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Pre-service science teachers' understanding of argumentation

Senait Ghebru and Meshach Ogunniyi

Abstract

The study is part of a larger project concerned with addressing the problem that Eritrean science teachers face in their attempt to implement a new learner-centred science curriculum. Specifically, the study attempted to determine the effects of the use of an Argumentation-Based Instructional Model (ABIM) on 25 pre-service science teachers' understanding of argumentation and its role in science teaching. Responses to an open-ended Learner-Centred Argumentation Instruction Questionnaire and interview responses were analysed qualitatively using open coding and the generation of categories. The Contiguity Argumentation Theory categories were also used to describe the type of cognitive shifts made by the group of pre-service teachers. The findings show that as a result of their experience with ABIM, the participants: (a) made noticeable cognitive shifts from seeing argumentation as a debate to win a case to a form of dialogue for reaching consensus; (b) became aware of the difference between everyday and scientific types of argumentation; and (c) came to recognize the important role that argumentation could play in science education.

Introduction

Since 1991 the education system and the science curriculum in Eritrea have been continuously revised and updated to compliment the on-going programme of nation building (Ministry of Education, 2010). In 2005, the Ministry of Education revised the curriculum at all levels into a learner-centred curriculum (LCC) (Ministry of Education, 2005). The aim of the LCC has been to transform classroom discourse from a predominantly teacher-centred to a learner-centred one in order to promote learners' participation and engagement with the learning process. As in other countries, studies and official documents indicate that science classrooms in Eritrea generally lack discursive exploration of scientific ideas or their implications even after the introduction of the LCC (e.g. Altinyelken, 2010; Aksit, 2007). Yet LCC-based studies have consistently recommended a pedagogy that would encourage discussion and inquiry. In this regard, argumentation instruction has been found to encourage classroom discussion and inquiry activities in science classrooms (e.g. Ogunniyi, 2007). However, such a teaching approach as has been noted in other countries (e.g. Erduran, Simon & Osborne, 2004; Ogunniyi, 2007) was hard to find in Eritrean classrooms.

The paucity of argumentation instruction in science classrooms is largely because teachers lack the knowledge and skills to use such an approach in their teaching (Lawson, 2003). Zohar (2008) indicates that, to use argumentation instruction, science teachers need to make a fundamental shift in their pedagogical understandings. In agreement with this view, this study introduced the concept of argumentation to a cohort of Eritrean pre-service science teachers (PTs) and trained them on how to implement argumentation instruction in science classrooms. The effectiveness or otherwise of argumentation and argumentation instruction in enhancing teachers' and PTs' ability to generate classroom discourse has been reported in several studies (e.g. Aydeniz & Ozdilek, 2015; Dawson & Venville, 2010; Ogunniyi, 2007). This is because their understanding of the protocols of argumentation is critical to their ability to generate a participatory classroom.

While these earlier studies were conducted in a socio-cultural environment where children are empowered to share their ideas with their elders (e.g. teachers, parents), the current study was carried out in a conservative socio-cultural environment were children are prohibited from doing so. Such traditions tend to hinder Eritrean children's personal development. Consequently, most Eritrean PTs have difficulty in expressing their viewpoints freely in class discussions. In addition, the instructional practices employed in Eritrean classrooms are highly dominated by a teacher-centred approach. Thus, the PTs had little exposure to teaching strategies that are associated with a learner-centred approach. It is in the light of this background that the current study attempted to examine the effect of the ABIM on Eritrean PTs' understanding of argumentation and its role in science teaching. The current study further attempted to explore the specific aspects and activities of the intervention training programme that contributed to changes in the PTs' understanding of argumentation and its role in science teaching.

Purpose of the study

The aim of the study was to determine the effects of ABIM in enhancing PTs' understanding of argumentation and its role in science teaching. In pursuance of this aim, the study was guided by the following questions:

- What conceptions of argumentation did the PTs hold before and after being exposed to an argumentation-based instructional model?
- What views did the PTs hold about the role of argumentation in science teaching before and after being exposed to ABIM?
- What aspects of ABIM contributed to changes in the PTs' understanding of argumentation and its role in science teaching?

