combination of content and pedagogy such that learners understand how specific topics, problems, or issues are arranged, taught, and simplified according to the various interests and capacities of learners, and presented for teaching purposes (Shulman 1987). The nature of the teaching and learning activities that the pre-service teachers plan should be aligned with the purpose of the subject.

An algorithm approach (see Figure 1) to solving problems involves presenting and reflecting on the problem, defining the problem, seeking alternative solutions, solving the problem and evaluating it (McCormick 2004). The heuristic approach (see Figure 1) to learning provides learners with opportunities to investigate and examine the problem, and to seek a solution independently. Teachers structure the problem and allow learners to discover the solution without influencing them (Kumar, Krishna, and Rao 2004; Singh and Nath 2005). Metacognition is a regulatory system that assists individuals to comprehend and regulate their own cognitive performance and is frequently referred to as 'thinking about thinking' (Hacker et al. 2009). This implies that pre-service teachers should allow learners to take charge of their own learning. In essence, pre-service teachers should provide learners with the activities that stimulate them to discover technological solutions on their own whilst also taking control of their cognitive process.

In Technology Education in South Africa, there are criteria for teaching and assessing the artefacts that learners have developed. These include, *inter alia*, originality, value for money, fitness-for-purpose, and ease for manufacture (DBE 2011). In relation to resources, technology as a subject does not require ultra-modern, state-of-the-art technological apparatus (DBE 2011). Simple tools such as pliers, hammers, hand drills, hacksaws, tape measures, bradawls, screwdrivers, files, soldering irons, and electronic systems are sufficient to build the appropriate artefacts. The Technological Pedagogical and Content Knowledge (TPACK) framework emphasises that effective teaching be flexible and influenced by rich, well-organised knowledge from various spheres, including knowledge of learners' thinking and prior learning, and, progressively, knowledge of technology (Kochler and Mishra 2009).

To teach Information Communication Technology (ICT) successfully involves generating, developing and sustaining a vibrant balance among all these components. Time allocation is also key in teaching technology; learners should have sufficient time to complete their activities. As Layange and Bartlett (2010) assert, teachers' professional practice is informed by regular critical reflection. After presenting a lesson, pre-service teachers should reflect on the effectiveness of the lesson planned. This practice enables them to determine whether the lesson objectives were met or not, and to identify specific areas of lesson planning or teaching that require improvement.

Method

Context

The author teaches a third-year module entitled the Method of Technology for Educators at the University of Bokone (pseudonym) in South Africa. The content of this module involves learning theories, teaching methods, lesson planning, assessment, and reflective practice. The module is a compulsory part of the Bachelor of Education (B.Ed.) in Technology Education programme. According to the Department of Higher Education (DHET 2011), a B.Ed. degree in South Africa is intended to develop qualified teachers who can demonstrate focused knowledge and skills in teaching technology. The degree is studied over a period of four years. In their third year, pre-service teachers are required to spend four weeks in the first semester and an additional three weeks in the second semester conducting their teaching practice. Teaching practice provides an authentic experience for pre-service teachers to implement lessons they have previously planned. Hence, action research on lesson planning is important as they prepare these lessons before conducting their teaching practice. This study used a qualitative approach wherein the third-year pre-service teachers were considered as a sample. The class consisted of 49 (n = 49) pre-service teachers who all agreed to participate in the action research. All the third-year pre-service teachers were taught how to prepare lesson plans in their second year of study. They were also advised to plan the lesson based on mechanical or electrical systems and control to determine coherence. These pre-service teachers' role in this study was limited to preparing the lesson plans and discussing aspects of their lesson planning.

