The South African pre-service teacher's physics pedagogical orientations.

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Abstract. To come up with ways on how teacher training institutions should train pre-service teachers is one of the most discussed topics among teacher educators and researchers. Some of the reasons for this change is to integrate new teaching methods such as inquiry-based learning and problem-solving instructions to mention few. However, it is discovered that most universities provide students with limited exposer to different methods of teaching science. The current study investigates physical science pre-service teacher's physics pedagogical orientations when they are at university. The phrase orientation denotes teachers' knowledge and beliefs for teaching science. Pedagogical orientations are classified into four approaches; direct didactic, direct active, guided inquiry and open discovery. To establish the physical sciences pre-service teacher's physics pedagogical preferences, we used an instrument comprising of five items that portrayed an actual teaching scenario for a physical sciences topic. Each item had four teaching alternative methods and respondents were requested to select the most appropriate choice. A quantitative method was used to obtain teachers pedagogical orientations. The findings indicate that students preferred the direct approach aligned with the direct active, while a smaller group preferred learner-centred orientation.

- **Introduction 1.**

In the past, teacher preparation programs around the world faced criticisms about the quality of their programs. However, these institutions are trying to change the way of teaching/training pre-service science teachers to develop pedagogical competencies that are in line with the reform goals outlined in major documents such as National Science Education Standards (National Research Council, 1996). Reform goals are different ways of teaching sciences through argumentation, problem-based learning and inquiry using assessments for formative tenacities and making learning relevant to learners' cultural backgrounds and prior knowledge (Aydeniza & Kirbulutb, 2014). Currently, reform goals are used by researchers to understand how best to produce graduates who are equipped to teach learners from diverse backgrounds (Ludwig, Kirshstein, & Sidana, 2010). The physical sciences Further Education and Training (FET) document in South Africa promotes the development of scientific process skills through the process of inquiry. The reason behind this is to develop teachers who can teach science through inquiry and produce learners or future citizens who can take care of their environment and those who will be able to meet the demands of the future workplace (Department of Education (DoE), 2011). The goals of the curriculum are in-line with the central goals for science teacher education around the world, which are to produce pre-service teachers who are competent and understand different ways of teaching science topics (Cobern, Schuster, Adams, Skjold, Muğaloğlu, Bentz, Sparks, 2014).

The South African department of education encourages the inquiry-based approach in sciences for learners to comprehend science concepts (Department of Education, 2011). The document addresses the importance of scientific investigation and the role of physical science. The document states that "the purpose of physical sciences is to make learners aware of their environment and to equip learners with investigating skills relating to physical and chemical phenomena, for example, lightning, and solubility" (DoE, 2011, p. 8). The document places less emphasis on traditional ways of teaching which are mostly teacher-centred instructional approaches and more emphases on teacher-guided or student-driven inquiry-based instructional approaches. It is found that the stipulated goals from different documents are not executed in the classroom (Ramnarain, 2014). The teaching methods employed are entirely teacher-centred, where teachers still believe in rote learning (Nargund-Joshi, 2012). The stipulated goals are not implemented due to (i) limited availability of science teachers (ii) large numbers of under-qualified or non-qualified physical science teachers (iv) no facilities to teach and learn science through problem-based learning, argumentation and by inquiry and (iii)overcrowded classes (Makgatho & Mji, 2006).

- **Inquiry-Based Learning 2.**

The current South African school curriculum is known as Curriculum Assessment Policy System (CAPS) document drastically shifted away from the first school curriculum after democracy is known as Outcome-Based Education (OBE) because subject boundaries were no longer ambiguous, and the document had a week-by-week teaching plan. However, the CAPS document or structure had less room for teacher creativity and possibly even more constricted space for the integration with other teaching methods. Curriculum Assessment Policy Statement emphasis is more on inquiry-based learning as a teaching approach for science subjects. The CAPS document prescribed inquiry-based learning as a teaching approach and the focus on inquiry is reflected in Specific Aim two (2). The specific aims are teacher's guiding principle on how to prepare learners to meet the challenges of either society, future world (DoE, 2011). Specific aim two inspire teachers and learners to (i) promote knowledge and skills in scientific inquiry and problem solving, (ii) the construction and application of scientific and technological knowledge. (iii) Lastly, an understanding of the nature of science and its relationships to technology, society and the environment (DoE, 2011). The purpose of these skills is to develop learners' scientific skills and ways of thinking scientifically at the level of academic and scientific literacy that enables them to read, talk, write and think about scientific processes, concepts and investigations (DoE, 2011).