The intervention: Argumentation-based Instructional Model

Training material for the Argumentation-based Instructional Model

Learning materials for the training of PTs in the use of Argumentation-based Instructional Model (ABIM) were adapted from Ideas, Evidence and Argument in Science Education (IDEAS) developed by Osborne, Erduran and Simon (2004) for professional development of practising science teachers in the UK. Slight modifications were made in order to adjust to the developing nation (i.e. Eritrean) context, in terms of the topics stipulated in the middle

school science curriculum, the limited availability of teaching-learning materials and the physical environment of Eritrean classrooms.

Implementation of ABIM

An argumentation-based intervention training programme was organized for the PTs for a period of three weeks. The main purpose was to equip them with the pedagogical knowledge and skills that could enable them to employ ABIM in science classrooms. The training, conducted five times a week, formed an integral part of the teaching practice course that was offered during the second semester (final term) of their diploma programme. Each training session included a three-hour workshop based on a modified version of the IDEAS workshop (Osborne et al., 2004). The total time allocated for the training sessions was 45 hours (i.e. 3 hours/session × 5 days × 3 weeks).

The programme underpinned by argumentation theories entailed the integration of different aspects of the learner-centred curriculum (LCC), learner-centred instruction (LCI) and the nature of science (NOS). The training comprised four parts: (a) an overview of LCC and LCI; (b) an overview of the different aspects of NOS; (c) an introduction of the concept of argumentation; and (d) a practice in learning- to-teach an argument-based lessons. To save space only a summary of the content delivered during the third part of the programme, i.e. the 'introduction of the concept of argumentation' has been presented in this paper. Argumentation was introduced by providing topics for discussion close to the PTs' everyday experiences. The PTs were then introduced to the idea of 'evidence' and its importance in supporting or refuting claims and in building strong arguments. They were also introduced to the concept of scientific argument (as opposed to argumentation people use in their daily lives), emphasising the need for providing scientific evidence to support scientific knowledge claim using Toulmin's argumentation pattern (Toulmin, 1958/2003) and its elements, e.g. claims, data, warrants, qualifiers, backings and rebuttals. The notion of grounds of an argument was introduced by combining data, warrants and backings of an argument into a single term (Erduran et al., 2004). PTs were then introduced to the notion of what makes a good argument (Osborne et al., 2004) including its features and language. Examples of warranted and unwarranted evidence were also provided. Each session was concluded by explaining the centrality of argumentation in science teaching. All the lessons were task-based and framed by ABIM which was deployed to scaffold the discussion.

Methodology

This case study involved 25 (16 males and 9 females) PTs who were enrolled in an institute of higher education in Eritrea. The PTs were diverse in terms of age, gender, socioeconomic backgrounds, ethnicity and religious beliefs. None of them had taken any formal course work, workshops or seminars on argumentation before the intervention. The study adopted a qualitative interpretive research method (Najike & Lucas, 2002). The data-set was derived from the PTs' responses to the Learner-Centred Argumentation Instruction Questionnaire (administered before and after the intervention) to address research questions 1 and 2, and reflective interview responses to address all the research questions. Specifically, the questionnaire was developed based on critique from five science education experts, whose

rating showed a Spearman rank difference of 0.92, indicating a strong face validity, content validity and construct validity. Subsequently, the adjusted questionnaire was piloted. For this study the first three open-ended questionnaire items are used for soliciting views about (a) argumentation, (b) the differences between scientific and everyday argumentation and (c) the role of argumentation in science teaching. The individual reflective interview was administered towards the end of the study. It required the PTs to reflect on their understanding of argumentation and its role in science teaching from the start to the end of their participation in the study. It also required the PTs to indicate aspects of the intervention programme that contributed to the changes in their views of argumentation and its role in science teaching. The interview schedule was critiqued by the same panel of experts for face validity, content validity and construct validity. All interviews were audio- and video-recorded with accompanying field notes, and the recordings were transcribed verbatim. Data collected from both instruments were analysed qualitatively using open coding and the generation of categories and subsequent themes using a grounded theory approach (Strauss & Corbin, 1990). Content analysis of text was used according to Silverman (2001, p. 122) by establishing categories and 'then counting the number of instances those categories are used in a particular section of text, thus gauging a level of significance of the categories'. Two researchers coded the data and identified broad codes/themes independently. The initial inter-rater agreement was 81%. After discussion and further review, the researchers reached an agreement of 90%.

