Cogent Education

ISSN: 2331-186X (Online) Journal homepage: www.tandfonline.com/journals/oaed20

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To cite this article: Albert Tarmo | (2016) Pre-service science teachers' epistemological beliefs and teaching reforms in Tanzania, Cogent Education, 3:1, 1178457, DOI: 10.1080/2331186X.2016.1178457

To link to this article: https://doi.org/10.1080/2331186X.2016.1178457

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Published online: 11 May 2016.

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Tarmo, *Cogent Education* (2016), 3: 1178457
http://dx.doi.org/10.1080/2331186X.2016.1178457

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TEACHER EDUCATION & DEVELOPMENT | RESEARCH ARTICLE

Pre-service science teachers' epistemological beliefs and teaching reforms in Tanzania

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Received: 21 January 2016
Accepted: 11 April 2016
Published: 11 May 2016

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Reviewing editor:
Stuart Bevins, Sheffield Hallam University, UK

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Abstract: In an effort to understand why recent initiatives to promote learner-centred pedagogy in science teaching made a little change in the actual teaching practices of science teachers, this study explored pre-service science teachers' beliefs about science knowledge and their teaching practices. Six pre-service science teachers were interviewed to explore their beliefs. Moreover, lessons taught by pre-service teachers were observed to see how their beliefs manifest in their teaching practices. This was followed by post-observation interviews focusing on critical incidences observed. Findings showed that pre-service science teachers hold dualist views about science. They viewed science knowledge to be simple, rigid and derivative of specific bodies of knowledge handed down by authorities such as textbooks and experts. Consistent with their beliefs, pre-service teachers asked factual questions and sought pre-determined textbook-based answers from students. They adopted transmissive teaching strategies to propagate textbook-based science knowledge. It was concluded that the way science teachers uptake the aspired learner-centred teaching may be partly due to incompatible beliefs they hold.

Subjects: Education & Training; Science Education; Secondary Education; Teacher Education & Training; Teachers & Teacher Education; Teaching Practice – Education

Keywords: learner-centred pedagogy; teacher belief; teacher education; science teaching; teacher change; Tanzania

ABOUT THE AUTHOR

Albert Tarmo is a faculty member in the Department of Educational Psychology and Curriculum Studies, University of Dar es Salaam School of Education. He is currently pursuing doctoral studies at the Centre for International Education, University of Sussex, UK. Broadly, his research focuses on science teacher education and professional development. This research article is part of his doctoral research which aims to illuminate the difficulties science teachers face in adopting learner-centred science teaching envisaged in the recent school curriculum reforms in Tanzania.

PUBLIC INTEREST STATEMENT

This paper argues that science teachers' hesitancy to enact teaching reforms may be partly rooted in their beliefs about science knowledge and how it can be learned. Teachers' beliefs formed for many years of teachers own schooling and training processes may be resistant to change. These beliefs may be incompatible with the aspired teaching reforms and thus, influence the extent to which reforms are enacted. The paper recommends science teacher education programmes in which prospective teachers are offered opportunity to reflect, challenge and transform their beliefs about science knowledge and knowing. This should be associated with a supportive environment for prospective teachers to develop beliefs compatible with the aspired teaching reforms.

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1. Introduction

For over a decade since learner-centred pedagogy was introduced in secondary school science teaching in Tanzania, research still reiterates little change in the actual science teachers' practices. It attributes this to unfavourable contextual factors (Hamilton, Mahera, Mateng'e, & Machumu, 2010; Paulo, 2014; Semali & Mehta, 2012; Tilya & Mafumiko, 2010; Vavrus & Bartlett, 2012, 2013). However, science teachers' beliefs about scientific knowledge and knowing which form the basis for their decisions and justifications for teaching practices appear to receive little attention (Feucht, 2010; Kagan, 1992; Pajares, 1992).

Subsequent sections will focus on the initiatives set up to promote learner-centred pedagogy and why these appear to have made little impact in changing the core practices of science teachers. Specifically, the ways in which teacher belief about knowledge and knowing may mediate actual change in teaching practices and the implications for promoting learner-centred pedagogy will be highlighted.

1.1. Introducing learner-centred pedagogy in science teaching in Tanzania

In an effort to improve science teaching and learning in secondary schools, the government introduced learner-centred pedagogy in the school curriculum and subsequently disseminated this through initial and in-service teacher education.

Notably, these initiatives began with in-service training programmes which have been conducted by the Ministry of Education and Faculties of Education in public Universities since 1996 (Osaki, 2007). However, it was in the early 2000s that policy discourses on learner-centred pedagogy gained more attention when the Secondary Education Master Plan (SEMP) of 1998 and Teacher Education Master Plan of 2000 were formulated and implemented (Ministry of Education and Culture, MoEC, 2005).

The SEMP advocated a greater emphasis on learner-centred pedagogy in science teaching following the curriculum review (MoEC, 2005). Specifically, the reviewed curriculum stated that "the implementation of the current secondary school curriculum shall emphasize learner-centred pedagogy" (MoEC, 2005, p. 29). Learner-centred pedagogy was conceptualised as an approach to instruction with the learner at the centre of all decisions regarding curriculum design and delivery (MoEC, 2005). In addition, both the learner and the teacher were expected to actively participate in knowledge construction with the role of the teacher stipulated as follows:

> The teacher shall become a facilitator, motivator and a promoter of learning during the classroom interactions. Teachers shall be required to plan and design relevant tasks that will let students question; *critically think; form new ideas; create artifacts and, therefore, bring sense in the learning process* (MoEC, 2005, p. 29, emphasis added).

Further, the curriculum clearly appealed to constructivists' views on learning by stating that "learning shall be rooted in the conception of constructivism where the student gets opportunities to interact with the environment through well-organized tasks, dialogue and reflections on learners' conceptions and eventually arriving at agreed solutions" (MoEC, 2005, p. 29). It should be noted that in Tanzania, the curriculum development and design process is centrally done by the Tanzania Institute of Education which is a government parastatal under the Ministry of Education (Mosi, 2013). Curriculum materials including syllabi, textbooks and other teaching and learning materials are also centrally determined and approved before dissemination to schools.

Initial teacher education was expected to play a vital role in laying the foundations for this approach and foster its adoption in schools. To start with, initial teacher education courses were reviewed to emphasise learner-centred pedagogy as an approach to teaching in Teacher Education Colleges and Universities (Osaki, 2007; Ministry of Education and Vocational Training, MoEVT, 2009a). The introductory sections of each course outline for science method courses clearly stressed the need for science teacher trainees to competently use learner-centred pedagogy for teaching science subjects in

secondary schools (MoEVT, 2009b). An extract from a biology pedagogy syllabus states that "A student-teacher *should have the ability to apply learner-centred approaches*, strategies and techniques in the teaching and learning of biology to learners" (MoEVT, 2009b, p. v, emphasis added).

