The Effect of an Argumentation-based Training Programme on Pre-service Science Teachers' Ability to Implement a Learner-Centred Curriculum in Selected Eritrean Middle Schools

Senait Ghebru Berhe

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Supervisor: Professor Meshach Ogunniyi

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ABSTRACT

This study is part of a larger school-based research project aimed at training science teachers to integrate argumentation into K-12 science instruction. The current study examined the effect of an argumentation-based training programme on pre-service science teachers' ability to use an argumentation-based instructional model (ABIM) to implement a learner-centred curriculum in selected Eritrean middle school science classrooms. The study was situated within the social constructivist and argumentation theoretical frameworks. A predominately qualitative research approach was utilized to address the purpose and the research questions of this study. The research design was primarily a case study of a cohort of 25 undergraduate middle school pre-service science teachers, enrolled in a teaching practice course in January, 2013 under the auspices of the Department of Science, College of Education at Eritrea Institute of Technology (EIT). None of the pre-service teachers involved in the study had taken a formal course work, workshops or seminars on argumentation instruction. Six of the 25 pre-service teachers were selected for an in-depth qualitative analysis using purposive sampling technique (Groenewald, 2004; Flyvbjerg, 2006).

This study utilized multiple data collection instruments including, questionnaire, argument-based tasks, classroom observation, interview, reflective questionnaire, video-tape class lessons and field notes. Argumentation framework as espoused in the work of Toulmin (1958) and Ogunniyi (2004) were utilized as the units of analysis for the data collected in the study. Furthermore, the study considered a variety of validity and ethical protocols to ensure the findings and interpretation generated from the data were valid.

The findings of the study seem to show that ABIM improved the pre-service teachers' understanding of a learner-centred curriculum and argumentation instruction. While a good number of the participating pre-service teachers seemed to hold a basic understanding of a learner-centred curriculum, an overwhelming majority expressed a predominately limited understanding of the different aspects of argumentation at the pre-test stage. Positive changes were evident at the post-test where the majority had a reasonably good understanding of a learner-centred curriculum and argumentation. The findings of the study seem to corroborate earlier findings that argumentation instruction is effective in enhancing pre- service and practicing teachers' ability to implement a learner-centred science curriculum (Qhobela, 2010). Also, as a result of the intervention majority of the participants were able to construct every day, socio-scientific and scientific argumentation. In the three tasks examined, they were able to, (a) provide evidence (data) to support their claims, and (b) connect the data with the claim (warrant). In addition, some of them were even able to generate arguments with rebuttals.

More importantly, the findings reveal that it is possible to implement a learner-centred curriculum in science classrooms using an argumentation-based instructional model. Furthermore, the findings show that the argumentation-based training programme enabled the pre-service teachers to initiate the practice of teaching science as an argumentative discourse rather than a completive body of knowledge or rhetoric of conclusions (Ogunniyi, 2006; Schwab, 1962). Also, this study has further shown that the pre-service teachers who had reasonably good skills in argumentation were able to use the skills effectively to implement a learner-centred curriculum in science classroom than those who lack these skills, a finding that can be unpacked further in future studies.

The findings of this study showed that the effect of the argumentation-based intervention training programme and the reflective workshop sessions were the major factors that enhanced the pre-service teachers' ability to use argumentation-based instructional model to implement a learner-centered curriculum in science classroom. The pre-service teachers' comments suggest that they see argumentation instruction as a viable approach of teaching. The pre-service teachers recommended an argumentation-based instructional model should be introduced into Eritrean schools. Overall, they were enthusiastic about using argumentation as a teaching strategy. The major factors that hindered them from using an argumentation-based instructional model to implement a learner-centered curriculum in their respective classrooms include problems associated with students, teachers, the curriculum and the stakeholders. Others problems relate to the learning environment and nature of the teacher education programmes.

Keywords: Argumentation, argumentation-based instructional model, pre-service science teachers, learner-centred curriculum, learner-centred instruction, middle schools, teacher education, social constructivism, Toulmin's argumentation pattern, contiguity argumentation theory

DECLARATION

I declare that **"The Effects of an Argumentation-based Training Programme on Pre-service Science Teachers' ability to Implement a Learner-Centred Curriculum in Selected Eritrean Middle Schools" is** my own work; that it has not been submitted before for any examinations or degree purposes in any other university, and that all sources I have used or quoted have been indicated and acknowledged by complete references.

Senait Ghebru Berhe

Signed: ……………………………….. Date: ………………………………………

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DEDICATION

This thesis is dedicated to my late father Ghebru Berhe and late mother Senbetu Adhanom, who encouraged me to pursue my education. I salute them in retrospect for all their contribution to my life!

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ACRONYMS AND ABBREVIATIONS USED IN THE STUDY

ATTI	Asmara Teacher Training Institute
ABITP	Argumentation-based Intervention Training Programme
ABIM	Argumentation-based Instructional Model
CAT	Contiguity Argumentation Theory
CPD	Continue professional Development
ESRC	Economic and Social Research Council
EIT	Eritrea Institute of Technology
IDEAS	Ideas, Evidence, and Argument in Science Education
LCAIQ	Learner-Centred Argumentation Instruction Questionnaire
LCC	Learner-Centred Curriculum
LCE	Learner-centred Education
LCI	Learner-Centred Instruction
LCCI	learner-centred Curriculum and Instruction
LCP	learner-centred Pedagogy
MOE	Ministry of Education
NOIK	Nature of Indigenous Knowledge
NOS	Nature of Science
PTs	Pre-service Teachers
SIKS	Science Ingenious Knowledge System
SIKSP	Science and Indigenous Knowledge Systems Project
TAP	Toulmin's Argumentation Pattern
UWC	University of the Western Cape

CHAPTER ONE

INTRODUCTION

1.1 Introduction

Traditionally, science curriculum has focused on what one needs to know to do science. Schwab (1962) calls this the “rhetoric of conclusion” approach to science education in which the construction of scientific knowledge is conveyed as empirical, literal and an irrevocable truth. However, over the past few decades science educators have taken initiatives to reform science curriculum and the process of teaching and learning science at all school levels (e.g., Penuel & Means, 2004). Among others, a conception of science as argument has come to be widely advocated as a framework for science education (Berland & Reiser, 2009; Bricker & Bell, 2008; Driver, Newton, & Osborne, 2000; Duschl, 2008; Jimenez-Aleixandre & Erduran, 2008). Within this perspective, various science educators (e.g., Driver et al., 2000; Kuhn, 1993, 2010; Ogunniyi, 2007a & b) have proposed frameworks for conceptualising science learning through argument. Such a view of science learning has broader goals than just learning scientific content.