The Contiguity Argumentation Theory (CAT) categories developed by Ogunniyi (2007) were also used to describe the type of changes evident in PTs' viewpoints about argumentation. The two researchers identified and judged the nature of the perceptual shifts using CAT categories. CAT draws on several theoretical constructs such as the Platonic–Aristotelian contiguity association theory as well as Ubuntu—the central African worldview theory which stresses the relatedness, reciprocity, complementarity and unity of ideas (Ogunniyi, 2007). It explores both logical and non-logical affective and socially embedded issues critical to the attainment of cognitive harmony. CAT consists essentially of five dynamic cognitive states that an arguer might use to appraise and adapt to different contexts. The five categories are:

- dominant —one idea exerts more cognitive force than the other;
- suppressed —an idea that was previously dominant becomes suppressed in favour of a more powerful idea;
- assimilation —the weaker idea becomes assimilated or incorporated into a stronger idea;
- emergence —newly acquired ideas not previously existing or clearly formed in the mind;
- equipollence —where two competing ideas exert equal cognitive force on the mind (Ogunniyi, 007).

Results

Pre-service teachers' conceptions of argumentation

A summary of the findings based on the pre- and post-intervention Learner-Centred Argumentation Instruction Questionnaire responses are presented in Table 1. To ensure confidentiality, participants are designated as PT1, PT2 and so on.

Before the intervention, the PTs described argumentation in various ways. Slightly more than a third of the PTs (36%) associated argumentation with the delivery of information using examples. For instance PT5 said: 'I think argumentation is a process of presenting ideas or information using concrete examples from our daily life'. Eight PTs (32%) described argumentation as a discussion or debate rather than framing it through the language of critical discussion or reasoned discourse. One such PT said: 'Argumentation is a process whereby two or more than two people have a discussion or a debate on a certain topic or issue' (PT16). About one-quarter of the PTs (6) defined argumentation as a dialog to win the argument. The following view is representative of these PTs' understanding of argumentation.

Argumentation is a type of discussion but rather in a quarrel form where members disagree and shout at each other to win the argument (PT8).

Only a very few PTs (8%) at the pre-test seemed to have a valid understanding of argumentation before the intervention. For example, PT12 at the pre-test described argumentation as follows:

I think to engage in argumentation is to be able to speak about an issue by reasoning or proofing it on the basis of evidences.

Table 1. Pre-service teachers' pre-and post-intervention views about argumentation

Response theme	Categories	Pre-test frequency (%)	Post-test frequency (%)
Understanding of argumentation	Presenting an idea using concrete example	9 (36)	
	… a discussion or debate	8 (32)	4 (16)
	… a dialog but rather in a quarrel form *to win the argument*	6 (24)	
	Attending critically to others argument		4 (16)
	Supporting or refuting a claim by giving reasons	2 (8)	10 (40)
	Debate and negotiation to reach mutually acceptable conclusion through logical and non-logical reasoning		7 (28)
Total		25 (100%)	25 (100%)

After the intervention, however, the majority of the PTs (84%) had a reasonably good understanding of argumentation. Some defined argumentation as a means of supporting or refuting a claim by giving logical and sometimes non-logical but socially justifiable reasons to justify their claims. Others defined argumentation as a means to debate and negotiate in order to reach mutually acceptable conclusions based on plausible reasoning. Still others described it as assessing critically other people's argument and expressing one view or another about it. As examples, PT5 and PT8 changed and expressed their views about argumentation at the post-test stage as follows:

I think argumentation is a process where two or more people discuss on controversial issues and supply evidence to either support or oppose one's claim. (PT5) Argumentation is an activity where individuals who hold contrasting positions attempt to convince each other's claim using evidence. (PT8)

PTs were further asked in the interview to reflect on and express their views about argumentation at the time they started participating in the intervention and at the end of the intervention. The PTs responded that the intervention programme helped them to change their views about argumentation. This was succinctly articulated by PT8 who stated that:

Initially, I thought that argumentation is a debate in a form of quarrel between two or more people to win an argument. After the intervention, I have learnt that in argumentation arguers have to think in advance on how to back up their claim to convince the discussion partners before airing out their views using logical and non-logical reasons.