Action research procedure

According to Kemmis (2009), the purpose of action research is to change three things, namely, the practitioners' practice, their understanding of their practice, and the conditions in which they practice. In this study, data collection was guided by Kemmis' (2009) Action Plan Model, which involves *planning, acting, observing* and *reflecting*. This action research on lesson planning was conducted within a period of four weeks, two periods a day each week. Data collection involved multiple sources to provide a broad perspective (Yin 2014); these included an open-ended questionnaire from each participant, video analysis, and lesson plans. This action research study had four phases, and at each stage, the aspects of planning, action, observing, and reflecting were explored.

In the first phase (first week), the third-year pre-service teachers were assessed by means of a short, open-ended questionnaire to determine their level of competence in lesson planning (see Appendix A). The five questions, based on the lesson plan framework used for teacher training at the university (see Table 1), were:

- *Why do teachers plan a lesson?*
- *What is the importance of setting learning objectives?*
- *As a pre-service teacher, what influences you to select a specific teaching method when planning a lesson?*
- *How do you identify teaching and learning activities?*
- *Why do teachers reflect after presenting a lesson?*

The responses from the pre-service teachers were analysed to determine the deficiencies (*observe*). The pre-service teachers were provided with feedback on their responses and there were several debriefing sessions (*planning and action*) to collectively reflect on the lesson planning. In addition, a video was presented to demonstrate what constitutes effective lesson planning. The video, entitled 'Teaching methods for inspiring the students of the future' by Joe Ruhl, was identified from YouTube. In this video, five essential features of teaching that should be considered when planning a lesson were highlighted, namely, choice, collaboration, communication, critical thinking, and creativity. Then the 49 pre-service teachers were divided into seven groups to discuss the dynamics of lesson planning and were given the opportunity to exchange their understanding of lesson planning. In the subsequent three weeks, lesson planning was conducted piecemeal to ensure steady progress in each stage of the lesson (introduction, presentation, assessment, and conclusion).

During the second phase (second week), the pre-service teachers focused on lesson objectives and teaching methods (*planning and action*). In this instance, planning and action happened concurrently. The researcher planned what the pre-service teachers should focus on and they then directed their attention to a specific aspect of lesson planning. Furthermore, the researcher observed the manner in which the pre-service teachers developed the learning objectives and selected the teaching methods. Subsequently, the pre-service teachers submitted their assignments and the researcher documented and reflected on their submission. A debriefing was planned to provide feedback on their assignments and the researcher allowed them to share their experiences.

In the third phase (third week), emphasis was placed on the teaching and learning activities that were used for lesson introduction and presentation (*planning and action*). The researcher observed the approaches used by the pre-service teachers to identify activities for lesson introduction and presentation. Afterwards, the researcher reflected on the assignments and planned intervention strategies. Another debriefing session was planned to provide feedback on the approaches used by the pre-service teachers.

The last phase (fourth week) dealt with assessment activities and lesson conclusion (*planning and action*). The pre-service teachers were asked to identify assessment activities and formulate a lesson conclusion. The researcher again observed the approaches used by the pre-service teachers. After their assignments were submitted, the researcher documented and reflected on the approaches used. As a result, a final debriefing was planned to discuss the pre-service teachers' understanding of the assessment activities and the lesson conclusion.

Data analysis

A thematic analysis procedure was used to analyse the data (Braun and Clarke 2006). The statements from the open-ended questionnaire were transcribed and arranged into meaningful analytical units. Different ideas were sorted into themes and repeated patterns of meaning were identified. The pre-service teachers also reflected on the video that was presented to enable them to consider what should be taken into consideration before planning a lesson. As McNiff (2014) notes, the essential feature of action research writing is that it is generally a narrative procedure. Twenty-one lesson plans (seven sets of lessons per group) were narratively analysed, and data gathered through debriefing was used to identify strategies to develop aspects of the lesson plans that required further improvement.

Results

Phase one: open-ended questions and video analysis

Five themes emerged from the five open-ended questions, namely, efficiency, meaningful lessons, learning styles, curriculum policy, and lesson analysis.