Argumentation as a teaching strategy has the potential to stimulate learner participation and engagement in structured discussion in science classrooms (Jimenez-Aleixandare & Erduran, 2008). Successful introduction of argumentation activities in learning contexts, therefore, involves extending teaching goals beyond the understanding of facts and concepts, to include an emphasis on cognitive and meta-cognitive processes, epistemic criteria and the reasoning (Simon & Richardson, 2009). However, argument in most science classrooms appear to be a monologue, a one-way conversation, where the learners cannot engage in questioning their teacher because they lack the resources to challenge or question the assertions made by their teacher (Erduran, Ardac, & Yakmaci-Guzel, 2006). Science educators identified the limitations of one-sided (rhetorical) form of argument in educational settings. This form of argument occurs when teachers marshal evidence and construct arguments for their students (Driver, et al., 2000, p. 291). In such classrooms students consider science as absolute; characterized by right and wrong answer with the origin of scientific ideas and any element of uncertainty is simply excised (Erduran, Ardac, & Yakmaci-Guzel, 2006; Osborne, 2010). Driver, et al. (2000) argue that if students are to develop skills for scientific argumentation for themselves, they should not just provide an audience for the teachers’ reasoning. Thus, students in science classrooms will need opportunities to practice such reasoning for themselves.

In keeping with the above assertions, the National Education Policy of Eritrea stipulates that "teaching method at all levels should aim at strengthening teaching-learning relationships that affirm the active participation of the learner in his/her own learning and development" (MOE, 2003, p.10). To fulfil policy level intentions, the Ministry of Education (MOE) revised the traditional-teacher-centred curriculum and developed new a learner-centred curriculum in 2005. The new learner-centred science curriculum in Eritrea emphasises on the process skills of science, such as interpreting, analysing, evaluating and problem solving (MOE, 2005) which require students to discuss and participate in classroom discourses. Likewise, the new pedagogical framework is explicitly a learner-centred system involving activities that require investigation, discovery and critical discussion. Ogunniyi (2007a) cites several research studies which show that curricula which encourage discussion; argumentation, dialogue and reflection are more effective in promoting understanding of the nature of science than those lacking such elements of discourse. This idea is consistent with the view of Erduran (2006) who agrees that promoting ideas, evidence and argument in science teaching is likely to engage both teachers and students in modes of thinking that characterize those of scientists.

However, attempts to introduce a new curriculum without helping teachers to translate this practice to the classroom are inadequate (Ogunniyi, 2004). Hence, Cuban (1990) notes that although curriculum changes occurs regularly, much attention is not paid to pedagogic change in teachers' classroom practice in the area of utilisation of argumentation. In a similar study, Sanders and Kasalu (2004) assert that transforming curriculum reform initiatives into practice is difficult for many teachers as they lack the awareness of the pedagogical shift required of them. Eritrean science teachers are facing the same problem as they lack the required knowledge and skills to implement the new curriculum (Department of General Education, 2010). However, research indicates that if teachers are made aware of appropriate strategies and materials to use they can stimulate meaningful learner participation in classroom activities (Scholtz, Watson, & Amosun, 2004; Webb & Treagust, 2006).

Further, Ogunniyi (2005, 2006) asserts that the most effective way to get teachers involved in the implementation of the new curriculum is to engage them in a long-term mentoring process in the form of dialogue, argumentation and explicitly reflective instructional approaches. In the light of this, this study is an attempt to train a cohort of pre-service science teachers to implement a learner-centred curriculum using an argumentation-based instructional model (ABIM) in selected Eritrean middle school science classrooms.

The effect or otherwise of argumentation-based intervention training programme was examined using appropriate qualitative and quantitative research methods. This precisely was what the study attempted to do. The current study was situated within a socio-constructivist and argumentation theoretical frameworks.

1.2 Background of the study

This study was carried out in Eritrea, a small country situated in the north eastern part of Africa. Eritrea borders with Sudan to the north and west, Ethiopia and Djibouti to the south, and the Red Sea to the east. It shares also maritime borders with Saudi Arabia and Yemen (Tekeste, 1987). Its capital and largest city Asmara is situated on the north western edge of the Eritrean highlands (Tesfai, 1999). It has an estimated population of about six million and has nine major ethnic groups (Amara, 1967; James, 1998). Many languages are spoken in Eritrea today. There is no official language as such, as the Constitution of Eritrea establishes the equality of all the Eritrean languages though Tigrigna and Arabic are the two most predominant languages used for official purposes (Government of Eritrea, 1997). Eritrea has two dominant religions, Christianity and Islam. Various approximations have estimated that 50 to 62.5% are Christians (mostly followers of Orthodox Christianity and, to a lesser extent, Roman Catholicism) and 36.5 to 50% of the population is Sunni Muslim (Tracy, 2009).

Eritrea was colonized by Turkey, Egypt, Italy, British and lastly Ethiopia (MOE, 2001). Each one of them had their own educational policy as well as social, political and economic policies aimed at disintegrating the social, economic, cultural values and political aspiration of Eritreans (Kidane, 2004). The history of Eritrean Education is divided into various periods on the basis of social and political epochs (MOE, 2001). A new chapter in the Eritrean educational system was opened in 1991 when Eritrea finally emerged as a sovereign country. Like many other countries that have experienced colonial subjection, political emancipation created the context for the national government to address educational needs. After independence, the Government embarked on educational reform in an attempt to contribute towards the transformation of Eritrean society (Weldemichael, 1992). Nevertheless, before discussing educational reforms and developments in Eritrea, it is imperative to present a cursory historical account of formal education in Eritrea.

Education during the Italian colonial era (1890-1941)

A formal European style of education was first introduced into Eritrea during the Italian colonial period (1890-1941). The purpose of Italian education in Eritrea was to indoctrinate Eritreans with a devotion to Italy and a respect for Italian culture and civilization. The schools were opened for Eritreans to become worthy elements of the native troops, interpreters, clerks, telephone operators and typists (Rena, 2005). Eritreans were allowed to learn or study up to grade four which was extended to grade five at the end of the colonization period. The medium of the instruction during this period was mainly Italian (Allen, 1953) though the widely spoken languages of Tigrigna and Tigre were also used to help the novice students (Kidane, 2004). The curriculum was later expanded to include history, geography, language, hygiene, and arts and crafts. A close review of the literature would show that there was no planned and structured education system implemented during this era (Allen, 1953; Kidane, 2004).