Overall, science teacher trainees are required to acquaint themselves with a learner-centred pedagogy as they prepare to teach science in secondary schools. This includes applying learner-centred pedagogy during their Block Teaching Practice in secondary schools.

1.2. Teacher beliefs and learner-centred pedagogy

It has been argued that for pre-service science teachers to embrace learner-centred teaching approaches aspired by teaching reformers, teachers need to hold compatible beliefs about science knowledge and knowing (Chai, Khine, & Teo, 2006). However, it has been established that when teacher trainees join teacher education, beliefs about science knowledge have already been moulded as a consequence of trainees own schooling experiences (Kagan, 1992; Levin, 2008). Depending on the views of science knowledge promoted in schools, these teacher trainees are likely to join teacher education with beliefs incompatible with the learner-centred teaching practices they are expected to embrace. In a Tanzanian context, teacher trainees are likely to be the product of a school system dominated by teacher-centred propagation of absolute science facts. They are therefore likely to hold views of science incompatible with the envisaged learner-centred pedagogy.

As Pajares (1992) suggested, teachers usually adhere to their deep-rooted conceptions and beliefs unless they are strongly confronted with alternative ideas that better account for their background experiences. This means prior beliefs that teacher trainees bring as they begin learning to teach may be maintained throughout their training unless these are strongly challenged and the uptake of the aspired learner-centred teaching is fostered. Moreover, it is worthwhile noting that learner-centred pedagogy was introduced in a context where teachers and students had well-established beliefs about knowledge and knowing. Furthermore, the principles and spirit of learner-centred teaching necessarily require re-negotiation of teachers' deeply held beliefs about knowledge and knowing. For example, a teacher who views knowledge as "fixed truth" provides little room for knowledge construction (Otting, Zwaal, Tempelaar, & Gijselaers, 2010). Thus, such views need to be reconsidered and changed.

In the current teacher education programmes in Tanzania, substantial emphasis is placed on equipping pre-service teachers with knowledge and skills on procedural aspects such as organising group discussions or inquiry activities. The underlying principles and spirit of learner-centred pedagogy get downplayed. Brodie, Lelliott, and Davis (2002) described this as embracing the form rather than the substance of learner-centred pedagogy. Thus, pre-service teachers might not have been challenged adequately enough to dislodge and reconstruct beliefs they hold about knowledge.

Levin (2015) argued that policy-makers often wonder why teaching reforms are not enacted with fidelity by every teacher. In her view, teachers' resistance to teaching reforms is rooted in their well-entrenched beliefs which may influence how they adopt reforms. Moreover, teachers' beliefs are often hardy to change because they form the core of teacher identities (Helms, 1998; Kagan, 1992). In light of the foregoing discussion, this study, therefore, explored pre-service science teachers' beliefs about science knowledge and how these are translated into their teaching practices. The aim is to understand how pre-service teachers' beliefs may be mediating their uptake of learner-centred pedagogy.

1.3. Epistemological beliefs and teaching practices

So far number of studies involving pre-service or in-service science teachers has consistently established a connection between teachers' beliefs about science knowledge and their teaching practices (Çetin-Dindar, Kırbulut, & Boz, 2014; Chai et al., 2006; Chen, Morris, & Mansour, 2015; Deniz, 2011; Hashweh, 1996; Mansour, 2013; Yerrick, Pedersen, & Arnason, 1998).

Studies suggest that science teachers holding relativist beliefs about knowledge are more likely to employ inquiry-oriented and learner-centred teaching practices than their counterparts who hold dualist beliefs (Deniz, 2011; Hashweh, 1996; Tsai, 2006). Hashweh (1996), for example, observed the teaching practices of science teachers who held objectivists' view of science knowledge. Hashweh found that their teaching practices were dominated by transmission of science knowledge through lectures. Meanwhile, those who held a relativist view of science were sensitive to students' divergent understandings and employed a wide repertoire of teaching strategies to foster cognitive restructuring among students. A recent study by Çetin-Dindar et al. (2014) found that pre-service chemistry teachers with relativist epistemological beliefs expressed a preference for a constructivist learning environment in their future teaching.

Conversely, Tsai (2006) showed that Taiwanese science teachers who held dualist views of science knowledge directed their students' attention to test scores and devoted more instructional time and efforts on lectures, tutorials and drilling. They tended to focus on the absolute correctness of knowledge and facts and rely on the authority of teachers and textbooks (Tsai & Kuo, 2008). Similarly, Mansour (2013) reported that science teachers who viewed science knowledge as valid, absolute and cumulative consistently viewed teaching as conveying knowledge to learners. They perceived learning as the passive accumulation of knowledge. Moreover, their practices were characterised by transmissive teaching strategies such as lecturing, recitation and class control (Mansour, 2013).

Overall, the studies highlighted so far present evidence of the link between teachers' views of science knowledge and their teaching practices. Generally, teachers who held dualist views of science knowledge appears to be more aligned to transmissive teaching practices while those who held relativist views of science tend to be more aligned to learner-centred constructivist-oriented practices. This suggests that the government's aspiration for more learner-centred teaching in schools could be favoured in contexts where science teachers hold relativist beliefs about science knowledge.

Other studies, however, (see Abd-El-Khalick & Lederman, 2000; Tsai, 2002; Waters-Adams, 2006), highlight more complexity within such relationships. Abd-El-Khalick and Lederman (2000), for example, demonstrated that multiple variables including lack of resources, pressure to cover the curriculum and students abilities might mediate and thwart the translation of teachers' beliefs about knowledge into practice. Extending this idea, Tsai (2002) proposed that teachers' beliefs might coexist such that different sets of beliefs exert influence on each other. Thus, it is difficult to predict teachers' practices from their beliefs (Waters-Adams, 2006).

1.4. Conceptualising epistemological beliefs

Beliefs that individuals hold about knowledge and knowing is a subject of interest for researchers, notwithstanding terminological disunity. Terms such as personal theories (Hofer & Pintrich, 1997), epistemic beliefs (Bendixen, Schraw, & Dunkle, 1998), personal epistemology (Hofer, 2001; Kang, 2008), epistemological beliefs (Schommer, 1990), and epistemological reflection (Baxter-Magolda, 1992), are pervasive. However, the main focus that unites this body of research is the personal conception of knowledge and knowing.