An inquiry-based approach is a strategy employed in education, where learners follow methods and practices like those of professional scientists when constructing knowledge (Keselman, 2003). The National Research Council (1996) refers to an inquiry as activities where learners must develop understanding and knowledge of how scientist develop ideas and how they study the natural world. In literature, an inquiry has been used to depict good science teaching and learning (Anderson, 2007). The benefits of inquiry-based learning are that learners are expected to discover new knowledge, a teacher act as a facilitator, learners formulate hypotheses and testing them by making observations (Pedaste, Mäeots, Leijen, & Sarapuu, 2012), inquiry-based teaching also promotes autonomy and encourages learners to actively construct knowledge (Ramnarain & Hobden, 2015). Sciences teachers in South African welcome the perception of inquiry approach (Ramnarain & Schuster, 2014) as it assists learners to develop experimental skills and make science more interesting. Ramnarain and Hlatswayo (2018) assert that teacher's attitudes and beliefs towards inquiry-based learning are important when implementing and teaching through inquiry. Although there is strong advocacy of inquiry-based learning around the world, there is a strong consensus that inquiry-based learning is based on the epistemology of scientific research and this suggests learners need to attain thinking skills, science theoretical content and process skills (Haug, 2014; Breslyn & McGinnis, 2012). These skills are still lacking among secondary learners in South Africa. Therefore, the above reasons made the researcher conduct the study of this nature, exploring physical sciences pre-service teacher's pedagogical orientations.

To address the above uneasy on inquiry-based learning, a key dimension in science education is being investigated as teacher's pedagogical orientations. Teacher's orientations are knowledge and beliefs about teaching science (Magnusson, Krajcik, & Borko, 1999). The aim of this study was to explore the physics pedagogical orientations of physical science pre-service teachers. To achieve this, the following research question was set:

i. What are the physical sciences pre-service teacher's physics pedagogical orientations in one of the South African university?

To understand pre-service teacher's physics pedagogical orientations, we administered questionnaires to all physical sciences' final year students' teachers.

- **Theoretical and Conceptual Framework 3.**

Pedagogical Content Knowledge (PCK) underpins the study as a theoretical framework. PCK is a blend of pedagogical and content knowledge that formulates the transformation knowledge of content and pedagogy into most powerful, teachable forms to formulate subject and make the subject comprehensible to learners (Shulman, 1987). PCK give emphasis to the significance of content representation for learners understanding and distinguishes science teacher's knowledge from the scientist's knowledge given that science teacher knowledge is different from scientists' knowledge in terms of organisation. Science teacher organise their content knowledge in various forms learners can easily understand, scientists have specialised knowledge to develop new things or transform the universe (Cochran, 1998). Therefore, PCK is an act of transforming content knowledge from teachers' personal understanding of various forms to assist learners to comprehend science concepts. The PCK definition varies from one author to another; however, there is a consensus that PCK is the transformation of content knowledge by a teacher for the purpose of effective teaching and learning (Park & Chen, 2012). The literature shows a limited research conducted on science pre-service teacher's PCK, the available literature is mainly on how science pre-service teachers develop PCK and whether there are possible ways to gain access to expert teacher's PCK to develop pre-service teacher's pedagogical knowledge and various PCK models focus on how to gain access to teacher's PCK (Evens, Elen, & Depaepe, 2015).

- **Pre-service teacher's PCK 4.**

The literature does not agree about the key elements for preparing teachers (Barnhart & van Es, 2015). There are four general areas of teacher knowledge that can be viewed as the foundation of a knowledge base for teaching, these are; (i) General Pedagogical Knowledge, (ii) Subject Matter Knowledge, (iii)Pedagogical Content Knowledge and (iv) Knowledge of Context (Grossman, 1990, p. 5). A series of investigation is being conducted to assist pre-service science teachers to develop adequate PCK before graduating, although it is difficult to measure pre-service science teachers' PCK since it is elusive in nature and hidden (Aydeniza & Kirbulutb, 2014; Kind, 2009).