Education during the British Military Administration era (1941-1952)

As there was no organised and structured education system for Eritreans during the Italian era, one of the fundamental measures taken by the British Military Administration was to establish and implement a new education system. In 1941, a new educational system was established in Eritrea. It was during this era that the first middle schools were established in Eritrea and a system of teacher training was also opened in 1943 to train elementary school teachers (Allen, 1953; Teshome, 1974). Yet, education during this period was limited to just the completion of middle school (up to grade eight). The primary aim of the British education policy was to divide and rule Eritreans and force them into a wage economy. During this era, Tigrigna for the Christians in the highlands and Arabic for the Muslims in the lowlands became the languages of instruction in elementary schools. Italian was replaced with English language as a subject at this level and was institutionalised as the language of instruction in middle schools (Trevaskis, 1960). By 1950, English had become the medium of school instruction (Trevenski, 1960).

Education during the federal era (1952-62)

During the Federation period with Ethiopia, the establishment of schools and the progress of education were maintained. In addition to the elementary and middle schools, two secondary schools, a vocational trade school, and a nursing school were opened (Taye, 1992). The education system practised was similar to that introduced by the British Administration. English was taught as a subject in elementary schools and was maintained as the language of instruction from middle school up to higher education. The standard of education and the standard of English as a second language were maintained. Writing was considered (Rena, 2005) an essential skill for academic success. But the high demands and expectations of Eritrean school children were not yet met.

Education during the Ethiopian colonial era (1962 - May 1991)

As a result of the Ethiopian annexation on 14 November 1962, Eritrean educational system was merged into the Ethiopian educational system. The purpose of Ethiopian education in Eritrea was to instil the culture and tradition of Ethiopia and, thereby, infuse Ethiopian nationality among Eritrean citizens. Amharic language was introduced as a subject in some Eritrean schools in 1958. Gradually Amharic language became the medium of instruction first from grade one in 1962 and eventually substituted Arabic and Tigrigna in Eritrean elementary schools (MOE, 2001). English was maintained as the language of instruction from middle school up to higher education and Amharic was taught as a subject. During this period the quality of education was at its lowest level. Moreover, Eritrean youths did not get educational opportunity that would enable them to become productive citizens (MOE, 2003, p. 1).

Education after Independence

After the independence in 1991, the Provisional Government of Eritrea abolished the education system and curriculum that was being practised by the Government of Ethiopia. The Government embarked on educational reform in an attempt to contribute towards the transformation of Eritrean society (Weldemichael, 1992). Since independence, the Eritrean education system and curriculum have been continuously revised and updated to fit and compliment the on-going nation building process (MOE, 2010). However, the changes and improvements made were too limited in scope, intensity and coverage (MOE, 2003). Thus, a nation-wide situational analysis and needs assessment survey was undertaken in 1996 at all grade levels and for all subjects taught in schools (MOE, 2010). The objective was to evaluate the effectiveness and suitability of the National Curriculum in general and the teaching-learning process in particular (Department of General Education, 1997; MOE, 2003). Findings from the document analysis showed that the instructional practices employed in Eritrean science classrooms were highly dominated by a teacher-centred approach. Most of the instructional time was spent in listening to the teacher and copying notes from the board, although some general class discussion activities and some question and answer sessions took place. Furthermore, the situational analysis and needs assessment survey reported that students did not seem to get on with any work by themselves, either individually or in group (Department of General Education, 1997).

Findings from the document analysis also showed that the curriculum is predominantly supply driven, does not satisfy the needs and interests of the student and has little relevance to the country's job market demand (Department of General Education, 1997; MOE, 2003). In the same vein, the national education policy document criticizes the previous education system as it was not aligned with the country's development objectives and priorities. The policy document indicates that the education system has failed to deliver expectations of producing efficient and skilled human power for the Eritrean economy (MOE, 2003). The document further explicates that the system is highly academic in orientation and focuses on preparing students for tertiary education rather than preparing them for the labour market through a diversified curriculum (MOE, 2003, p.7).

To alleviate the problems indicated in the findings of the situational analysis and needs assessment survey and other related research findings immediate measures need to be taken to bring a new, forward looking, flexible and efficient educational system in place (MOE, 2003). This is precisely why the Government of Eritrea drafted a concept paper for a rapid transformation of the Eritrean education system in 2002. The concept paper aimed at an extensive change in the previous educational system (Government of Eritrea, 2002; MOE, 2010) and formative changes into the old curriculum (MOE, 2010). The primary objective of the concept paper was to create a qualitative and relevant educational system that complements national development plans by cultivating highly qualified teachers capable of the development process skills among learners as well as implement a culturally relevant curriculum (Government of Eritrea, 2002; MOE, 2010). To achieve the intended objective of the concept paper, the MOE reviewed the school curricula at all levels and developed the new learner-centred curriculum in 2005.

The new curriculum aims at transforming classroom discourse from a teacher-centred to a learner-centred method. It respects the learners' needs and thereby promotes learners participation and engagement. The curriculum expects learners to make decisions using critical and creative thinking skills; solve problems, construct their own knowledge and meaning and work with others as members of a team or group (MOE, 2005). The new learner-centred curriculum draws its inspiration from constructivist theories of learning.

MOE envisages the effective implementation of the new learner-centred curriculum in classroom contexts to ensure the quality of education offered in the country. However, the Department of General Education (2010, p. 18) reported that teachers were still employing the traditional approach of teaching and were unable to link the lessons with the day-to-day life of students. The department further noted that most of the instructional time was still dominated by classroom teachers. The above finding is supported by the researcher's experience. In her supervision of the performance of student teachers and in-service teachers in the teaching practice sessions of the College of Education in Eritrea for a period of 10 years, the researcher found that most science teachers often employ the teacher-centred approach. They do not seem to be able to connect school science to the students' day-to-day experience and cultural background. It cannot be overemphasized therefore, that effective introduction of a learner-centred curriculum in Eritrean science classrooms implies a change in the instructional strategies that teachers tend to use and an adoption of those that are more effective for learning. In light of this, the Eritrean Ministry of Education and the College of Education have taken the initiative to organize training programmes aimed at professional development of teachers.