A preliminary work on epistemological belief or personal epistemology was undertaken by Perry (1970). Perry proposed a stage-like development of epistemological beliefs beginning with dualism, followed by multiplism, relativism and ultimately commitment within relativism (Hofer, 2001). Dualists view knowledge as either wrong or right. They believe absolute truth exists and can be known for certain. In contrast, Multiplist view knowledge as a tentative point of view. Relativists tend to accept diverse points of views as equally valid. Eventually, committed relativists begin to recognise that amongst diverse viewpoints, some are superior to others (Hofer, 2001). Unlike Perry and others who advocated sequential models, Schommer (1990) appears to favour multidimensional nature and asynchronous development of personal epistemology. Schommer viewed personal epistemology to be the system of more or less independent beliefs (Duell & Schommer-Aikins, 2001). Thus, she proposed a multidimensional model of personal epistemology in which belief about

Table 1. Categories of epistemological beliefs (Schommer, 1990)

Dimension	Naïve belief	Sophisticated belief
Structure	Fragmented bits of concepts	Integrated set of concepts
Stability	Unchanging/Certain	Ever changing/Uncertain
Source	Authority/expert	Evidence and reasoning
Speed of knowing	Quick all or none	Gradual
Ability to know	Fixed at birth	Improvable with time/experience

knowledge and knowing is categorised into naïve and sophisticated categories along five dimensions as shown in Table 1.

According to Schommer (1990), individual's beliefs about knowledge vary along the continuum from naïve to sophisticated beliefs. Individuals with naïve beliefs consider knowledge to be simple, clear and specific. For them, knowledge is certain, unchanging and reside in experts. They believe knowing to be "quick all" or "not at all" and the ability to know as inborn. In contrast, individuals with sophisticated beliefs consider knowledge to be uncertain, tentative and consist of complex interrelated concepts. For them, knowledge can be acquired progressively through reasoning processes and even constructed (Schommer, 1990).

Studies on teachers' epistemological beliefs (see Chan, 2004; Chan & Elliott, 2004; Cheng, Chan, Tang, & Cheng, 2009; Deniz, 2011; Kang, 2008; Ozgelen, 2012) often utilise Schommer's model. This study adopted Schommer's multidimensional perspective on personal epistemology to understand pre-service science teachers' beliefs about science knowledge and how these are manifested in their teaching practices. All dimensions of beliefs (structure, stability, source, speed and ability to know), as initially proposed by Schommer were explored during interviews with pre-service science teachers. Moreover, teachers' classroom teaching practices were observed to explore how their beliefs actually manifest in the way they present scientific knowledge. In this study, pre-service science teachers who viewed science knowledge to be simple, certain and absolute factual information to be conveyed by the authority are considered to hold dualist beliefs. Conversely, those who recognise science knowledge to be tentative, evolving and defined by interrelated complex concepts that can be actively constructed by knowers are considered to be holding relativist beliefs (Tsai & Kuo, 2008). While the study does not advocate for either of the positions, the fact that science teachers holding relativist views of science favour learner-centred constructivist-oriented teaching ideas and practices is acknowledged (see Çetin-Dindar et al., 2014; Mansour, 2013; Markic & Eilks, 2010; Schraw & Olafson, 2002; Tsai, 2002).

2. Methods

2.1. Data collection

The need for an in-depth exploration of pre-service teachers' thinking necessitated the adoption of an interpretive approach in which semi-structured interviews were conducted. This was done using a set of guiding questions with the opportunity for detailed probing and reflection. Questions were set by the researcher basing on the insights gained from the literature on teacher beliefs about knowledge (see Chan & Elliott, 2004; Schommer, 1990; Tsai, 2006). Sample questions and the major themes explored are presented in Table 2.

At the time when interviews were conducted, pre-service teachers had completed 14 of the 16 weeks, which in total constitute two Blocks Teaching Practice periods they are obliged to undertake in secondary schools during year 1 and 2 of the 3 years [1]BSc. with Education programme. Each interview session lasted for 60 min.

Table 2. Themes and sample questions

	Theme	Sample questions
1	Questions science teachers ask in the classroom	When you ask a question in the classroom, do you expect single or multiple responses from students?
2	Relationship between subjects and topics	How would you view a student who uses knowledge from other subjects to answer questions on the subject you are teaching?
3	Responding to disagreement or confrontation by students	Suppose your student disagree or question the accuracy of the procedure or solution to a problem you presented, how do you justify your position?
3	Variation in textbooks explanations	If one science textbook contradicts with another textbook on the same concept, Which one will you trust most? Why?
4	Variation in students learning speed and abilities	Why do you think some learners learn quickly while others take a long time? Why do you think some concepts are learned quickly while others take a long time?

Simultaneously, classroom lessons were observed and post-observation interviews focusing on stimulated-recall of events were conducted soon after observation. Three lessons, each lasting 40 min, were observed for each of the six pre-service teachers. The observations focused on the way teacher beliefs about scientific knowledge manifest in teaching practices. During the classroom observations, extensive observation notes were made on classroom questioning, learning tasks, the roles of the teacher and students, the role of students' experiences and classroom organisation. Post-observation interviews often took less than 20 minutes.

2.2. Participants

The participants were six pre-service science teachers studying at the University of Dar es Salaam, Tanzania. They were doing final Block Teaching Practice in two secondary schools in Dar es Salaam, Tanzania. As a mandatory part of their programme, pre-service teachers undertake field teaching practice in secondary schools nationwide at the end of their first and second years. The two schools involved had three to seven pre-service teachers each.

Initially, during the last week of the semester, pre-service science teachers who were expecting to undertake their field teaching practice in Dar es Salaam region were invited to partake in the study. Those who consented were requested to inform the researcher before the sixth week of the teaching practice. Twenty participants consented to participate. However, six participants, two for each science subject were randomly selected. Participants were Hayodaa and Moya who taught Physics, Amsi and Lohay who taught Biology and Alutoo and Wakri who taught Chemistry. Participants' names are pseudonyms. Students' grade levels they were teaching ranged from form one (13 years old) to form three (15 years old).

3. Results

3.1. Pre-service science teachers' beliefs about science knowledge

The current science curriculum in Tanzania demands teachers to adopt constructivist-oriented learner-centred pedagogies (MoEC, 2005). Therefore, science teachers are expected to portray science knowledge as meaning to be constructed rather than absolute facts to be given and received. However, this study found that pre-service science teachers at the final year of teaching preparations still hold a dualist view of scientific knowledge. In subsequent sections, different categories of pre-service teacher beliefs emerging from the analysis of interview narratives are presented before highlighting respective practices in which teachers' beliefs manifested.

3.1.1. Science questions have single correct answers

The views that science teachers hold about questions they ask when teaching may reveal their beliefs on the structure of science knowledge. Interview responses showed that pre-service science teachers in this study believed that questions they ask in the classroom have single than multiple correct answers. For example, Hayodaa illustrated:

> For example, when I ask the meaning of something which I have just taught in the class, then that should have one constant answer…but even if I ask for example the application Gas laws, there should be a recurring pattern of answers which most students will adhere to when answering.

Talking about this issue, Lohay said:

> You know biology like all other science subjects constitute facts and therefore, questions about them have single correct answers. For example, if you ask a student to define "a nephron" there is only one answer to that isn't it?