The excerpts above show that both PT5 and PT8 made a noticeable perceptual shift from their initial stance at pre-test. For instance, the shift in PT8′s view from seeing argumentation as a debate to win the argument at the pre-test, to that of construing argumentation as a means of justifying a claim using plausible evidence is evident in his response during the post-test. In terms of CAT, it could be said that his pre-test views of argumentation (which was dominant) have become suppressed as a more cohesive understanding of argumentation gradually emerged. In other words the emergent idea about argumentation replaced the older which construed an argument as a debate or contestation to win a case.

Pre-service teachers' understanding of everyday vs scientific argumentation

PTs' understanding of scientific argumentation was probed by inviting them to describe the differences between everyday argumentation and scientific argumentation. A summary of their views is presented in Table 2.

Initially, slightly more than half of the PTs (15 or 60%) pointed out that there is no difference between scientific and everyday argumentation *as both are concerned with reaching consensus*. In other words, more than half did not realize that a scientific argumentation is presented in a formal mode and has less competitive role than is the case in its everyday usage. Although 10 of PTs (40%) seemed to be aware of the differences between scientific and everyday argumentation they had vague conceptions about the differences between the two forms of argumentation. Some of these PTs noted that, in everyday argumentation, arguers use their experiences to back up their knowledge claims while in scientific argumentation arguers mobilize content-based evidence such as scientific theories and principles to support their claims. Other PTs stated that, in everyday usage, argumentation is characterized by disagreement among arguers, whereas in science, argumentation is characterized by a conversation in which arguers easily reach consensus. The following excerpts taken from PTs' questionnaire responses are representatives.

In everyday argumentation arguers argue on the basis of their experiences; whereas in scientific argumentation the arguers or debaters elaborate their view based on scientific knowledge. (PT16) Everyday argumentation is characterized by disagreement between two or more people which may create undesirable behaviours such as, quarrelling, shouting to one another and there is a high probability that the arguers may not reach consensus; whereas in scientific argumentation arguers never disagree because they all provide reasons with reference to scientific knowledge which are absolute. (PT13)

Table 2. Pre-service teachers' pre-and post-intervention views about the difference between everyday and scientific argumentation

Response theme	Categories	Pre-test frequency (%)	Post-test frequency (%)
Differences between scientific and everyday argumentation	No, both are used to reach to a common point or conclusion	15 (60)	5 (20)
	Yes, in everyday argumentation arguers argue on the basis of their experience; whereas in scientific argumentation the constructed arguments are based on scientific knowledge	6 (24)	
	Yes, in everyday argumentation there is a high probability of disagreement among the arguers; whereas in scientific argumentation arguers never disagree because they all provide reasons on the basis of scientific knowledge which are absolute	4 (16)	
	Yes, in everyday argumentation most arguers are emotional and defensive rather than providing reasons for their claim; whereas in scientific argumentation arguers are not defensive and attempt to provide evidence to justifying the claim or conclusion made		6 (24)
	Yes, in everyday argumentation arguers reach to a conclusion but don't attempt to validate it using acceptable evidences; where in scientific argumentation arguers attempt to construct and validate a conclusion on the basis of legitimate evidences. In everyday and scientific argumentation arguers may agree or disagree.		14 (56)
Total		25 (100%)	25 (100%)

However, after the intervention, the data showed that about half of the PTs (56%) had better understanding of the difference between the two forms of arguments than was previously the case. Some of these PTs indicated that in everyday argumentation arguers do not tend to validate the acceptability of the evidence that supported the claim; whereas in scientific argumentation arguers attempt to construct a conclusion and validate it with acceptable pieces of evidence. Others noted that in both forms of argumentation the nature of the dialogue

may be pleasant or unpleasant. PT16 and PT13 expressed their views about the two forms of argumentation at the post-test stage as follows:

In everyday argumentation arguers could reach to a conclusion but don't attempt to validate it using evidences; where in scientific argumentation arguers attempt to construct and validate a conclusion on the basis of legitimate evidences. (PT16) As in the case of everyday argumentation, in scientific argumentation arguers may agree or disagree when discussing on controversial issue … In both forms of argumentation the dialogue may range from pleasant to unpleasant. (PT13)

It is notable that the PTs responses to the reflective interview in relation to this item was that ABIM and related activities assisted them to (a) realize the difference between the two forms of argumentation and (b) describe scientific argumentation more clearly than was previously the case before. For instance PT16 stated that:

Initially, I was aware that the two forms of argumentation are not the same. Yet, I had misconceptions about the two forms. I thought that everyday argumentation is based on personal experiences; while scientific argumentation is grounded on well-articulated scientific theories or principles. During the intervention I was able to have a better picture of scientific argumentation. I began to realize that in scientific argumentation a claim is accompanied with specific structure. It requires arguers to generate adequate explanations and validate them using appropriate evidence and reasoning.