Yet, much should be done to minimize the gap between the national education policy intentions and the context of the science curriculum. While the policy gave prominence to the socio-cultural dimension of science (MOE, 2003), the national science curriculum paid little to no attention in this regard. This is in sharp contrast with the view of many science educators (e.g., Aikenhead, & Huntley, 2002; Emeagwali, 2003; Ogunniyi, 2007a &b, 2011; Ogunniyi and Hewson 2008) who have argued for the importance of connecting school science curriculum with the learners' cultural backgrounds. There seem to be a need for a science curriculum that would require a science educational perspective that views science as a process of crossing the border between the learners' worldview and the scientific worldview (Ogunniyi 2005).

1.3 Statement of the problem

As indicated above, during the past decade, the education sector of Eritrea has gone through various stages that were often not smooth. Nevertheless, despite the hiccups, it is safe to state that significant strides and worthwhile accomplishments have been witnessed during this period. So far, there remained many challenges to be met in order to provide improved access, equity, quality and relevant education. The government must implement all the necessary changes and reforms so that the Eritrean education system would measure up to the needs of the nation. It is against this background that a critical reflection on the past trends and experiences was necessitated to ensure that rapid transformation takes place within the Eritrean education system (MOE, 2003). The concept paper aspired to "bring basic changes in the Eritrean education system which encompass**es** the structure, the objectives, the curricula and nature and content of the different components of the system at all" (MOE, 2001, p. 11). The development of the new learner-centred curriculum, therefore, is among the changes introduced into the Eritrean education system.

As indicated above, the new learner-centred curriculum in Eritrea emphasises on the process skills of science such as, interpreting, analysing, evaluating and problem solving (MOE, 2005). Such skills require appropriate teaching-learning strategies and a conducive learning environment that encourages students to reason, argue and think critically through the process of argumentation. However, my extended work experience in classroom practices indicates that in Eritrean science classrooms, the discursive exploration of scientific ideas, their implications and their importance are generally absent even after the introduction of the learner-centred curriculum. Consequently, science students and graduates of science are unable to provide evidence and justification to some of their claims when discussing or critiquing ideas. The concept paper for rapid transformation of the Eritrean education system (Government of Eritrea, 2002) explicated the above case as one of the major deficiencies observed in the old education system and recommended rapid transformation of the Education system at a national level.

The Eritrean National Education Policy statement stipulates that "teaching method at all levels should aim at strengthening teaching-learning relationships that affirm the active participation of the learner in his/her own learning and development" (MOE, 2003, p.10). The policy statement accords with the views of scholars of argumentation (e.g., Erduran, 2006; Ogunniyi, 2004; Osborne, Erduran, & Simon, 2004a) who contend that interactive classroom argument and dialogue encourage teachers and students to externalize their view points and present valid reasons for different stances. However, supervision report on the performance of pre-service teachers and in-service teachers in the teaching practice sessions of the College of Education in Eritrea reveals that teaching strategies that promote discussion and argument are not implemented in Eritrean classrooms (College of Education, 2009). In a similar study, the Department of General Education (2010) confirms that conceptual understanding and practical applications of science to real life are all seen as missing from Eritrean teachers' pedagogical strategies, rendering teaching and learning mainly theoretical. Erduran, Ardac, and Yakmaci-Guzel (2006) and Osborne (2010) argue that in such classrooms students tend to consider science as an absolute body of knowledge rather than a tentative and dubitable discourse. The common explanation of the absence of argument and discursive practices in science classroom is that it is a product of overemphasis by teachers, curricula and textbooks on what we know at the expense of how we know (Driver, Newton, & Osborne, 2000).

The prevalence of a teacher-centred instructional practice in most classrooms could be attributed, among others, to the nature of the teacher training programmes, quality of teachers and lack of teachers' awareness about the on-going paradigm shift. Simon and Maloney (2006) state that many teacher training programmes are so focused on the delivery of a content-laden curriculum that they ignore the actual cognitive needs of the learners in terms of acquiring ownership of what they are learning. As a result, trainees have little opportunity to broaden their instructional approach to teach science as an inquiry rife with conjectures and refutations rather than a completive product-orientated enterprise. Erduran (2006) adds that the initial training of science teachers does not conventionally place an explicit emphasis on how teachers can be supported in teaching new aspect of the curriculum. Teachers produced from such training programmes will then be rigid in their teaching style and stick closely to their prepared notes or textbook with minimal teacher-student interactions (Stoll, 1994).

Lack of the required knowledge and skills of science teachers to adapt the contemporary approach of teaching, such as teaching argument-based lessons and facilitating argumentation was found to be the bottleneck for the proper implementation of the new curriculum (Department of General Education, 2010). The document further, indicates that most Eritrean teachers are struggling with their new role as facilitators of learning and tend to stick with the traditional transmission model of teaching.

The underlying assumption of this study is that most Eritrean science teachers are neither aware of what is called for in the new curriculum nor conversant with compatible instructional strategies or the pedagogical shift they need to make in their endeavour to transform curriculum reform initiatives into practice. The validity or otherwise of this assumption of course will depend on the findings of this study. Fullan (2001) has noted that reforms can only succeed if implementers understand the concepts in the new practice. Ogunniyi (2005) has argued that teachers are the key to any curriculum change endeavour. They can make or mar any curriculum no matter the quality of its design or content. These issues have combined to challenge MOE and science teacher educators to think about reforming the teacher education programme in general and the curriculum in particular.

1.4 Rationale of the study

The prominence given to interactive pedagogy in the new learner-centred curriculum in Eritrea stand in sharp contrast to the old instructional approach that focused mainly on the mastery of scientific facts and generalization. The new curriculum aims at transforming classroom discourse from a teacher-centred to a learner-centred method; it respects the learner's needs and, thereby, promotes the learner's participation and engagement. It encourages learners to compare, contrast and distinguish different lines of reasoning (MOE, 2005). The aims of the new curriculum accords with the view espoused by Brown's (2003) construal of a learner-centred classroom as a classroom that places learners at the centre of the classroom organization so as to encourage them to work individually or in pairs and small groups on distinct tasks and projects to make decisions using higher-order thinking skills.

MOE envisages the effective implementation of the new learner-centred curriculum in classroom contexts in order to ensure the quality of education offered in the country and fulfil policy level intentions stipulated in the Constitution of Eritrea, the Concept paper for a rapid transformation of education system in Eritrea, and the National Education Policy, just to mention but a few.