Rusznyak and Walton (2011) conducted research on lesson plan guidelines used to scaffold the construction of pre-service teachers PCK in their first-year undergraduate teacher's module in one of the South African universities. Their findings indicate that previous lesson planning guideline used by the university endorsed an unsophisticated conception of lesson planning as the isolated consideration of more than a few features of the lesson. Students perceived lesson planning as linear paperwork for teaching only and to them, a lesson-planning template was like a step by step process dominated by teacher's procedures of teaching rather than the consideration of how to enable learning (Rusznyak & Walton, 2011). Another South African study investigated twenty-four final year pre-service teachers on the effect of an intervention for developing a construct of PCK located at a topic level called Topic Specific Pedagogical Content Knowledge (TSPCK). The intervention was underpinned by explicit discussions of the five TSPCK knowledge components: (i) learner prior knowledge (ii) curricular saliency (iii) what is difficult to teach (iv) representation and (v) conceptual teaching strategies (Mavhunga, Mamvura & Akinyemi, 2016). They observed that from their study pre-service teachers had a clear improvement in the quality of their TSPCK. In the pre-test, the pre-service teachers understood learner's misconception but there were no explicit discussions regarding strategies employed. However, in their post-test, they seemed to have an improved and were able to discuss approaches employed (Mavhunga, Mamvura & Akinyemi, 2016). These studies coincide with that there are two important aspects observed in the literature about pre-service teachers PCK, which are (i) a good understanding of CK and (ii) PCK is developed over time through teachers' reasoning and reflection on practice (Mavhunga, 2014). Even with an improvement from both content knowledge (CK) and pedagogical knowledge (PK), teacher's proficiency in translating their own understanding to that of learners appears lacking (Lederman, Gess Newsome & Latz, 1994). The sciences pre-service teachers occasionally display the level of competency seen inexperienced teachers and even with an improvement from both content knowledge and pedagogical knowledge. It is hence implied that PCK is likely to develop if teachers are introduced to this journey in the early years of their teacher practice (Mavhunga, 2014). Apart from PCK, there is another important component that needs to be researched and this concept is called pedagogical orientation.

- **Pedagogical orientations 5.**

Within PCK, Magnusson, Krajcik, and Borko (1999) identified a key dimension in teaching that was not fully explored by previous researchers apart from Grossman (1990) and this knowledge is referred to as teacher's orientations. Their model introduced teaching orientations as the important factors that shape teacher's PCK. Orientations shape teacher's knowledge of science curricular and knowledge of learner understanding which includes learner's prior knowledge (Gess-Newsome, 2015; Magnusson, et al., 1999).

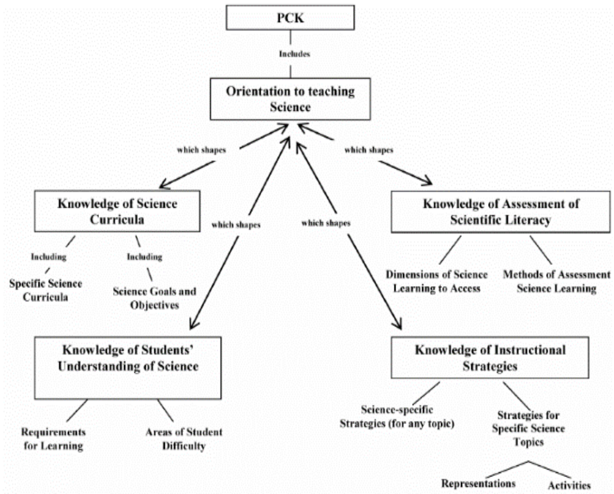


Figure 1: Magnusson et al. (1999) model of PCK.

Figure 1 shows the theoretical relationship between PCK and pedagogical orientations in science teaching (Magnusson et al., 1999). The above figure shows that orientations shape all the components and have a direct influence on other subcomponents within this model because every knowledge a teacher has is influenced by the pedagogical orientations. Teaching orientations are important because knowledge and beliefs work as a conceptual map guiding teachers decisions when preparing a lesson, for example, daily objectives of the lesson, content of student assignments, the use of textbooks and other curricular materials, and the evaluation of student learning among others (Magnusson et al., 1999). Magnusson et al. (1999) proposed nine orientations towards science teaching and learning these are; orientations toward science teaching, academic rigour, didactic, conceptual change, activity-driven, discovery, project-based science, inquiry, and guided inquiry.