A perusal of the above excerpts reveals that both PT16 and PT13 made a considerable perceptual shift from their views at pre-test. For instance, the dominant stance of PT16 at pre-test stage was: 'in scientific argumentation the arguers use scientific theories and principles to back up the knowledge claim while in everyday argumentation the arguers use their experience'. At the post-test, his previous stance was suppressed, assimilated and consequently a new conception about the differences between the two types of argumentation emerged. At this stage he realized that 'in scientific argumentation arguers validate a conclusion using valid evidence while in everyday argumentation the arguers don't'.

Looking at PT13′s pre-test view it seems evident that acceptance of the nature of dialogue in scientific argumentation as pleasant and in everyday argumentation as unpleasant was dominant. At post-test his previous stance was suppressed in favour of a more valid view about the two forms argumentation. At this stage he realized that in both forms of argumentation the nature of a dialogue ranges from pleasant to unpleasant. CAT placed this category as emergent where newly acquired ideas about the nature of scientific argumentation are clearly formed in the mind.

Pre-service teachers' views about the role of argumentation in science teaching

Before and after the encounter with the ABIM-based intervention the PTs were asked in the questionnaire to indicate whether or not argumentation has any role to play in science teaching. Table 3 presents a summary of their responses.

As can be seen in Table 3, all the PTs indicated that they were not aware of the role of argumentation in science teaching before they were exposed to ABIM. The major reason given for their lack of awareness was that science tells us the truth about the world, which implies that there is no need to argue or negotiate to find out the truth. The following expressed view taken from PTs' questionnaire responses is representative.

Table 3. Pre-service teachers' pre- and post-intervention views on the role of argumentation in science teaching

Response/broader theme	Categories	Pre-test frequency (%)	Post-test frequency (%)
Role of argumentation in science teaching/ education	No, … argumentation doesn't have any role in science because scientific knowledge is absolute	17 (68)	4 (16)
	No, because scientific knowledge is synthesized by experimentation and observation not by discussion	8 (32)	
	Yes, scientific argumentation has a significant role in science teaching, particlarly in scientifc knowedge construction		9 (36)
	Yes, scientific argumentation promote conceptual understanding of scientific concepts		7 (28)
	Yes, scientific argumentation develop students' critical thinking and communication skills		5 (20)
Total		25 (100%)	25 (100%)

I think argumentation doesn't have any role in science because science tells us the truth about the world, which is absolute truth. Therefore, there is no need to argue or negotiate to find out the truth. (PT21)

After intervention, the majority of the PTs (84%) had made noticeable perceptual shifts from their initial stances at the pre-test. At this stage, they acknowledged the benefits of argumentation in science teaching and in science education. This is indicated more explicitly in PT21's post-test response.

After the intervnetion, I realized that argumentation played a great role in science teaching and science education. It has a potential in knowledge builidng and in promoting understanding of scientific concepts. It is also a useful mechanism in developing communciation skill of students. (PT21)

PTs were asked in the interview to further elaborate on their view of the role of argumentation in science teaching and science education before and after the intervention. The majority indicated that they were only aware of the role of argumentation in science teaching after their involvement with ABIM and related activities. PT21 puts this succinctly as follows:

Initially, I never thought that argumentation is helpful in science teaching. It was only after my engagement in the argument-based tasks which were administered during the intervention programme that I start to realize the role of argumentation in science teaching in general and in knowledge building in particular.

A close analysis of the excerpts above seemed to show that PT21 made a discernible perceptual shift from his initial stances at the pre-test, where he thought that argumentation has no role to play in science education/teaching to his post-test stance where he acknowledged the benefits of argumentation in science teaching and in science education in general. In terms of CAT category his negative stance towards the role of argumentation in science teaching has become suppressed and acceptance of the role of argumentation in science teaching has become dominant at the post-test stage. PT21 had developed new knowledge about the role of argumentation in knowledge building and in enhancing students' understanding of scientific concepts as a result of his exposure to the intervention i.e. CAT's emergent.