Although the MOE made commendable efforts to meet the postulates and aspirations of the policy statements and, thereby, implement a learner-centred curriculum into science classrooms, the instructional time is still dominated by classroom teachers (Department of General Education, 2010, p. 18). The above finding is supported by my experience. As indicated earlier, the student-teachers and in-service teachers in the teaching practice sessions of the College of Education in Eritrea show the predominance of traditional expository instruction over other instructional strategies. Similar practices have emerged in other countries as well. A plethora of studies have shown that a learner-centred curriculum has not taken root in many classrooms. Country profiles developed for sub-Saharan African countries by the Vrije Universiteit, Amsterdam, as part of a larger study on Science, Maths and ICT in Secondary Education in sub-Saharan Africa (SMICT Study, 2005) indicated the prevalence of traditional and outmoded styles of teaching.

Fullan (2001) indicates that reforms can only succeed if implementers understand the concepts in the new practice. Nonetheless, as earlier indicated, most Eritrean science teachers are unacquainted with new pedagogical skills needed to transform the curriculum from being simply an aggregation of scientific facts into one that encourages intellectual engagement and conceptual development among learners. In this regard, Sanders and Kasalu (2004) note that most teachers lack awareness of the required pedagogical shift and encounter difficulty in transforming curriculum reform initiatives into practice. However, research indicates that if teachers are made aware of appropriate strategies and materials to use they can stimulate meaningful learner participation in classroom activities (Brodie, 2004; Schultz, Watson, & Amosun, 2004; Webb & Treagust, 2006). Also as stated earlier, the most effective way to get teachers to be involved in the implementation of the new curriculum is to engage them in a long-term intensive dialogues, argumentation, and explicitly reflective instructional approaches (Ogunniyi, 2005, 2006).

In the light of this, the researcher organized an intervention programme aimed at training pre-service science teachers to use ABIM to implement a learner-centred curriculum in science classrooms. Barad (as cited in Ogunniyi & Hewson, 2010) states that there has been increased interests in determining the effectiveness or otherwise of argumentation in enhancing teachers' and students' understanding of the nature of science. The findings from these studies show the importance of argumentation and dialogue in enhancing teachers' and students' conceptual understanding and also as a way to increase their awareness of the tentative and material-discursive nature of scientific practice.

In view of the foregoing, the current study investigates the effectiveness or otherwise of an argumentation-based intervention training programme on the pre-service teachers' ability to use ABIM to implement a learner-centred curriculum in Eritrean middle school science classrooms. Efforts were also made to examine factors that promoted or hindered pre-service teachers' from using ABIM in science classrooms. It was envisaged that the structured discussion resulting from attempts at argumentation using ABIM would galvanize pre-service teachers and learners to engage science concepts more critically than would have otherwise been the case (Herrenkhal & Guerra, 1998; Zohar & Nemet, 2002), which is the main concern of this study.

1.5 Purpose of the study

The main purpose of this study was to investigate the effect of ABIM on pre-service teachers' ability to implement a learner-centred curriculum in Eritrean middle school science classrooms. It examined pre-service teachers' understanding of a learner-centred curriculum and argumentation before and after being exposed to an argumentation-based intervention training programme. The pre-service teachers' ability to construct arguments and to participate in an argumentation discourse was also examined. The study further explored the ability of the pre-service teachers in structuring argument-based tasks on the one hand and facilitating argumentation discourses in science classrooms on the other hand. The factors that promote or hinder the use of ABIM in Eritrean science classrooms were also explored. The study attempted to propose possible recommendations to improve the effectiveness of the instructional practices employed in learner-centred science classrooms and, thereby promote the understanding of scientific concepts among learners with concrete logical reasoning and justified arguments for the fact.

In pursuance of the purpose of the study answers were sought to the following questions:

1.6 Main Research Question

How effective is an argumentation-based instructional model in enhancing pre-service science teachers' ability to implement a learner-centred curriculum in Eritrean middle school science classrooms?

Sub-research questions

1. What conceptions of learner-centred curriculum and argumentation did the pre-service teachers hold before and after being exposed to ABIM?

2. To what extent are the pre-service teachers able to construct quality arguments and participate in an argumentation discourse?

3. To what extent are the pre-service teachers able to use ABIM to implement a learner-centred curriculum?

4. What are the factors that promoted or hindered the pre-service teachers from using ABIM to implement a learner-centred curriculum in their science classrooms?

1.7 Theoretical Framework

The study was situated within socio-constructivist and argumentation theoretical framework. A contemporary approach to understanding learning in science that has gained much support in science curricula is constructivism (Driver, 1989). Drive, Goldberg, and Neidderer (as cited in Driver, et al., 2000) indicate that the rise of constructivist learning approach in science led to an emphasis on discussion and group work in science lessons. Driver, et al. (2000, p.298) have extended this view by noting that the literature on constructivist teaching continues to be an important source of information about appropriate strategies for promoting discussion and argument in order to develop students' conceptual understanding. A prominent feature of this theory is that it uses learners' prior knowledge; imagination and experience together with the opportunities provided by the teacher, in helping learners construct new meaning and making sense of their ideas through argumentation (Moodley & Hobden, 2010).

Dougiamas (1998) identified six branches of constructivism and out of these, the current study focuses on social constructivism because, this branch of constructivism has been found to link well with the contemporary teaching and learning of science (Driver et al., 2000). In addition, the new learner-centred curriculum in Eritrea, which is the central concern of this study, draws inspiration from constructivist theories of learning and extends the ideas of 'constructivism' into 'social constructivism' (MOE, 2005). Moreover, social constructivism takes into account the social nature of the learning environment as a collaborative atmosphere between teachers and learners and among learners (Dougiamas, 1998; Roesler, 2002). This is the central concern of the new learner-centred curriculum.

Cole and Engestron (1993) have asserted that social interaction is an essential component of cognitive development and learning. Jimenez-Aleixandre (2008) further explicates the role of social interaction in the development of higher thinking skills. A plethora of studies on classroom discourse has shown the important role that dialogical argumentation plays in the development of knowledge and collaborative consensus building (Grace, 2005; Kolsto, 2006; Leitao, 2000; Mercer, 2000). In other words, argumentation as a social activity (Jimenez-Aleixandre, 2008) has a catalytic role in enhancing understanding, co-construction of ideas, clarification of doubts and even belief revision in the light of a more potent argument. This notion coincides with the constructivist view of learning (Jimenez-Aleixandre, 2008). More specifically, this study is underpinned by Toulmin's (1958) Argumentation Pattern (TAP) and Ogunniyi's (2004) Contiguity Argumentation Theory (CAT). While TAP addresses the logical aspect of argumentation CAT addresses both logical and non-logical metaphysical and axiological aspects of an argument. A more detailed discussion of these constructs will follow in chapter two, sections 2.6 and 2.7.