Efficiency

Efficiency means the ability to execute the task without wasting time or energy. The teacher's objective in the classroom is to convey new information efficiently in order to identify and clarify complex concepts and to adjust their presentation accordingly (Anderson et al. 2013). When the participants were asked why teachers plan a lesson, they responded as follows:

> *To avoid dwelling on one thing and waste* [sic] *time. Set objectives to be achieved.*
> To avoid teaching out of context.
> Lesson planning enable[s] teachers to organise information to be presented to learners.
> To make teaching and learning more effective.
> To save time and have a focused lesson.
> To have a productive lesson.

Meaningful lessons

One of the features of teaching technology, as highlighted by McCormick (2004), is the notion of activity as authentic. However, authenticity is two-fold: personal authenticity and cultural purpose. Personal authenticity infers that the learner must be involved, and the learning has to be meaningful for them. If learners are given an activity to solve a problem, it should be one that matters and means something to the learner. When the participants were asked about the importance of setting learning objectives, they responded as follows:

> To be able to know what the teacher want[s] to achieve.
> Learning objectives help to establish the desired results.
> The teacher and learners know what is expected from them.
> To direct learning.
> To set achievable goals of the lesson.
> For learners to know what they are going to be assessed on.

Learning styles

Learning styles are not permanent behaviours that learners always display (Pritchard 2009); instead learners are able to adopt different styles in different settings. Honey and Mumford (1992) established four types of learners, namely, activists, reflectors, theorists, and pragmatists. Activists prefer to learn by doing instead of reading or listening. Reflectors prefer to observe. Theorists acclimatise and fit all their observations into frameworks to determine the relationships between them. Pragmatists have the desire to search for new ideas. When the participants were asked what influenced them to select the specific teaching methods, they responded as follows:

> Every learner is different and learns differently.
> Take into account the learners' differences.
> Assess the kind of learners to be taught.

Knowing how learners are learning.
The types of learners that I will be teaching.
The topic to be taught and the types of learners.
Learners' abilities, topic at hand, and the number of learners.

Curriculum policy

The National Curriculum Statement for Grade R-12 gives expression to the knowledge, skills and values deemed worth learning in South African schools (DBE 2011). CAPS outlines the purpose of Technology Education, the features and scope of the subject, the teaching methodology, the content for each grade, and the nature of the assessments. When asked how they identified learning activities, some participants provided the following statements, which implied that they did not know how to identify learning activities. Others attempted to respond but provided 'off topic' statements.

By checking learners' syllabus and what they are supposed to learn.
Refers to CAPS document.

Lesson analysis

After presenting a lesson, teachers should determine whether they were able to achieve the learning objective(s), and whether the teaching methods used were effective. The answers to these questions should be based on evidence. In addition, teachers should identify any aspects of the lesson that require improvement. When the participants were asked why teachers reflect after presenting a lesson, their responses were as follows:

To determine if the learning objectives were met.
To develop an innovative method of teaching.
Determine if learners understood the lesson.
To be able to identify their own shortcomings and improve them.
To asses if learners are on the same level and what needs to be addressed in the next lesson.
To identify the strong and weak aspects of their presentation and correct the weakness in the next presentation.

Video analysis

The video on teaching methods to inspire the students of the future was presented to the pre-service teachers to help them to identify the key aspects of lesson planning. The video exposed them to what makes a better teacher, and the aspects of teaching that should be considered before preparing a lesson. The video presenter, Joe Ruhl, emphasised five essential skills that are relevant to the 21st century, namely, choice, collaboration, communication, critical thinking, and creativity. At the end of the video presentation, the participants were asked to reflect on what they had observed. The statements below represent their views:

I have realised that effective teaching is rather learner-centred meaning the teachers should play a facilitating role.
Learners should be allowed to choose their learning preferences.
Learning should be purposeful.

I thought lesson planning is about completing the lesson plan template without anticipating the class dynamics or learners' responses.
Information communication technology (ICT) simplifies teaching, the teacher remove[s] himself from the centre and allow[s] learners to explore.