Others like Alutoo believe that it depends on the topic and question; though essentially there is one true answer as she commented during the interview "that depends, some topics, for example, you will find … or basically, it depends on the question, when I ask the meaning of something which I taught in the class definitely that has one correct answer". Typical of all pre-service teachers interviewed, these responses illustrate teachers' dualist belief towards scientific questions having simple right or wrong answers.

3.1.2. Science knowledge is subject specific

Pre-service teachers believe that content they teach in a particular science subject is specific to that subject. This was evident in their responses on how they would view students who use knowledge and content from one subject to answer questions in another subject as Lohay expressed:

> You know the knowledge I teach in chemistry is specific to chemistry so I think it would be improper to use an explanation from let's say biology to respond to chemistry question… chemistry examples are chemistry examples, they can't be biology examples.

The comment above illustrates teachers' views that knowledge of one science subject cannot be used to answer questions in another subject. It implies that teachers often view scientific knowledge as isolated facts unrelated to other subjects.

Consequently, pre-service teachers find it very difficult to accept responses drawn from knowledge of subject domain other than those they teach themselves. When confronted with topics taught across scientific subjects, for example, "the scientific method"—a topic taught in all the three secondary school science subjects as per the school syllabus, pre-service teachers claimed that the depth, breadth and language are different even when the same topic is taught across subjects. This is what Hayodaa said:

> It differs, I teach five stages in physics… others teach up to 8 stages. That's how their books indicate but in physics books they indicate only five of them, So you see…now if I ask my students to discuss stages of scientific investigation they can't just pick…those they learned in chemistry or biology…in fact, this is very confusing, I should be asking you how many stages are correct?

For Hayodaa, stages of scientific investigation differ between scientific domains and the correct number of stages depends on what the authority for particular discipline indicates. Moreover, the content of similar topics differs between subjects and the accuracy of content relies on what is written in books for each particular subject. Pre-service teachers struggled to teach topics such as "stages of scientific investigation". This is also related to their views of science as a collection of isolated facts.

Together, the results in Sections 3.1.1 and 3.1.2 provide important insights into pre-service teachers' beliefs about the structure of science knowledge. Generally, they view science knowledge as a collection of discrete facts that are not related to each other. Thus, they may be considered to be holding a dualist view of science knowledge (Mansour, 2013; Schommer, 1990; Tsai, 2002).

3.1.3. Science knowledge is vested in external authority

Typically, pre-service teachers believed that science knowledge is derived from scientific experts, books and teachers. This was evident in the strategies they used to convince students who disagreed with teachers' explanation of a particular scientific phenomenon. For example, Alutoo suggested: "I will give him a book from where I read the explanation about that concept and I'll ask a student to present a book from where he read the contradicting explanation". Similarly, Hayodaa claimed that when confronted by students on what she is teaching, she would tell them what she knew from the books she read first, then she would give more examples from more trusted books. She tells them what she knows from the books she read first, then she gives more examples from more trusted books. She said:

> I will give them what I believe and have read as a teacher, then I'll provide more examples from the books I trust will never make a mistake, for example, in physics, we have books like Principles of Physics or Abbot. (*Principle of Physics by Nuffield or Physics by A. F. Abbot*) in which when something is explained there it is never flawed.

Moreover, pre-service teachers viewed knowledge written in trusted books to be absolutely true. Talking about this issue, Lohay said:

> I will just consult more reliable books like BS (*Biological Science by D. J. Tylor*) or "Understanding" (*Understanding Biology for Advanced Level by Glenn Toole and Susan Toole*). Explanations from these books are always correct.

Notably, pre-service teachers also considered themselves to be knowledge authorities. They share these beliefs with their students, who view teachers as experts with the ultimate knowledge of the subject they teach. As Hayodaa alluded:

> But they trust us … you will hear them saying "this was what the teacher said, we should take as it is"… now if you find them arguing among themselves … or when I met them they will ask and the answer I gave them is often the ultimate resolution for their argument … they believe … so it must be true. So they trust their teacher most.

Overall, when a disagreement about a scientific phenomenon arises in the class, pre-service teachers repeatedly explained and emphasised what they knew as teachers. They also presented the source of their explanation and asked students to present a source with a contrasting explanation. They believed that students are eventually convinced since they trust teachers as knowledgeable authorities. Presenting what they read and the source from where they read is an evidence that pre-service teachers attribute knowledge to external sources. Intriguingly, some pre-service teachers claim that some scientific books are never flawed. Thus, knowledge in such books is considered an absolute truth. According to Schommer (1990), individuals who attribute knowledge to omniscient authorities such as books and teachers hold dualist beliefs about knowledge. These findings concur with Hashweh (1996) who observed that teachers with a dualist view of science employed explanation and repetition to convince students to change conceptions in contrast to the orthodox theories presented by teachers. Similarly, Kang (2008) observed that pre-service teachers who held dualist views of science detached themselves from science. They viewed science as a distinct body of knowledge to be obtained from external sources of knowledge such as the teacher or the textbook. For them, such knowledge can be propagated from such sources to the recipient.

3.1.4. Science as an unchanging body of knowledge

For some pre-service teachers (Hayodaa, Alutoo and Wakri), teachers teach relatively stable scientific knowledge. They expressed this when asked whether variation in the way textbooks explain scientific concepts are due to changes resulting from scientific discoveries. Wakri said:

> Also, as their teacher, I emphasise that... that is what is right. I can't teach lies .... You know in that situation, things do not change that much. We can say there might be additions or reductions. That, this one had this formula and now they have added new explanations to elaborate more but the formula as the main formula do not change. To make oxygen, you follows the same method, nothing else has ever happened but only the language of expression varies.

For Wakri, when variation in textbook explanation arises, she tells what is right. For her, true science knowledge does not change significantly. It is only elaborated upon. Making similar comment, Hayodaa said:

> In physics, for example stating principles and laws remain the same even if this one has used Oxford, another one used Abbot, and another one used Principles, but things remain the same.

For these pre-service teachers, scientific discoveries do not significantly change school science apart from minor additions or reductions. Science knowledge as written in textbooks hardly changes. Thus, from their experiences, teachers or books only differ in the details of explanation but fundamental concepts remain the same. Abd-El-Khalick and Lederman (2000) maintained that scientific theories and laws can never be absolutely proven regardless of the enormousness of empirical evidence gathered to support them, thus subject to change in light of the new discoveries.

3.1.5. Some learners are born capable of learning science, others aren't

Some participants believed that students are born with varying abilities to learn science. Those capable of learning science are born highly intelligent. "Yeah, some students are born less able academically... because science subjects are difficult... require quick understanding... it's hard for them to learn and pass it" (Interview-Moya). Furthermore, they believed that for intelligent students, science learning is quick. "...they vary in their intelligence, those who are more intelligent understand and remember quickly so they answer questions correctly than others..." (Interview-Alutoo).