1.8 Research Methodology

The study used a case study approach to investigate pre-service middle school science teachers' ability to use ABIM to implement a learner-centred curriculum in selected Eritrean middle school science classrooms. It employed a predominately qualitative interpretive design approach in the form of a survey. A qualitative research approach was viewed to be a suitable approach for the study in that it addresses the complexity and fluidity of issues that tend to arise in a classroom discourse. In the study 25 pre-service middle school science teachers from the College of Education, Eritrea Institute of Technology (EIT), Eritrea volunteered to participate. None of the participants had taken formal course work related to argumentation. The 25 pre-service middle school teachers were chosen as they would be teaching in middle schools where the science concepts taught at that level are pivotal in laying the foundation to biology, chemistry and physics concepts in the successive levels of education. The study took place in four selected middle schools.

This study utilized multiple primary data sources including, questionnaires, argument-based tasks, classroom observations, interviews, reflective questionnaires, video-taped class lessons and field notes. The use of these multiple sources of data allowed triangulation and cross checking of emergent hypothesis. Toulmin's Argumentation Pattern (TAP) modified after Erduran et al. (2004) was used as an analytical framework to examine the extent in which pre-service teachers (PTs) were able to: (a) construct quality arguments; and (b) participate in argumentation discourse in everyday, socio-scientific and scientific discourses. According to this instructional model, the PT's written and verbal expressions were coded into different levels representing different abilities of argumentation. The Contiguity Argumentation Theory (CAT) categories developed by Ogunniyi (2004, 2007a) were used as the unit of analysis to describe the type of changes that might have occurred in pre-service teachers' understanding and skills of learner-centred curriculum and argumentation before and after the intervention.

Efforts were made to establish the credibility, transferability, dependability and confirmability of the instruments (as deemed appropriate), including the protocols of triangulation. All research instruments designed for this study were examined by five experts in the field of science education. Additionally, the modified version of the intervention instructional tool was also examined by the same experts. The experts gave their comments on quality, relevance and suitability for the intended purpose. Moreover, learner-centred argumentation questionnaire and argument-based tasks were piloted before using them in the main phase of the study. The study was conducted in three phases, namely, pre-intervention phase, intervention phase and post-intervention phase. A more detailed description of these phases will follow in chapter three, section 3.8.

1.9 Ethical consideration

This study made commendable efforts to comply with the ethical standards laid down by the Senate Research Committee of the University of the Western Cape. Apart from that, I consulted the basic principles stipulated in the international standard ethical practices, such as, ESRC guidelines (2001, 2005, 2006), Department of Health (2001, 2005) and The British Psychological Society (2009). This awareness helped me to know which procedures and formalities to follow while collecting the data for the study. Before the commencement of the study I sought the permission of all the stakeholders: Eritrea Institute of technology (EIT) and MOE officials, school directors, science teachers and the pre-service teachers.

The participating pre-service teachers were informed about the aims and nature of the study, what their participation would entail, who would have access to the data, how data would be stored, and the extent to which confidentiality and anonymity will be protected. As an important component of ethical standard, psychologists respect the knowledge, insight, experience and expertise of potential participants (Department of Health, 2001, 2005, ESRC, 2005). This awareness helped me to respect the individual, cultural and role differences, including those involving age, sex, ethnicity, language, religion, family situation and socio-economic status of the participants.

The most important ethical issues for this study were related to pre-service science teachers and their institution; school directors, their learners and the selected middle schools in which the research was conducted. In this regard, I made conscious effort to protect the integrity, autonomy, privacy and dignity of all the participants. To achieve this I consulted the guidelines indicated above and emphasized on minimising risks, ensuring informed consent, privacy and confidentiality. A more detailed discussion on ethical issues in accordance with the extant literature and conventional research practices will be presented in chapter three.

1.10 Scope of the study

The study examined the effectiveness or otherwise of the ABIM on pre-service middle school science teachers' ability to implement learner-centred curriculum in the Eritrean middle school science classrooms. In this study no attempt was made to link the effect of pre-service teachers' ability to use ABIM on student outcomes. As indicated above, data was collected through questionnaires, argument-based tasks, classroom observations, interviews, reflective response questionnaires/reflective interviews, video-taped class lessons and field notes. There were many pre-service middle school science teachers in the College of Education, and also many middle schools in the country. However, the administration of the research instruments was limited to twenty five pre-service middle school science teachers. The study was also limited to four selected middle schools in Eritrea. Due to resource and time constraints the study was limited only to four selected middle schools in Eritrea.

1.11 Significance of the study

The researcher is not aware of any study in Eritrea that has examined pre-service science teachers' ability to use ABIM to implement a learner-centred curriculum in science classroom. It is hoped that the findings will contribute towards efforts directed at effecting change in science, ameliorate the problems encountered in science classrooms and achieve the desired outcome.

Also, it is hoped that this study will shed light on how science teachers should help their learners to identify prominent evidence for many common beliefs, construct a written argument and promote understanding of argument itself. It is anticipated that learners will utilize the skills of argumentation developed in science lessons in other disciplines and in their everyday life. Duschl (2008) attests that argumentation and debate are useful means of engaging the thinking and reasoning process in science classrooms, and to reflect the discourse practices used in real life in the advancement of intellectual and scientific knowledge. It is hoped that the findings of this study will motivate curriculum designers to address the importance of argumentation in science teaching and accordingly, shape the curriculum and the resource materials used in Eritrean teacher training programmes and at schools. It is also hoped that the findings would provide new information for further research in introducing argumentation in other disciplines other than science and in introducing other instructional and learning programmes such as project-based science instruction, problem-based instruction and cooperative learning in science classrooms.

1.12 Limitations of the study

The following were considered as limitations of this study. Attempts made to ameliorate the limitations were also noted.

The restriction of the intervention training programme to only 45 hours was one of the limitations of this study. In their study, Supovitz and Turner, (as cited in Kyle, Penick & Shymansky, 1979) found that teachers exposed to a professional development programme for less than 40 hours did not make any meaningful pedagogical shift and did so only after 80 hours of training. It was hoped that the intensity and the quality of the intervention programme as well as the careful planning of the training sessions and other nuanced data collected would compensate for the short duration of the intervention programme.