However, it is worthy of note that four pre-service teachers (16%) seemed not to realize the role of argumentation in science teaching even after the intervention. The following excerpt is representative of this group of PTs:

I still couldn't understand and see the role of argumentation in science teaching. Based on my own and my fellow PTs experiences I claim that we have sound content knowledge of scientific concepts without using argumentation … Here at our university we are able to perform several experiments in the laboratory using laboratory manual successfully not through argumentation process. (PT5)

Aspects of the intervention programme contributing to changes in PTs' understandings PTs were prompted to reflect on the major aspects of the intervention programme that contributed most to the changes in their understanding of argumentation and its role in science education. An analysis of the interview responses depicted in Table 4 showed five major aspects that contributed to the changes in their understanding of argumentation and its role in science teaching.

As displayed in Table 4, three-quarters of the PTs (19 or 76%) indicated that ABIM was the aspect of the intervention programme that promoted PTs' understanding of argumentation and its role in science teaching. The following excerpt derived from the reflective interview response of PT12 is representative.

The argumentation based teaching strategy that was employed during the intervention programme had played a great role in enhancing my understanding of argumentation and its role in science teaching.

Table 4. Major aspects of the intervention programme that enhanced PTs' understanding of argumentation and its role in science teaching

Aspects	No. of references	Percentage
Argumentation-based instructional model	19	76
Active participation and interaction within ABIM	16	64
Lecture series	15	60
The nature of the argument-based tasks	12	48
Video clips of ordinary teachers dealing with how to structure and approach the teaching of argument in science	8	32

Note: Some PTs contributed more than one aspect.

This strategy gave me an opportunity to interact with my fellow PTs, share and discuss my opinions on argumentation and how it can be used as a teaching strategy.

Sixteen (64%) of the PTs pointed out that collaborative and interactive classroom arguments and dialogues comprised another aspect of the intervention programme that helped them to share their ideas and gained new insights about argumentation and its role in science teaching. A PT who had 12 years of teaching experience stated that:

My experiences in the discussion sessions during the intervention programme helped me to change my perception about argumentation and its role in science teaching. Acknowledging the importance of argumentation, I now share the knowledge and skills I acquired with my former college teachers who have not got the opportunity to participate in such intervention.

Fifteen (60%) of the PTs gave credit to the lecture series delivered during the intervention. They indicated that the lectures improved their understanding of argumentation and its centrality in science education. Slightly less than half of the PTs (12 or 48%) stated that the nature of the argument-based tasks administered during the intervention improved their understanding of argumentation and its role in science teaching. Few of the PTs (8 or 32%) noted that the video clips of ordinary teachers dealing with how to structure and approach the teaching of argument in science enhanced their understanding of argumentation and its role in science teaching.

Discussion

Our data showed a change in the PTs' understanding about argumentation and its role in science teaching as a result of their encounter with ABIM and the related activities. Our selected verbatim quotes revealed perceptual changes that occurred between the pre-test and the post-test as a result of the intervention programme using the CAT as a unit of analysis. Such perceptual shifts can be described as a change in stance from a general lack of awareness to that of considerable awareness about scientific argumentation and its role in science teaching.

As revealed in the questionnaire and reflective interview responses, the majority of the PTs had a limited understanding of argumentation at the pre-test. While at the pre-test some of the PTs construed argumentation as no more than a mere presentation of views, others saw it as a disagreement between people to win a debate. However, after the intervention some conceptual change was discernible. For instance, PT8 made a noticeable perceptual shift from his pre-test stance to his post-test stance. At the pre-test he saw argumentation as a debate to win a case (Bricker & Bell, 2008). In their study, Bricker and Bell (2008) indicated that young people equate argument with social dispute and consider quarrelling as a genuine way to win an argument. However, at the post-test PT8 construed argument as a means of justifying a claim using plausible evidence (e.g. Finocchiaro, 2005). In terms of CAT, it seemed evident that his pre-test view about argumentation (which was dominant) had become suppressed as a more valid view of argumentation was gradually assimilated and new conception of argumentation emerged.