Based on the research conducted around the world by (Cobern et al., 2010; Ramnarain and Schuster, 2014:2016; Schuster et al., 2012) they used a similar definition provided by (Magnusson et al., 1999) defining pedagogical orientations but classified pedagogical orientations into four categories which are; direct didactic, direct active, guided inquiry and open discovery. We used the same definition, classification of pedagogical orientations and instrument produced by (Schuster et al., 2007; Cobern et al., 2010; Schuster & Cobern, 2011; Schuster et al., 2012; Cobern et al., 2013); Ramnarain et al., 2014:2016) as a theoretical lens for this paper.

- **Measuring Pedagogical Orientations 6.**

A group of the University of Western Michigan produced a set of case-based assessment items presenting actual teaching scenarios for many science topics to measure in-service and pre-service teacher's pedagogical orientations (Cobern, et al., 2014). These items are multiple-choice questions but are slightly different from the traditional multiple-choice questions in that each of the response options represents a pedagogical orientation. The purpose of the items is to bring about teachers' orientations towards teaching science and encourage them to visualise themselves teaching a science topic in a real classroom. Below are the four pedagogical orientation used to classify the pre-service teachers with their explanations.

Didactic Direct	Teacher presents the science concept or principle directly and explains it. Illustrates with an example or demonstration. No student activities, but teacher takes student questions and answers them or clarifies.
Active Direct	Same as the direct exposition above initially, but this is followed by a student activity based on the presented science, e.g. hands-on practical verification of a law.
Guided Inquiry	Topics are approached by student exploration of a phenomenon or idea, with the teacher guiding them toward the desired science concept or principle arising from the activity. Teacher may explain further and gives examples to consolidate. Questions are dealt with by discussion.
Open Inquiry	Minimally guided by the teacher, students are free to explore a phenomenon or idea in any way they wish, and devise ways of doing so. Teacher facilitates but does not prescribe. The process is generally considered the most important thing and students present what they found.

Figure 2: A description of each of the pedagogical orientation *Adapted from* (Cobern, et al., 2014).

The first two pedagogical orientations are direct approaches, these are referred to as teacher-centred and the last two orientations are inquiry approaches, are more learner-centred.

- **Methodology: Research Design 7.**

The study employed a quantitative method exploring physical science pre-service teacher's physics pedagogical orientations (Creswell, 2003). We collected and analysed data, then integrated the findings, and drew inferences using quantitative methods (Tashakkori & Creswell, 2007). An explanatory sequential design was employed as a research methodology (Creswell, 2003). In an explanatory sequential design, a researcher first collects quantitative data, then collects qualitative data to help elaborate the quantitative results (Creswell, 2014). Respondents were required to select the most appropriate choice from the four choices provided on each of the questionnaire items. The most appropriate choice is the teaching approach pre-service teachers considered employing if they were to teach a similar lesson.

- **Questionnaire structure and data collection 8.**

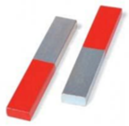
A questionnaire with five (5) items was administered to Bachelor of Education physical sciences final year undergraduate students at the beginning of the year. All items in the questionnaire were in a standard multiple-choice question and the instrument comprises of a vignette, question, and four response options. Each option corresponds to a pedagogical orientation, namely direct didactic, direct active, guided inquiry and open discovery. Figure 2 below shows the general structure of test items measuring pre-service pedagogical orientations.

Figure 2: The format of assessment items adapted from (Cobern et al., 2010).

At the end of the vignette, the respondent is asked to reflect upon the approach he or she would adopt when teaching in the given situation. This is followed by four options from which the respondent chooses the one considered to be the most appropriate. Figure 3 below shows an example of an assessment item used in the questionnaire.

Magnetic attraction

Mr. Hala is beginning a unit on Magnetism with his students, and his objective is for them to learn about magnetic attraction. He gives each student group a bar magnet and a tray that contains a paper clip, a coin, an iron nail, school scissors, a pencil, some keys, a marble, a crayon, aluminium foil, some sand, and students can add a few objects of their own. Mr. Hala introduces the term "magnetic attraction," and demonstrates how to test a couple of objects with a magnet. Student groups are then asked to sort the objects in their trays according to whether they are attracted by the magnet or not.



Thinking about how you would teach, of the following, how would you evaluate Mr. Hala's lesson?

A. Instead of beginning with terminology, Mr. Hala should have had the students first test the various objects themselves and discuss their ideas about it. In wrapping up the session, Mr. Hala could introduce the term magnetic attraction, and how it applies to what they observed.