Phase two: lesson objectives and teaching methods

Following the open-ended questionnaire that was used to assess the pre-service teachers' competence in lesson planning, the next phase focused on how they constructed lesson objectives and identified appropriate teaching methods. The participants were asked to construct the learning objectives within the scope of mechanical or electrical systems and control.

Lesson objectives

As highlighted earlier in the description of the lesson planning process, learning objectives are short-term, purposeful targets that are constructed for a particular activity. The quotes below represent the participants' statements regarding appropriate learning objectives:

Learners will be able to create a system of gears and explain it.
Learners should develop a skill to calculate and solve technological problems.
Learners will be able to calculate the mechanical advantages of a lever given the load.
Learners should be able to calculate voltage, current and resistance using Ohm's law formula.

The researcher observed that the participants constructed learning objectives without reference to the textbooks, although the textbooks provided guidance. During the debriefing, the pre-service teachers were asked how they constructed learning objectives. One of the participants, Mary (pseudonym) mentioned that:

Learning objectives are based on the nature of the activity that learners have to do. As long as one emphasise[s] that, learners will be able to …

Based on the above remarks, the researcher reflected on the appropriate approach to change these teachers' practice, and a lesson on how to construct learning objectives was planned and presented. Bloom's taxonomy was used to explain how to construct learning objectives and it was emphasised that the pre-service teachers should aim for higher-order thinking and use verbs such as 'analyse', 'design', 'examine', and 'evaluate'. Furthermore, the learning objectives should be measurable and avoid words like 'appreciate', 'improve', and 'believe'. An example of a learning objective that is measurable is as follows:

At the end of the lesson, learners should be able to apply syringe mechanics to explain transfer of forces.

The pre-service teachers were also advised to refrain from using the word 'will' in the learning objectives since it sounds commanding. A learning objective is an expectation not a command.

Improvement on constructing learning objectives

The participants reflected that they experienced a new perspective on constructing learning objectives. As novice teachers, they also realised how important it is to refer to

the textbook. Subsequently, the participants were asked to draft learning objectives. One of the paired groups mentioned that:

> At the end of the lesson, learners should be able to identify different types of gears and their applications.

The above statement confirmed that the pre-service teachers were now able to construct measurable learning objectives.

Teaching methods

De Jager (2014) asserts that teachers choose teaching methods that correspond with both the topic and the learners' needs, often based on the following pattern:

Demonstration
Explanation
Discussion
Question and Answer
Cooperation

Although the participants mentioned the learners' different learning styles and the lesson content as the main aspects that influenced them to select particular teaching methods, as alluded to earlier, the researcher observed that the methods they specified did not always correspond with the topic or the learners' needs. During the debriefing session, it was evident that they were not explicit about the approach they had selected as well as teaching methods. Therefore, the researcher reflected on a more suitable approach to selecting teaching methods, and a lesson on teaching methods was planned and presented. McCormick's (2004) four features of situated learning were presented, namely, (a) Knowing and doing, (b) Enculturation and participation, (c) Becoming someone, and (d) Activity as authentic. In essence, these features provide guidance on the nature of the teaching methods to be used, and they indicated that teaching methods relevant to teaching technology include problem-based learning, project-based learning, and design-based learning.

Improvement in selecting teaching methods

In response to this, the participants reflected that the design process is problem-based learning by default. In addition, they came to realise that the design process is collaborative in nature and that the cooperative teaching method could be used when solving technological problems. Sipho (pseudonym) noted that the policy document (CAPS) provides guidance on the types of teaching methods that could be used:

> Identify and solve problem using critical and creative thinking skills. Again, learners are encouraged to work as a group.

Based on the above remarks, the researcher observed that the participants were mindful of what influences the selection of teaching methods.