Our data also showed that majority of the PTs who were not aware of the differences between scientific and everyday argumentation at the pre-test became aware of the differences at the post-test. Of these, 14 contended that usually scientific arguments are supported with evidence and common everyday arguments tend to be less so. Some PTs (40%) who were aware of the differences between scientific and everyday argumentation at the pre-test seemed to lack sufficient knowledge of the nature of their differences. After the intervention, however, they became more knowledgeable about the differences between everyday and scientific argumentation. For instance, PT13 made a considerable perceptual shift from his initial pre-test stance where he characterised scientific argumentation as a pleasant dialogue to his post-test stance where he contended that scientific argumentation is not free from all forms of contestations (e.g. Kuhn, 1993; Popper, 1968). According to CAT, PT13's initial pre-test stance has become suppressed in favour of new knowledge/conception acquired during the intervention. The new conception developed in PT13's mind-set is categorised as emergent.

However, much as the PTs improved in their conceptions about argumentation or the differences between everyday and scientific arguments, their conceptions are to some extent too simplistic. A cursory examination of historical and sociological literature would easily reveal that in both everyday and scientific forms of arguments people do strive to support their claims with one form of evidence or the other, although the latter might have more empirically testable pieces of evidence than the former. Also, scientists as humans are not immune from an emotional presentation of their arguments, although they are nonetheless aware of the regulatory constraints of ethical considerations (Ziman, 2000).

In contrast to their pre-test stances most of the PTs (84%) seemed to have abandoned their previous view and developed a more valid view of the role that argumentation in science teaching. In terms of CAT, acceptance of the role of argumentation in science teaching, which was previously suppressed, became dominate at the post-test. The shift of view of this group of PTs could also be categorised in certain cases as emergent, a situation

where no prior idea/knowledge exists and a new one is acquired or developed as the result of individual's exposure to a more convincing information or concept. Yet a few PTs (16%) remained opposed to accepting the central role of argumentation in science education/science teaching after the end of the intervention programme, which is an indication that there was no discernible cognitive shift in their mindset. This group of PTs can be placed under the dominant category of CAT, probably reflective of their cultural background or commitment to traditional forms of teacher-dominated science instruction. Such a view was precisely expressed by PT5.

From the forgoing discussion, it seems evident that, although the participating PTs had had little to no prior experience to participate in discussion forums (owing to their cultural background and pedagogical practices experienced in Eritrean classrooms), the findings of this study seem to corroborate what earlier studies have reported about the positive effect of argumentation-based intervention programmes on PTs' conceptual development and belief revision about argumentation and its role in science teaching (e.g. Jimenez-Aleixandre & Erduran, 2008; Jin, Mehl, & Lan, 2015; Lawson, 2003; Leitao, 2000; McNeill & Knight, 2013; Simon & Johnson, 2008; Skoumios & Hatzinikita, 2009). Further, the findings showed that ABIM and active participation and interaction within ABIM were the aspects that contributied most in the intervention programme to enhancing the PTs' understanding of argumentation and its role in science teaching. Other contributing factors to this improved understanding, although to a lesser extent, are the argument-based tasks and the dialogues that accompanied lecture series. This finding has further corroborated earlier findings in the area (Ogunniyi, 2007). The fact that only eight out of the 25 PTs regarded video clips of ordinary teachers dealing with how to introduce argumentation instruction in science classrooms as an aspect of the intervention programme that improved their understanding of argumentation and its role in science teaching seems to imply that most of the PTs are probably auditory learners and only a few visual learners.

Conclusion

This study investigated the effect of an argumentation-based intervention programme on the PTs' understanding of argumentation and its role in science teaching. After participating in the intervention, the PTs: (a) seemed to have shifted from characterising argumentation as a debate to win a case to that of a process where people holding distinct viewpoints dialogue and negotiate to reach a mutually acceptable conclusion; (b) were to some extent better able to realize the difference between the day-to-day conversation and scientific argumentation than was the case before the intervention; and (c) were more willing to accept the central role of argumentation in science education/science teaching.

To some extent the study shows that CAT could be used as a suitable analytical framework for exploring the nature of cognitive shifts or belief revisions that may have occurred in areas other than science-Indigenous Knowledge System.

Of the five aspects of the intervention training programme that were regarded as prominent in assisting the PTs to improve their understanding of argumentation and classroom

discourse, ABIM was found to be the most important. The implications of the findings are worthy of further consideration by science educators not only in Eritrea but in other developing countries as well.

Disclosure statement

No potential conflict of interest was reported by the authors.