They view non-science major[2] students to be incapable of learning science and therefore, attempts to push them to improve their performance in science is of little value. Sharing her opinion on this issue, Alutoo admitted: "Aaah that's absolutely true, they can't learn science and if you carefully look, not only that they can't learn science but also the arts subjects they opted for" (interview-Alutoo). This belief is strengthened by low scores in science exams which they perceive as an indication of low intelligence. "They do not only perform poorly in science but even in social science subjects they opted for, they are not doing very well compared to science streams...so even if you work hard to help them, they can hardly excel" (Interview-Lohay).

Together, these responses suggest that pre-service teachers view learning as quick or non-existent depending on the intelligence individuals are born with. For those born less intelligent, sustained effort will not significantly improve their performance. In view of Schommer (1990), teachers who believe learning to be quick or non-existent hold dualist beliefs about knowledge. For them, learning ability is innate and fixed at the time one is born. Teachers who hold the belief that learning must be quick or will struggle to occur at all do not bother to engage students in sustained practice. They stop instantly once a concept is explained because capable students would have acquired it.

3.2. Pre-service science teachers' teaching practices

Science teachers' epistemological beliefs impact their teaching practices (Hashweh, 1996; Tsai, 2002). To examine how pre-service teachers' beliefs about science knowledge manifest in their

teaching actions, three lessons were observed for each participant, focusing on the way they organised the classroom, presented science, asked questions and responded to students' answers. Pre-service teachers' teaching practices were characterised as follows.

3.2.1. Teachers asked factual questions with pre-determined answers

Teachers' views of science knowledge may be manifested in their classroom questioning practices. During the classroom lessons, the type of questions asked, how they were answered, kind of responses sought and teacher feedback provided were observed. Questions were categorised based on the Question Category System for Science (QCSS) (Blosser, 2000). In QCSS, questions are categorised into managerial, rhetorical, close and open. Initial description proposed by Blosser was adopted for all the categories except for rhetorical questions. Findings showed that teachers sought students' affirmative responses apart from using rhetorical questions to emphasise their points. Such affirmative responses which were mostly limited to simple "yes/no" signified students' agreement with teacher's points. It also signalled that students were attentive, on task and understanding. For these reasons, the term "affirmative" was found more sound than "rhetorical". Moreover, close and open questions were divided into sub-categories as indicated in Table 3.

The results shows that pre-service science teachers mostly asked closed factual questions on previous subject content. They sought single, pre-determined and textbook-based answers which often constituted a word (34.36%), a list of items (20.3%), short phrase (8.14%) or an affirmative answer to teachers' question tags (29.18%). They hardly ever accepted students' personal opinions and experiences of the scientific phenomenon as valid answers. Further results are shown in Table 4.

Teacher questioning in which students' answers are pre-determined and restricted to definitions, words, phrases or computations are typical of teachers holding a dualist view of science (Yerrick et al., 1998). Very often, questions were answered by individual students or the whole class in a choral format. Out of the total 946 questions asked by all teachers in three lessons observed, 404 (42.7%) were answered by individual students while 542 (57.3%) were chanted. Teachers could determine correct and incorrect responses by referring to a textbook or lesson notes instead of reasoning. Thus, they

Table 3. Categories of teacher questions (Blosser, 2000 p. 3)

Category	Description	Examples from this study
Managerial	Questions focused on keeping the classroom going	Can I wipe this part of the chalkboard?
Affirmative	Questions requiring simple affirmation of students	Do you know Eureka cane?
Close-word	Questions requiring predetermined single word answer	What is a chemical symbol for Aluminium?
Close-list	Questions requiring a list of short predetermined answers often one to three words long	Who can name types of cells?
Close-define	Questions requiring short predetermined often textbook based definition or description of the concept	What is a cell?
Close-Procedure	Questions requiring short predetermined textbook based list of events/procedures	What steps do we follow when writing the chemical formula?
Open-probing	Questions requiring a wide range of justifiable answers with follow-up beyond the initial answer	What happens when a person with blood group A receives a blood from a person with blood group B? Why?
Open-Divergent	Questions with no definite answers but range of possible answers	Why do people smoke despite known health effects?

Table 4. Major types of questions asked by pre-service science teachers

Major categories	Sub-categories	Total no. of questions in 18 lessons	Average number of questions per lesson	% of each category
Managerial Affirmative		47	3	4.97
		276	15	29.18
Close	Words	325	18	34.36
	List	192	11	20.30
	Define	77	4	8.14
Open	Events/Process	18	1	1.90
	Probing	10	1	1.06
	Divergent	1	0	0.11
Total		946	53	100.00

often followed students' responses with an affirmation e.g. okay, that's right, correct or applause e.g. good, brilliant! It was very unusual to witness a teacher who rephrased, elaborated or built on students' responses or asked students to explain and justify their responses to questions. The introductory part of a lesson by Lohay illustrates the typical practice among pre-service teachers:

(1) Teacher: before we proceed with today's topic … "Cell differentiation and Specialization" let's review what we discussed so far. We discussed the concept of the cell. Who can tell me what is a cell?

(2) Students: no reply.

(3) Teacher: *Walks between rows of desks as he repeats* "What is a cell?"

(4) Students: A couple of raised hands.

(5) Teacher: eeeh! You (*point to one student*).

(6) Student1: Stands up … answers "A cell is a unit of life.

(7) Teacher: No! No! No! The life of what? Another one—you! (*Points to another student*).

(8) Student2: It's the basic unit of life of a living organism.

(9) Teacher: Good! A cell is a basic unit of life of…? (*Cued question*).

(10) Students: chanted "living organism"

(11) Teacher: Okay! What are some types of cells?

(12) Students: Some put their hands up.

(13) Teacher: Yes Pili? (*Not real name*).

(14) Student3: Red blood cells, white blood cells … (*Wants to continue but interrupted*)

(15) Teacher: no no no! Red blood cell, heeeh! No!

(16) Students: other students break into laughter. Ha! Ha! Ha! Ha!

(17) Teacher: another one! You! (*Pointing to another student*)

(18) Students4: Plant cell and animal cell.

(19) Teacher: no! Not at all! (*The class break into even bigger laughter*). Someone else, you! (*Pointing to one student*).

(20) Student5: eukaryotic cell and prokaryotic cell

(21) Teacher: very good! Eukaryotic and prokaryotic cells, okay?

(22) Students: chant "Yes"

(23) Teacher: Now what is a Eukaryotic cell?

(24) Students: silent.