Phase three: lesson introduction and presentation

In the introduction phase of the lesson plan, the participants were required to determine the learners' prior knowledge and outline the teaching and learning activities to follow. To determine prior knowledge, a teacher might set a scenario to expose learners to the problem or portray the real context in which the problem is found (Du Plessis, Conley, and Du Plessis 2007). The statements below represent the participants' comments:

Teaching activities	Leaning activities
Explain gear systems.	Learners observe the object the teacher present[s].
Determine prior knowledge.	Learners answer questions and take notes.
Ask questions, introduce new concepts.	Learners describe their own understanding.
Define what is a 'lever'.	Learners calculate the resistance.
Ask learners what they understand about Ohm's law.	

Based on the participants' statements, the researcher realised that the participants could not identify appropriate teaching and learning activities to determine the students' prior knowledge. During the next debriefing, the participants were asked to explain how they assessed prior knowledge. Peter (pseudonym) mentioned that:

> Prior knowledge involves what learners know already about what the teacher is about to teach. By means of questions, the teacher determines the level of knowledge or knowledge gaps.

Peter's view was echoed by many of the participants. As a result, the researcher observed that the participants were not aware that the questions that are aimed to determine prior knowledge should also be planned and specified in the lesson plan. Subsequently, the researcher planned a presentation on the techniques used to determine prior knowledge. These included asking learners to write a quick list of at least two or three facts that they already know or think about the topic. Alternatively, a teacher might display a photograph or a diagram related to the topic and ask learners to analyse it.

Lesson presentation

During the lesson presentation phase, teachers specify the activities for the subject matter and present new information. In addition, they provide learners with activities to measure their level of understanding once the lesson has been presented. Working in paired groups, the participants mentioned the following as teaching activities:

Facilitate learning.
Interpret the resistor's colour codes.
Demonstrate how to calculate the potential.
Explain the mechanical advantages of the lever.

For learning activities, the following comments were made:

Learners design, make, evaluate and communicate.
Learners take notes.
Allow learners to ask questions.
Learners calculate resistance, current and potential differences.
Determine mechanical advantages of a lever.

After assessing the participants, the researcher observed that they did not specify the actual teaching and learning activities. Therefore, a lesson was planned and presented by the researcher to outline these activities, with reference to the textbook. It was stressed that the participants should summarise the teaching activities in the space provided in the lesson template. Alternatively, they should highlight the activities intended to be used for teaching. An example of a learning activity is given below:

> *John sets up a circuit consisting of a battery and 4□ light. The voltage measures 5,4V over the light. Calculate the strength of the current in the circuit.*

As a result of the lesson, the participants realised how important it is to specify both the teaching and learning activities. Clearly specified activities enable the teacher to measure the learners' performance in relation to the learning objectives. Furthermore, the participants understood that clearly specified activities could be used effectively by another subject teacher should the pre-service teacher fail to present the lesson due to unforeseen circumstances. The participants were then given the opportunity to summarise the teaching activities for lesson presentation and demonstrated significant improvement. The statements below represent the improvements made:

Teaching activities	Leaning activities
Explain the difference between pneumatics and hydraulics systems.	*Learners explain the context in which pneumatics and hydraulic systems functions.*
Provide a chart with different lifting mechanism and ask learners to identify the appropriate lifting mechanism.	*Learners identify and provide reasons on how to lift an object easily.*
Explain different types of gears and their applications in real life.	*Learners describe instances where they have observed the application of different gears.*

Phase four: assessment activities and lesson conclusion

Gathering information from learners is the starting point of any assessment process because this provides evidence of their knowledge or understanding of the design activities. Learners' ability to execute the given activity is essential (Meyer et al. 2010). The quotations below represent the paired participants' teaching and assessment activities:

> Facilitate class activity.
> Calculate mechanical advantages of a lever.
> Give learners a classwork and check their progress.