B. This is a good lesson because Mr. Hala introduces the important terminology right at the start. However, having demonstrated how to test an object using a magnet, he might as well have demonstrated what happens with all the objects, sorting as he goes.

C. Mr. Hala should have allowed the students to explore freely with magnet and objects, without bringing up terminology. He could then let them discuss any ideas they might have about it and share these with the class. The only contribution he needs to make is to present the term magnetic attraction at the end.

D. This is a good lesson because Mr. Hala introduces the important terminology right at the start and follows up with the students doing a hands-on activity, testing and sorting the objects themselves.

Figure 1: An example of a teaching Scenario administered to students.

Each option corresponds to a pedagogical orientation either direct didactic, direct active, guided inquiry and open discovery.

- **Data analysis 9.**

The quantitative data was in the form of MCQ responses and results were analysed by employing a statistical software SPSS—PASW version 25 to determine the physical sciences teacher's preferred pedagogical orientations. The statistics data was obtained and analyse d in the form of tables including mean score and standard deviations. We ran tests to determine whether there are any significant differences in physical sciences pre-service pedagogical orientations based and school type. The results were arbitrarily ordered along a scale of 1–4, with direct didactic assigned 1, direct interactive 2, guided inquiry 3 and open inquiry 4.

- **Research findings 10.**

The purpose of the study was to explore physical sciences physics pedagogical orientations. To achieve this, we used SPSS software to generate tables. Table 1 below provides a descriptive statistic on the physical sciences physics pedagogical orientations for the five items.

Table 1: Distribution of the most appropriate physics pedagogical orientations of physical sciences pre-service teachers in percentages (%).

	Direct didactic	Direct active	Guided inquiry	Open discovery	Mean score	St dev
Thermometers and how they work	2,2	**51,1**	35,6	11,1	2.56	0.725
Lesson on force and motion	20,0	**40,0**	17,8	22,2	2.42	1.055
Volume and displacement	33,3	**51,1**	6,7	8,9	1.91	0.874
Light and shadows	0	6,7	28,9	**64,4**	3.58	0.621
Light reflection	17,8	28,9	**44,4**	8,9	2.44	0.893

When zooming at each topic or item, a direct active was the most preferred orientation followed by both guided inquiry and open discovery. It was evident that the nature of the concept/topic influenced the physical sciences pre-service teacher's physics pedagogical orientations. Three out of five items were centred within the direct active, one out of five items were centred within guides inquiry and the remaining was centred within open discovery as the most preferred pedagogical orientation. We then looked at the overall pedagogical orientations in percentages. The table below present the overall preferred orientation, mean scores and standard deviations for the five physics items.

Table 2: Descriptive statistics for the overall preferred pedagogical orientations by physical sciences pre-service teachers in percentages (%).

	Direct Didactic	Active Direct	Guided Inquiry	Open Inquiry	Mean score	Std. Dev
Overall physical sciences pre-service teachers preferred orientations for the ten items (n=45).	15	**36**	26	23	2.6	0.835

The overall percentage distribution of the four preferred pedagogical orientations as indicated above, the most preferred orientation with a 36% was a direct active, followed by a 26% guided inquiry. The overall mean score was 2,6 which means that the most preferred pedagogical orientation is centred within the direct active and with a 0,835-standard deviation. We then established whether school context influenced the teacher's preferred pedagogical orientation.

On the questionnaire, we requested the respondents to indicate the type of schools they were placed in their previous teaching practicum at the beginning of the year. We divided schools into three groups, which are; township, rural, private or suburban schools. South Africa is a diverse country compared to other countries around the world comparing school contexts and how teaching and learning are conducted. The South African national department of basic education grouped public schools into five groups and referred to these groups as quintiles. Quintiles are classified in terms of poverty rankings and other socio-economic factors (Hall, Leatt & Rosa, 2007). All public schools are arranged into quintiles one to five. 60% of the schools in the country, largely in rural areas and townships quantile one, two and three. All these schools are referred to as non-fee school. We determined the pedagogical orientations of pre-service teacher placed in township schools and the table below indicates their orientations.

Table 3: Township school's pre-service teacher's physics pedagogical orientations in percentages.