The attempt made to determine pre-service teachers' progress and development to implement argumentation instruction in middle schools over a short duration of a teaching practice period (that is, one semester which is four months) was a further limitation. Perhaps, the outcomes of pre-service teachers' progress overtime might be significantly noticed in a longer duration. In this regard, Martin and Hand (2009) argue that the shift in pedagogical practices is not easy, requires trial and error and takes a long time. To minimise the impact of this problem, micro-teaching sessions were organized after the intervention programme and reflection sessions were administered after each round classroom visit. A one-to one feedback discussion held between the researcher and the pre-service teachers after each classroom visit was also utilized as a way to ameliorate the effect of the problem.

The findings of this study seem to show that the intervention programme had an effect in pre-service teachers' understanding of argumentation and in their ability to use ABIM to implement a learner-centred curriculum in science classrooms. Yet, it may not be possible to convincingly demonstrate a causal link between the intervention programme or the new instructional model and the outcome of the study as there are extraneous variables that could not be easily measured, controlled or accounted for. It was envisaged that the teacher factor, such as pre-service teachers' enthusiasm, and feelings might have influenced the outcomes of the study despite the intensive efforts made to ameliorate the effect of such a factor.

As a non-participant observer, I carried out classroom observations to examine pre-service teachers' ability to use ABIM to implement a learner-centred curriculum in science classrooms. However, there is a general assertion that showed that the presence of an observer may lead people, in this case pre-service teachers to behave differently, thus invalidating the data obtained (e.g., Bottorf, 2004).To ameliorate the effect of the problem, the researcher conducted formal classroom observations of three different argumentation lessons for each of the 25 participating pre-service teachers on the specified period.

Although the sample was limited to 25 pre-service teachers from a cohort of 150 pre-service teachers assigned to only four selected schools, generalization was not a concern because there were other criteria such as trustworthiness for judging and checking the quality and soundness of the qualitative research studies.

1.13 Definition of terms

The following are brief descriptions of some of the key terms used in this study.

Learner-centred curriculum

Learner-centred curriculum is a foundation for clarifying what is needed to create positive learning contexts to increase the likelihood that more students will experience success McCombs (1997). In its National Curriculum Framework, the MOE in Eritrea, specifically defines the term learner-centred curriculum as a framework that promotes learners' participation and engagement in decision making and in constructing their own knowledge and meaning using critical and creative thinking skills (MOE, 2005, p.13)

Argumentation: In this study argumentation was interpreted as a teaching strategy and a tool for scientific knowledge construction (Msimanga & Lelliott, 2010). This study considered the individual and social meaning of argumentation as espoused by Billig (1987), Driver, et al. (2000) and Ogunniyi (2007a).

Argumentation instructional model: This is an instructional model designed to engage learners in scientific argumentation to develop complex reasoning and critical thinking skills (Duschl & Osborne, 2002)

Argumentation-based training programme: For this particular study, it is an intervention programme aimed at training pre-service science teachers to implement an argumentation-based instructional approach in a learner-centred science classroom.

Pre-service training is a formal programme aimed at equipping pre-service teachers with the necessary skills and qualifications that will enable them to teach in middle schools.

Pre-service middle school science teachers: For this particular study, pre-service middle school science teachers referred to student-teachers registered in the Department of Science Education at the College of Education in Eritrea Institute of Technology, Eritrea. Upon completion of the programme they will be teaching General science in Eritrean middle schools.

Toulmin's Argumentation Pattern (TAP): is an argumentation framework developed by Toulmin (1958). It illustrates the structure of an argument in terms of an interconnected set of claim; data that support that claim; warrants that provide a link between the data and the claim; backing that strengthen the warrants and rebuttals which point to the circumstances under which the claim would not hold true (Erduran, Simon, & Osborne, 2004).

Contiguity Argumentation Theory (CAT): is a dialogical framework developed by Ogunniyi (2004, 2007) that offers explanation for both rational and non-rational interpretations made by people in general and learners in particular (Hewson & Ogunniyi, 2010).

Classroom interaction: refers to interaction practices and classroom communication (verbal and nonverbal) between the teacher and the students and among students.

Social constructivism: is a learning theory that takes into account the social nature of the learning environment as a collaborative atmosphere between the teachers and the students and among the students (Dougiamas, 1998; Roesler, 2002).

Eritrean middle schools: are schools at a level between elementary and high schools, including grades six through eight. It is a school for students aged between 12-15 years (MOE, 2003, p. 8).

1.14 Structure of the study

Chapter one was an introduction to the thesis and was divided into sections. The chapter started by highlighting the contextual background of the study, Eritrea. Then it gave a brief account of its educational development at various periods. The accomplishments that have been made after independence and the challenges encountered to improve quality and relevant education was also reflected. The statement of the problem, rationale and purpose of the study were stated in this chapter. An overview of the theoretical framework and research methodology developed for this study was also highlighted. The chapter ended by giving definitions of terms used in this study as applied within the context.

Chapter two presented the theoretical and practical considerations of the main concepts used in this study in relation to the purpose of the study and research questions. A review of the relevant literature provided a better understanding of the concepts used. This encompasses learner-centred curriculum, learner-centred instruction, and argumentation. The chapter focused on the role of argumentation in science teaching and in promoting conceptual understanding of science. It also sheds light on the school-based research in teaching argumentation and training of pre-service science teachers in argumentation.

Chapter three provided a rationale for the methodology utilized in this study. It outlines and justifies the research design and explains their various functions while pointing out the approaches used in conducting the current research study. This chapter also gave a detailed account of the research designs used, sampling procedures, research instruments, the procedures used to collect data and the methods of analysis. The trustworthiness of the study and ethical consideration was also discussed.

Chapter four presented the analyses and discusses the results of this study in response to the four research questions. It examines PTs' pre and post intervention conceptions of learner-centred curriculum and argumentation. This chapter also analyses and discusses pre-service teachers' ability to construct arguments and to participate in argumentation discourse. The pre-service teachers' ability to use ABIM to implement a learner-centred curriculum in Eritrean middle school science classrooms and their progress overtime was also examined and discussed in this chapter. The chapter further examined and discussed the factors that promotes or hinders the implementation of argumentation instruction in science classrooms.

Chapter five presented and discussed the major conclusions, implications and recommendations based on the empirical findings and discussions of the results presented in chapter four. Possible directions for future research that emerged out of this study were also put forward in this chapter.