References

Aksit, N. (2007). Educational reform in Turkey. *International Journal of Educational Development*, *27*, 129–137.

Altinyelken, H. (2010). Curriculum change in Uganda: Teacher perspectives on the new thematic curriculum. *International Journal of Educational Development*, *30*, 151–161.

Aydeniz, M., & Ozdilek, Z. (2015). Assessing pre-service science teachers' understanding of scientific argumentation: What do they know about argumentation after four years of college science? *Science Education International*, *26*(2), 217–239.

Bricker, L. & Bell, P. (2008). Conceptualizations of argumentation from science studies and the learning sciences and their implications for the practices of science education. *Science Education*, *92*(3), 473–498.

Dawson, V.M., & Venville, G. (2010). Teaching strategies for developing students' argumentation skills about socio-scientific issues in high school genetics. *Research in Science Education*, *40*(2), 133–148.

Erduran, S., Simon, S., & Osborne, J. (2004). TAPping into argumentation discourse. *Studies in Science Education*, *38*, 39–72.

Finocchiaro, M.A. (2005). *Arguments about arguments. Systematic, critical and historical essays in logical theory*. New York: Cambridge University Press.

Jimenez-Aleixandre, M.P., & Erduran, S. (2008). Argumentation in science education: An overview. In M.P. Jimenez-Aleixandre & S. Erduran (Eds.). *Argumentation in science education: Perspectives from school-based Research* (pp. 3–27). Dordrecht: Springer.

Jin, H., Mehl, C., & Lan, D. (2015). Developing an analytical framework for argumentation on energy consumption issues. *Journal of Research in Science Teaching*, *52*(8), 1132–1162.

Kuhn, D. (1993). Science as argument: Implications for teaching and learning scientific thinking. *Science Education*, *77*, 319–337.

Lawson A. (2003). The nature and development of hypothetic-predictive argumentation with implications for science teaching. *International Journal of Science Education*, *25* (11), 1387–1408.

Leitao, S. (2000). The potential of argument in knowledge building. *Human Development*, *43*, 332–360.

McNeill, K.L., & Knight, A.M. (2013). Teachers' pedagogical content knowledge for scientific argumentation: The impact of professional development on teaching K–12 teachers. *Science Education*, *97*(6), 936–972.

Ministry of Education, (2005). *The National Framework for Eritrea*. Eritrea: Ministry of Education.

Ministry of Education. (2010). *The Eritrean Education Sector: Progress and Challenges*. Eritrea: Ministry of Education.

Najike, S., & Lucas, K. (2002). *Learning Science in a High School Environment in Papua New Guinea*. Paper NAJ02039. Retrieved from http://www.aare.edu.au/02pap/naj02039.htm.

Ogunniyi, M.B. (2007). Teachers' stance and practical arguments regarding a science-indigenous knowledge curriculum, Paper 1. *International Journal of Science Education*, *29*(8), 963–885.

Osborne, J.F., Erduran, S., & Simon, S. (2004). Ideas, evidence and arguments in science. In *In-service training pack, resource pack and video*. London: Nuffield Foundation.

Popper, K.R. (1968). Remarks on the problems of demarcation and of rationality. In I. Lakatos & A. Musgrave (Eds.), *Problems in the philosophy of science* (pp. 430–440). Amsterdam: North-Holland.

Silverman, D. (2001). *Interpreting qualitative data: Methods for analysing talk, text and interaction*. Newbury Park, CA: Sage.

Simon, S., & Johnson, S. (2008). Professional learning portfolios for argumentation in school science. *International Journal of Science Education*, *30*, 669–688.

Skoumios, M., & Hatzinikita, V. (2009). Learning and justification during a science teaching sequence. *International Journal of Learning*, *16*(4), 327–341.

Strauss, A., & Corbin, J. (1990). *Basics of qualitative research: Ground theory procedures and techniques*. Newbury Park, CA: Sage Publications (pp. 1–21).

Toulmin, S. (1958/2003). *The use of argument*. Cambridge: Cambridge University Press.

Ziman, J. (2000). *Real Science. What it is, and What it means*. Cambridge: Cambridge University Press.

Zohar, A. (2008). Science teacher education and professional development in argumentation. In M.P. Jimenez-Aleixandre & S. Erduran (Eds.), *Argumentation in science education: Perspectives from school-based Research* (pp. 245–268). Dordrecht: Springer.