Teaching assessment activities involves providing individual learners with attention, monitoring their progress, providing support, and identifying deficiencies or misconceptions as they execute the activity. To a certain extent, the participants understood what was expected from them during the assessment activities; however, they were not explicit in terms of the nature of the assessment activities that they should provide. The statements below represent their comments:

> Learners write the classwork.
> Learners are required to draw [a] simple circuit.
> Calculate values in the given activity.

The above statements are not explicit. The participants should specify the nature of the assessment activities and these activities should be planned in advance. Therefore, a debriefing session was arranged to reflect on the participants' understanding of teaching and learning assessment. It was underlined that assessment activities for teaching are what the teacher does while learners execute the activity. Mary and Merriam (pseudonyms) from separate paired groups reflected that:

> *Giving an assessment activity is the responsibility of the teacher hence we wrote give learners a classwork.*

However, it was clarified that the above view does not describe a teaching assessment activity. It is the learners that execute the activity, not the teacher. After the debriefing session, the researcher reflected on the most appropriate method to support the pre-service teachers, and a lesson was presented on how to outline learning assessment activities. The activity below represents an example of a learning assessment activity within the context of mechanical systems and control:

(a) *Explain how the hydraulic system functions.*
(b) *Draw two different diagrams that demonstrate the first and second rule of hydraulics.*

Lesson conclusion

De Jager (2014) asserts that during a lesson conclusion, teachers customarily summarise the new content that was presented and provide feedback about the learners' performance. The remarks below represent the way in which the participants in paired groups planned their lesson conclusion:

> Give learners feedback about the activity.
> Emphasis[e] important information of the lesson.
> Revise the lesson.
> Summarise the lesson.

The remarks above, to a large extent, confirm that the participants were able to plan a lesson conclusion.

Improvement on teaching and learning assessment activities

After the debriefing session and the lesson presentation on assessment activities, the participants were asked to draft new learning and teaching assessment activities. They demonstrated improved knowledge and agreed that clear assessment activities would enable them to measure if the set learning objectives had been achieved. Subsequently, the pre-service teachers framed the assessment activity as set out below:

> Develop your own simple meshed gear train with reference to the following:
> Demonstrate the way in which two meshed gears run in opposite direction,
> Identify the driven and driving gear, and
> Explain how the gear train provides the mechanical advantage.

Discussion

Planning an effective lesson requires teachers' dedicated efforts to establish a coherent system of activities that stimulate learners' cognitive skills (Mishra 2008). The nature of these dedicated efforts relies on the teacher's creativity and capacity to facilitate learning, and to teach theories. Ball and Forzani (2011) avow that the primary imperatives of teaching as a profession are to enable learners to understand academic knowledge and skills. Hence, preparing a lesson plan prompts teachers to set appropriate learning objectives and provide learners with well-structured activities (Blatt and Kim 2011). Meyer et al. (2010, 10) describe learning objectives as the outcomes of the knowledge, skills and values that the teacher attempts to instil by the end of the lesson or series of lessons. Learners are thus required to demonstrate the ability to comprehend specific knowledge, skills and values. In South Africa, CAPS (Department of Basic Education 2011) stipulates that one of the specific aims of technology as a subject is to contribute to learners' technological literacy by giving them opportunities to, *inter alia*, develop and apply specific design skills to solve technological problems.

The purpose of technology education in South Africa is to stimulate learners to be innovative, and to develop their creative and critical thinking skills (Department of Basic Education 2011). In addition, the subject teaches learners to manage time and material resources effectively, providing opportunities for collaborative learning and nurturing teamwork. Furthermore, learners should be able to collect, analyse, organise and critically evaluate information, and demonstrate an understanding of the world as a set of related systems by recognising that problem-solving contexts do not exist in isolation.