	Direct didactic	Direct active	Guided inquiry	Open discovery
Thermometers and how they work	3.8	**50.0**	38.5	7.7
Lesson on force and motion	15.4	**38.5**	19.2	26.9
Volume and displacement	34.6	**61.5**	3.8	0
Light and shadows	0	0	42.3	**57.7**
Light reflection	15.4	30.8	**46.2**	7.7

When analysing the township school's pre-service teacher's physics pedagogical orientations, it shows that their orientation lies within direct active where three out of five of the items cantered within this orientation. However, some of the orientations **'Light and shadows'** were not selected or preferred by the respondents, these orientations are direct instructions "direct didactic and direct active". The same procedure was conducted for rural schools.

Table 4: Rural school's pre-service teacher's physics pedagogical orientations in percentages.

	Direct didactic	Direct active	Guided inquiry	Open discovery
Thermometers and how they work	0	**53.8**	30.8	15.4
Lesson on force and motion	30.8	**53.8**	15.4	0
Volume and displacement	15.4	**46.2**	7.7	30.8
Light and shadows	0	15.4	7.7	**76.9**
Light reflection	23.1	**38.5**	**38.5**	0

The rural school's pre-service teacher's physics pedagogical orientations, it shows that also their orientation lies within direct active where four out of five items are centred within this orientation. Few orientations were not selected or preferred by the respondents as preferred pedagogical orientations. Lastly, the remaining 40% are classified as quantile four and five, these schools are the most privileged schools and are in the richest communities such as suburban and city areas. Below is the table representing suburban schools' pre-service teachers' pedagogical orientations.

Table 5: Suburban school's pre-service teacher's physics pedagogical orientations in percentages.

	Direct didactic	Direct active	Guided inquiry	Open discovery
Thermometers and how they work	**50.0**	0	33.30	16.7
Lesson on force and motion	16.7	16.7	16.7	**50.0**
Volume and displacement	**66.7**	16.7	16.7	0
Light and shadows	0	16.7	16.7	**66.7**
Light reflection	16.7	0	**50.0**	33.3

The suburban school's pre-service teacher's physics pedagogical orientations, it shows that their orientation lies within direct didactic and open discovery, where two of each orientation were preferred. Unlike township and rural schools, suburban pre-service teachers did not select direct active as the most preferred orientation. Again, few orientations were not selected or preferred by the respondents as preferred pedagogical orientations.

When comparing school types, it shows that orientations are influenced by context, orientations that were selected as direct active by township and rural schools were not preferred by suburban pre-service teachers. 'Light and shadows' orientation seemed to be the most common preferred orientation by the respondents, as most respondents from different schools centred this orientation within the open discovery.

- **Discussions and conclusion 11.**

The findings of this study have brought to light that there are significant differences in physical sciences pre-service teacher's physics pedagogical orientations of rural, township and suburban schools from this South African university. Quantile one to three schools' pre-service teachers has a strong direct active orientation while suburban school pre-service teachers lie within direct didactic and guided inquiry orientation. Ramnarain and Schuster (2014) reported in their study that township in-service teachers were more centred on direct active, while suburban schools' teachers exhibit a guided inquiry orientation. However, the overall in-service teachers' orientation from this study was more on guided inquiry and this shows pre-service teacher have different pedagogical orientation compared to in-service teachers. The findings from this paper agree with (Ramnarain et al, 2014: 2016) that context influence teacher's orientations. Both findings from this paper and other papers mentioned above concur with (Magnusson et al., 1999) postulation that teaching orientations are like a map guiding teacher's decisions making process when preparing a lesson.

With regards to the topic/concept, it also indicates that, yes topic influence teacher's pedagogical orientations. The overall preferred orientation was direct active, however, when zooming to each concept it evident that the distribution is widely spread among different orientations. The concept of 'Light and shadow' is the only concept that was centred within open discovery (64.4%). To respond to the question, 'what are the physical sciences pre-service teacher's physics pedagogical orientations? The findings indicate a direct active orientation was the overall most preferred orientations. A direct active orientation is like direct didactic orientation where is it teacher-centred, but this is followed by a student activity based on the presented science content, for example, hands-on practical verification of a law.

To conclude, the findings indicated that the cohort of the physical sciences pre-service teachers in one of the South African universities embraces a direct active approach as pedagogical orientation for physics topics and from these results topic and context influence teacher's pedagogical orientations.

Having information about physical sciences pre-service teacher's physics pedagogical orientation has great importance. It is significant for future researchers to establish what are the factors influence pre-service teacher's orientations. It will be interesting to understand in the next paper the reasons behind these distributions among the different topics. The next paper will focus on factors affecting pedagogical orientations, I will use interviews and classroom observations.

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