(25) Teacher: what is a eukaryotic cell? (*With stressed intonation*)

(26) Students: silent

The passage above shows that factual questions (move 1, 11, 23), individual/choral responses (move 6, 8, 10, 22) and affirmative/praise feedback (move 9, 11, 21) featured in this lesson. Notably, Lohay rejected responses by students 3 and 4 and accepted response by student 5. When asked why this was the case, Lohay claimed: "that's what I taught them, types of cells are eukaryotic and prokaryotic… the other two weren't correct". This suggests that the teacher views differences in students' knowledge to be errors rather than a personal interpretation of questions. They attribute students' responses which diverge from textbook knowledge or lesson notes to low intelligence. Sharing his experience, Amsi commented:

> …those who are more intelligent understand and remember quickly so they answer questions correctly than others. They (students) easily memorize… because in science they have to answer questions as taught, not the way they see or feel it is correct to answer.

This excerpt shows that Amsi attributed the ability to understand, remember and answer questions correctly to student's intelligence rather than learning effort. For Amsi students', opinions don't count as valid responses to scientific questions. Such patterns of classroom questioning illustrate a dualist view of science knowledge. In a similar study, Mansour (2013) observed that Egyptian teachers who held objectivist beliefs on science bound students to adhere to and memorise science knowledge written in science textbooks.

3.2.2. Teachers bind student questions to immediate topics

Beliefs about science topics as isolated bits of knowledge were further demonstrated in the scenarios where students asked questions about previous topics or topics not directly related to the one that was taught. Pre-service teachers' responses demonstrated their disapproval of questioning beyond the ongoing lessons. Vignette below is typical of several similar scenarios observed:

(1) Teacher: after describing Charles' law and its mathematical representation, Hayodaa asked "do you understand?

(2) Students: In unison "Yes"

(3) A boy: raised hand

(4) Teacher: eeeeh! You (*points to the boy*)

(5) A boy: stood up and asked, "madam when we were discussing the expansion of liquids we said when liquids expand molecules move apart causing an increase in volume, are molecules of liquid faster than solid when they move apart? Because…" (*Interrupted*)

(6) Teacher: That's about the previous topic isn't it? You can't ask that! Now we are talking about gas laws. You should come to the office in your own time if you want to ask about that.

(7) A boy: Sits down.

Although the thermal expansion of substances, whether gas, liquid or solid is the same topic, Hayodaa treated these as isolated topics, consequently rejecting student's question. This illustrates the teacher's reluctance to allow questions or engage in subjects apart from those they are teaching at the moment. Most importantly, it indicates their view of science knowledge as discrete facts to be learned disparately. Concerned with disrupting the lesson flow, Hayodaa claimed: "…such a question will drive students' attention away from the ongoing lesson and disrupt the flow". Questions about different topics could be used to foster discussions and link various topics to achieve holistic understanding. Since lessons conducted with minimal interruption are considered successful, dualist science teachers often use multiple tactics to excise greater control. These include limiting students'

question to topics they want students to learn (Yerrick et al., 1998). They even confront and admonish students when their questions interrupt classroom routines.

3.2.3. Exploring recollection of previously taught knowledge

Ideally, students hold ideas about the world around them far before they encounter school science. These ideas are resistant to change unless schematic restructuring is induced in a learner's mind. The way participants explored students' prior experiences, the strategies they used and the purpose of doing this was noted. Results showed that teachers explored students' knowledge of previously taught content for three reasons. First, it was a ritual practice with a lack of rationale for doing it. "We just revise the last lesson because it is a first stage in the lesson plan, so we must do it" said Lohay during the post-observation interview. Thus, a teacher who forgot to review the content of the previous lesson could review it in the middle of the next lesson. Second, they do it to assess if students remember the content of a previous topic. "I want to find out if they remember what I taught them last period, you know some of them closed their exercise books since the last lesson and they never revised what they learned" said Wakri.

When reminding students about a previous lesson, teachers asked questions (Amsi, Lohay, and Moya), gave explanations (Alutoo) or asked questions and gave explanations (Hayodaa) about a previous topic. Often when they asked questions, students revealed their misconceptions of the previous topics by giving what most teachers considered being wrong answers. Most frequently pre-service teachers ignored these misconceptions and invited volunteers to provide correct answers (Hayodaa, Amsi, Lohay, and Alutoo). An excerpt from the introduction phase of a Chemistry lesson by Alutoo is illustrative of common practices:

(1) Teacher: We are going to introduce you to the mixture and types of mixture. So before proceeding, let's complete a short revision of compounds and elements. So please define the meaning of compound. What is a compound?

(2) Students: Initially listening, then some put up their hands.

(3) Teacher: Repeated "what is a compound? eeeeh! Yosef.

(4) Yosef: Stood up and answered "it is the mixture of two or more elements chemically combined together"

(5) Teacher: Congratulations! Another one! What is an element? Who can define an element?

(6) Students: Some of them enthusiastically raise their hands to bid for the chance to respond.

(7) Teacher: eeeeh Maria!

(8) Maria: "it is the combination of two or more elements chemically combined together" (*she actually defined compound but not an element*).

(9) Teacher: okay! Thanks for trying. Another one? You!

(10) Student: Stands up and answers "an element is a single pure substance that cannot be separated into simpler substances".

(11) Teacher: Very good. Another thing we looked at is the 20 first elements. So before proceeding who can write the chemical symbol for Aluminium?

The above excerpt shows a question and answer strategy employed by Alutoo to assess students' memory of basic facts covered in a previous lesson. Maria's response to teacher's question (move 5–10) reveals her misconception on the difference between the meanings of element and compound. Alutoo's follow-up shows that she noticed the confusion but chose to invite another volunteer to provide the correct answer. Occasionally, some pre-service teachers (Moya) repetitively explained the correct answers whenever they detected misconceptions in students' responses.

Generally, pre-service teachers revised the content of a previous lesson to remind students and assess their knowledge. However, they rarely explored students' prior experiences with the new

topic to be taught. Possibly, pre-service teachers do not acknowledge the existence of alternative views of the world around students apart from the mainstream science topics they plan to teach. In rare cases, when students' misconceptions are demonstrated, especially when students answered questions, teachers either ignored these alternative conceptions or explained the correct answers. Strategies that promote conceptual change were rare. These findings are typical of teachers holding dualist beliefs of scientific knowledge (Hashweh, 1996). Hashweh observed that dualist teachers were less likely to detect students' alternative conceptions of science. Even when they did detect them, they either ignored them or repeatedly explained the correct answer or the standard concept. These strategies rarely fostered conceptual change among students who held alternative conceptions.

3.2.4. Teachers adopted transmissive teaching strategies

The most frequently observed teaching strategies included verbal explanation interspersed with question–answer sessions. Occasionally, teacher demonstrations and students organised in small groups to copy responses from textbooks (misleadingly regarded as discussions) were used. In this approach, students watched and faithfully listened to teachers who apparently served as science knowledge repositories. Teachers conveyed knowledge through verbal instructions by explaining concepts and writing notes on the chalkboard. Students received knowledge and copied notes. Similar practices were reported among pre-service science teachers in the US by Kang (2008). Kang observed that pre-service teachers holding dualist beliefs on science taught by disseminating science knowledge, restraining the role of students to passive listening.