It is important to select the appropriate teaching methods to bring about effective learning, and the teacher should demonstrate a broad knowledge of different teaching methods in order to apply a suitable one at the opportune time (Du Plessis, Conley, and Du Plessis 2007). Marzano (2010) emphasises that pre-service teachers should grasp various skills, instructional strategies, and processes, which are considered as procedural knowledge. Learning these skills, instructional strategies, and processes requires a lot of practice. Thus, effective interventions on lesson planning are imperative to enable pre-service teachers to grasp the nature of their practice and improve their skills. In technology, the design process is applied to solve problems and develop technological solutions (Williams, Iglesias, and Barak 2008). Van Dooren et al. (2014) assert that design is a process that strives to enable the likelihood of future technology developments, analysing and seeking alternatives while solving technological problems. Hence, the design process forms the backbone of teaching technology in South Africa and it should be used to structure the achievement of all learning aims (Department of Basic Education 2011). This implies that the teaching methods selected should support learners to find technological solutions.

Technology is a practical subject and it is important to develop and assess skills and values together with the relevant subject knowledge. Knowledge without the skills that are required to implement a practical solution is worthless (Department of Basic Education 2011). In addition, skills cannot be taught without the knowledge required to design solutions to problems. The nature of the activities that are given and assessed by the pre-service teachers should take into account the kind of knowledge and skills

intended to be developed. Hence, the lesson planning model emphasises the knowledge base applicable to Technology Education. The nature of assessment in technology is both assessment for learning (informal) and assessment of learning (formal). Assessment for learning in technology, *inter alia*, involves observing how learners demonstrate the correct and safe use of tools. A Mini-Practical Assessment Task (Mini-PAT) is described as a set of short practical assessment tasks that make up the main assessment of a learner's skills and application of knowledge during each term (DBE 2011). It may be a specific activity that requires learners to apply the design process (IDMEC) systematically.

Limitations of the study

The limitations of this study need to be acknowledged. Due to the application of action research, the pre-service teachers were able to prepare lesson plans, but these lessons were not tested in a real classroom context to determine their effectiveness. In the paired discussions, some students might not have participated actively if they prefer to work individually, or some suggestions might have been suppressed. In addition, not all participants expressed their views during the debriefings.

Conclusion

Action research is intended to improve the practice of teachers; through this action research, the pre-service teachers learned that before a lesson is planned, teachers should first understand the content to be taught. Once the content is understood, the lesson objectives and teaching methods should be carefully outlined, considering the nature of the activities to be presented. In accordance with the lesson planning process (Figure 1), the pre-service teachers should be mindful of the curriculum policy imperatives. Teaching methods that have been listed (with the exclusion of questioning) do not necessarily stimulate learners to develop cognitive skills as stipulated by the curriculum. However, if applied appropriately, questioning is one of the effective teaching methods that enables learners to develop cognitive skills. Most importantly, teaching and learning activities for technology as a subject should either be informed by an algorithm or heuristic approach. Effective lesson planning reflects the ability to interpret and implement the curriculum.

In response to the first research question, i.e. How do pre-service teachers select the teaching methods and learning activities? The initial intervention revealed that the pre-service teachers selected the teaching methods with which they were most comfortable instead of considering the nature of the activities to be taught. In addition, they indicated that they referred to the learners' syllabus and CAPS document to select the teaching and learning activities. In addressing the second research question, i.e. What happens to the third-year pre-service teachers when taught how to develop a productive lesson plan?, the study was able to improve their lesson planning practice. The selected pre-service teachers are now able to prepare an appropriate lesson plan. Future research should be conducted on how the pre-service teachers implement a lesson in an authentic context and how they support learners to develop the cognitive skills as stipulated in the curriculum policy.

Note

1. This is in contrast to countries such as China where an experienced teacher is assigned to a pre-service teacher for support (Tsui 2009).

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Appendix A

Open-ended questionnaire for lesson planning

1) Why do teachers plan a lesson?

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2) What is the importance for setting learning objectives?

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3) What influence you to select a specific teaching method?

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4) How do you identify the teaching and learning activities?

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5) Why do teachers reflect after presenting the lesson?

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