To check if students were following, teachers occasionally asked questions which elicited collective choral responses often limited to a word, phrase or simple affirmation. During question and answer sessions, it was the teacher who initiated questions and approved the validity of students' responses. Occasionally, students observed teacher demonstrations, discussed in small groups and asked questions. In two cases (Hayodaa and Amsi) where they were asked to discuss questions provided; students in their groups assisted each other in identifying answers from the textbook, copied it onto a piece of paper and assigned one member to read it out to the rest of the class. This pattern of teaching is described as transmissive teaching by Mansour (2013) who observed similar practices among Egyptian teachers. Mansour reported that teachers who held objectivist views of science conducted teaching using teacher-centred pedagogy. They talked most, made decisions and conveyed textbook-based ideas in class.

Teachers also adopted a traditional classroom set-up consistent with the teaching strategies they employed. Students were typically seated in straight rows, one behind the other, all facing the chalkboard. The entire classroom constituted 5–7 rows of 6–8 chairs and tables depending on whether the school was private or community, with the community schools being overcrowded. Teachers stood at the front near the chalkboard, from where they conveyed knowledge verbally. Similarly, Yerrick et al. (1998) observed that interaction pattern in which a teacher stood almost exclusively in front of the class gave a sense of teacher domination over students. This conveyed a clear message about the expected forms of students' participation. This type of set-up is desirable in contexts where teaching is intended to disseminate knowledge with minimal student–student interaction and maximal teacher-whole class communication (McCorskey & McVetta, 1978).

Overall, teachers conveyed knowledge, wrote notes on the chalkboard, asked questions, determined correct responses, and occasionally demonstrated concepts. It was a routine similar to the one reported by Yerrick et al. (1998), in which a teacher explained concepts and presented formula. Students listened, received teachers' instructions, copied notes on their notebooks, answered teachers' questions and occasionally sat in groups to copy answers from textbooks. This pattern of teacher and students' roles is characteristic of dualist teachers. Similar observations by Mansour (2013) suggest that teachers who hold dualist views of science treated students as passive receivers of knowledge. Mansour further observed that these teachers dominated instructions in their classrooms and

adopted more transmissive teaching strategies when teaching. Meanwhile, relativist teachers adopted more transformative teaching strategies.

3.2.5. Correct answers are science textbook-based

An interesting observation during the question and answer sessions was that pre-service teachers accepted some answers and rejected others. They verdict on the validity of students' responses to questions. Extract from a lesson by Lohay illustrate:

(1) Teacher: Re-read his explanation while underlining key words and phrases.

(2) Students: Listen, sometimes repeat words after the teacher or complete incomplete sentences that the teacher leaves.

(3) Teacher: what are the reproductive parts of plants?

(4) Students: Silent. None of them volunteer to respond.

(5) Teacher: He complains "Aah! You did this last time, don't you remember?", then he points to one student "you tell us"

(6) Student1: Stand up, "stem"

(7) Teacher: Stem! No! Another one?

(8) Student2: Stands up and answers "Pollens"

(9) Teacher: No!, You! (*Point to another student*)

(10) Student3: Stands up and responds "Ovum or ovule"

(11) Teacher: Organ! Organ! Organ! (Repetitively said "Organ" to cue an answer he was seeking**)**.

(12) Students: Ha ha ha ah! (Laugh)

(13) Teacher: The reproductive parts of a flower are the male flower and the female flower. We did this last time, how come you don't remember! (*Pause then proceed*) So in vegetative reproduction part of the plant develops into a new plant without association with flowers. Is that clear?

(14) Students: chanted "yes"

(15) Teacher: Vegetative propagation has two types: natural vegetative propagation and artificial vegetative propagation.

(16) Students: listening.

(17) Teacher: So there is natural and artificial what?

(18) Students: chanted "vegetative propagation"

In this vignette, Lohay was initially writing lesson notes on the chalkboard before he began reading them (move 1–2) during which he also underlined key terms and phrases. I asked the reason for highlighting words and phrases in the notes and he commented "these are the things they should keep in mind, you know most of them don't even know what to read". This means he was highlighting concepts that students had to remember. Questions and answer exchange followed (move 3–14) in which the teacher judged whether the answer was correct or not. His question "what are the reproductive parts of plants?" elicited divergent but equally plausible answers. Divergent responses reflected a varied interpretation of the teachers' question since all the parts they listed are involved in reproduction though the stem is usually common in non-flowering plants. However, Lohay rejected most of these responses in search for a pre-determined answer. To prompt the expected answer he cued by repeatedly pronouncing organ! Organ! Organ! (Move 11). Even with the cue, students couldn't respond correctly. Consequently, Lohay had to answer the question himself. He then continued presenting facts, occasionally involving students in chanting (move 13–18).

When similar practices were observed in other pre-service teachers' lessons, I asked why they considered certain facts to be the only valid answers to questions they ask in class. Most of them claimed that it's because they are written in textbooks. A response by Hayodaa illustrates this:

> That's how the nature of the graph is explained in my textbook (the graph showing the relationship between volume and temperature as per Charles' law of gas expansion). I copied the same explanation when constructing my lesson notes. That's what I wrote on the board … and students copied the same in their notebooks. That's why I used that explanation.

Responding to a post-observation interview question on how he decided on correct answers and what he would have been done when disagreement arose, Amsi commented:

> I know if the answer is correct because I know biology, I have learned it myself. I can compare their answers with what is written in textbooks. Disagreement between students rarely happens with this kind of students I have. When they disagree I will ask the source from where they got the answers they disagree on. I will read the source myself or consult experienced peers.

These findings suggest that pre-service science teachers considered textbook-based answers to be the most valid answers. They believed science facts written in textbooks to be the most credible and representative of reality. Thus, they judged the validity of students' responses based on textbook knowledge. Consequently, when students answered teachers' questions using exact replicas of the answers from textbooks or teachers' notes, their answers were easily accepted as correct by the teacher. However, when they responded based on their own reasoning or experiences, their answers were not accepted. Such students who answered questions from their own point of views were not given the opportunity to elaborate on their responses or justify their claims.

4. Discussion: linking Pre-service teachers' beliefs with teaching practices

Research shows that teachers' beliefs about science knowledge may not directly translate into their classroom practice (Abd-El-Khalick & Lederman, 2000; Tsai, 2002; Waters-Adams, 2006). Factors beyond teachers' beliefs including the nature of students, scarce resources, pressure to cover the curriculum and assessment accountability also affect practices (Kang, 2008). In contrast, this study found cogent correspondence between pre-service teachers' dualist beliefs about science and their practices.

Pre-service teachers appeared to view science as right or wrong knowledge. They believed that each science question has a single correct answer. Consequently, they asked factual questions and sought single pre-determined answers which were based on a textbooks or teachers' lesson notes. In doing so, they rejected responses which were based on reasoning and opinion. Moreover, they viewed the content of a particular topic or subject to be specific to that topic or subject. Thus, when teaching, they tended to reject questions about topics or subjects other than those they were teaching at a given moment. They hesitated to accept explanations drawn from other subjects/topics in responding to questions they asked in class. In general, it seems pre-service teachers view science as discrete, unrelated facts rather integrated set of concepts.

Consistent with their belief that science is vested in external authorities such as teachers and books, pre-service teachers tended to reject students' responses other than those based on textbook or teacher lesson notes. They believe textbook-based science ideas to be the most credible and representative of reality. Thus, when they asked questions in the class, they expected exact replicas of responses from the textbook or teacher's lesson notes. For these teachers, answers based on reasoning and students' experiences appear to be invalid. In addition, pre-service teachers viewed science knowledge as a gift that they, as experts of the subjects they teach, hold. Consequently, they viewed their role in teaching as a simple transfer of given knowledge to learners whose role is bound to passive reception. In practice, they employed transmissive teaching strategies which were also evident in the way classrooms were set up.

Pre-service teachers viewed the ability to learn science as inborn. Consequently, some learners are born capable of learning science while others aren't. They view efforts geared at fostering science learning for non-science majors as insignificant. Basing on these tendencies, it could be argued that pre-service teachers in this study may be holding dualist views about science knowledge (Schommer, 1990). It is also likely that pre-service teachers' views are connected to their teaching practices. These results are consistent with those by Kang and Wallace (2004) who observed that teachers' beliefs about science are clearly reflected in their teaching practices.

Tsai (2002) argued that science teachers' have a tendency to view science as a certain, established body of knowledge, and teaching as a mere transfer of this knowledge to students. Tsai argued that this attitude is likely rooted in science teachers' own schooling and training experiences. This is possible if during their schooling and teaching preparation teachers were highly exposed to dualist views of science and instructions. The way science is taught in schools and teacher education colleges may have strengthened dualist views of science among pre-service and in-service science teachers (Tsai, 2002).

Another possible explanation is that such views of science knowledge might be rooted in traditional African epistemologies. In some African cultures, knowledge and truth comes from ancestors (the roots of the society) through divine revelation to privileged elders. Such knowledge, which is believed to be prefabricated, ready for use and challengeable only through subsequent revelation, is handed down by elders to minors through initiation and rituals (Guthrie, 2011; Hamminga, 2005; Tabulawa, 2013). Thus, in some African cultures, elders' opinion is certainly considered the infallible truth. Guthrie (2011) described this approach to knowing as a revelatory epistemology. The same may apply for knowledge handed down by authorities. Moreover, in most African cultures, togetherness, which is achieved through collective agreement, is the most valued aspect of social relations. Consequently, scientific values such as scepticism, questioning authority, seeking evidence and reasoning, are not generally welcomed (Hamminga, 2005).

5. Conclusion and implications for pedagogical reforms in Tanzania

Research shows that teachers holding dualist views about knowledge and knowing are more resistant to teaching reforms (Patrick & Pintrich, 2001; Sinatra & Kardash, 2004), while those with relativist views are more receptive to intervention and less resistant to teaching reforms (Feucht, 2010; Gill, Ashton, & Algina, 2004). This study has shown that pre-service science teachers in their last year of teacher training appear to be holding dualist views of science knowledge. Moreover, pre-service teachers are upholding transmissive teaching practices consistent with their views about science knowledge and knowing. It can thus be suggested that, the resilience of transmissive teaching practices in Tanzanian schools may be partly rooted in teachers' beliefs about science knowledge and knowing. Yerrick et al. (1998) argued that for reforms that promote new ways of teaching and learning to succeed they should be accompanied by alternative views of science and teaching. Thus, in addition to the mainstream beliefs, science teachers need critical stance about scientific knowledge. Such views might be more conducive to learner-centred teaching reforms.

However, studies indicate that entrants of initial teacher education often hold beliefs which may not necessarily align with the reform-based teaching practices (Abd-El-Khalick & Lederman, 2000; Deniz, 2011; Tsai, 2006). These beliefs about knowledge, teaching and learning are known to be resistant to change (Markic & Eilks, 2010; Nespor, 1987). Beliefs often remain unaltered if deliberate efforts are not made to change them. Findings in this study highlight the need for teacher education programme equipped with trajectories designed to explore, challenge and transform pre-existing beliefs. Such trajectories should help prospective teachers become reflexive and self-conscious of their beliefs (Nespor, 1987). It should also provide alternative beliefs upon which they can draw to replace the old ones. Trajectories that provide opportunities for teacher trainees to explicitly reflect upon their pre-existing epistemological beliefs has demonstrated promising results in some contexts (Brownlee, Purdie, & Boulton-Lewis, 2001; Deniz, 2011; Markic & Eilks, 2013; Tsai, 2006). Brownlee and others, for example, reported about the teacher education programme that

successfully fostered the development of more sophisticated epistemological beliefs. The programme involved encouraging pre-service teachers to explicitly reflect on their epistemological beliefs. In Tanzania, what is needed is to incorporate aspects of science teacher beliefs in the initial teacher education programme. Also, science teaching reform efforts need to focus on changing teacher beliefs beyond orienting teachers on the skills and knowledge required to the implement reforms.

Moreover, since beliefs are resistance to change, thus likely to exert a sustained influence on the learning to teach and eventually teaching practices, sustained efforts to foster aspired beliefs is imperative. This will inevitably require collaboration between teacher education institutions, curriculum developers, Ministry of Education and schools in Tanzania. The weak synergy between these agencies is likely to make changing teacher beliefs unsuccessful.

The impact of learning trajectories on teacher beliefs and its sustainability may be interim in the cultural context where values of the broader society are countervailing. This raises questions about the relevance of learner-centred constructivist-oriented teaching reforms publicised for the cultural context dominated by revelatory epistemology (Guthrie, 2011). This is because the assumptions about legitimate knowledge, how it comes into existence and how it can be known that underlie revelatory epistemologies may be incompatible with the aspired learner-centred teaching and learning (Tabulawa, 2013). Whether the differences between the revelatory epistemologies dominant in African cultures and learner-centred pedagogies grounded in western scientific epistemologies can be reconciled is the subject of debate and research. Further research in this area may illuminate the possibilities for reconciliation.

Funding
The author received no direct funding for this research.

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Citation information
Cite this article as: Pre-service science teachers' epistemological beliefs and teaching reforms in Tanzania, Albert Tarmo, *Cogent Education* (2016), 3: 1178457.

Notes
1. This is the formal teacher education programme for secondary school science teachers in Tanzania.
2. Students who opt for social science and language subjects e.g. history, geography.

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