CHAPTER TWO

LITERATURE REVIEW

2.1 Introduction

There is a general consensus among science educators that science education needs to diversify its emphasis beyond focusing on canonical abstract ideas by placing a greater emphasis on the nature of science (NOS) and the way it is communicated to students (e.g., Abd-El-khalick, 2004 & 2005; Abd-El-khalick & Lederman, 2000; Ogunniyi, 2004). Science teachers are therefore, admonished to reflect a more sophisticated version of scientific investigation and the concepts of evidence, argumentation, and explicit focus on capabilities such as analytical thinking, problem solving, communication and creativity in their instructional practices (Tytler, 2007, p. 31). The central focus of this chapter is to anchor the study within the on-going discourse on the conceptions of science learning as argument and science as a human endeavour. The chapter develops a case for the inclusion of argumentation as a form of pedagogy based on at least two reasons. The first is that learning to argue is learning to think (Billig, 1996). The other is from the work of social psychologists which reveals that students' knowledge and understanding can be facilitated by argumentative discourse and collaborative work between peers (Osborne, 2010). The latter has a direct link with the notion of a learner-centred curriculum, which is the central concern of this study. Literature on school-based research projects in argumentation practices and curriculum implementation aimed at professional development of pre-service and in-service science teachers abounds. These are presented in order to provide theoretical and practical guide to the study.

There is a great deal of talk today in education about a learner-centred instruction, where students talk more in class to each other and construct their own meaning about the natural world. Moreover, discussions on discursive practices and argumentation have emerged as a critical area for science education. In view of this, this chapter starts by exploring some theoretical and practical considerations of issues that deal with learner-centred curriculum and sheds light on current debates on argumentation. A review of the extant literature centred on the role of scientific argumentation in science teaching and learning, and the effect of an Argumentation-based Instructional Model (ABIM) in terms of: (a) promoting students' conceptual understanding; (b) developing students' argumentation skills; and (c) building scientific knowledge. Of special consideration in this regard is a general exploration of the literature that has attempted to explicate the on-going school-based research under the theme, "learning to teach argumentation for professional development of pre-service and in-service science teachers" (e.g., Erduran, Osborne, & Simon, 2004; Ogunniyi, 2007a & b; Simon, Erduran, & Osborne, 2006; Simon & Johnson, 2008; Skoumios & Hatzinikita, 2009). Finally, the chapter presents the theoretical frameworks in which the study is situated.

2.2 Learner-Centred Education (LCE)

Learner-Centred Education (LCE) is an education theory which has a long history of development. The origin of LCE could be dated back to the work of some of the well-known philosophers and educators such as, Confucius, Socrates, Jean-Jacques Rousseau and Pestalozzi (Cuban, 1993; Henson, 2003). Henson (2003) indicates that the history of learner-centred education has one foot in philosophy and another in psychology. Henson (2003) further discloses that the earliest individual teachers who had direct effect on LCE were Confucius, a Chinese philosopher and Socrates, the Greek philosopher (around the 5th and 4th centuries B. C.). Sometime later, around the 16th century, Johann Pestalozzi, influenced by the work of Rousseau opened a school in Switzerland with a learner-centred curriculum (Henson, 2003). In concurrent time, Fredrick Froebel borrowed ideas from Learner-Centred, Child-Centred, and experience-based education to develop the world's first kindergarten in Germany. Centuries later, influenced by the perspectives of various educators (such as Francis Bacon's scientific method, Immanuel Kant's pragmatics and others), John Dewey proposed the concept LCE to "embrace the idea that education should be both problem-based and fun" (Henson, 2003, p. 3). As opposed to the view of Rousseau who claimed that children have to be protected from a corrupted society and be allowed to develop naturally, Dewey asserted that "the only way a child would develop to its potential was in a social setting" (Henson, 2003, p. 3).

The above historical account highlights the contributions of educational philosophy to the development of LCE. However, for LCE to be considered to be a legitimate theory of education it should be supported by a psychological knowledge base since philosophical knowledge base does not prescribe or direct behaviour. During the 20th century, several psychological developments such as, perceptual psychology, constructivism, and disposition among others, influenced the development of LCE (Henson, 2003, p. 4). In the mid-twentieth century, psychologists recognized the effect of perception on behaviour in shaping the future of learners. In this regard, teachers have a great responsibility; to shape their students behaviour. Combs (1962) proposed strategies on how LCE can nurture the development of positive self-concepts, which includes: (a) assigning problems that challenge students, but are within their abilities; (b) encouraging students to succeed; and (c) recognizing students' success. Surprisingly, most teachers are often not aware of how to attain these learning goals.

Other educators such as Chisholm and Leyendecker (2008) acknowledge the contribution of Jean Piaget, Dewey and Vygotsky in the development of LCE. These scholars further indicate that the idea of LCE is derived mainly from the works of John Dewey, Lev Vygotsky and Jean Piaget (although Piaget is sometimes interpreted as a stage theorist only). Chisholm and Leyendecker (2008) assert that contemporary understandings of LCE are based mainly on Vygotskian cognitive psychology, and differ from pedagogies that are based on behaviourist psychology. According to them learner-centred education stresses such things as:

- Knowledge is not transmitted; it is constructed in the mind of the learner. Learning is a mentally active process, and learning results from personal interpretation of knowledge.

- Learning is a process in which meaning is developed on the basis of prior knowledge and experiences. Prior knowledge and experiences are determined by culture and social context.

- Language influences culture and thinking, and is central to learning and the development of higher cognitive processes.

Taken as a whole, LCE embraces terms such as, active learning, investigation, self-responsibility, learners' prior knowledge and skills as well as the construction of knowledge (Edmund & Stephens, 2000; Thompson, Licklider, & Jungst, 2003; Walczyk & Ramsey, 2003; Woelfel, 2004). If knowledge is to be constructed by learners, then the curriculum tends to be consistent with a learner-centred model of instruction (Duplessis & Muzaffar, 2010, p. 45) To attain such features of LCE the curriculum tends to be consistent with a learner-centred model of instruction (Duplessis & Muzaffar, 2010, p. 45) The sub-section below further elucidates on learner-centred curriculum and instruction.

2.2.1 Learner-Centred Curriculum (LCC)

Over the past few decades, a paradigm shift in curriculum has occurred where the teacher acts as a facilitator in a student-centred classroom. The learning goals and principles of learner-centred curriculum are in sharp contrast with the traditional, teacher-centred curriculum. McCombs (1997) defines LCC from a research-based perspective. For McCombs learner-centred curriculum is a foundation for clarifying what is needed to create positive learning contexts to increase the likelihood of more students experiencing success. Paris and Combs (2006) are of the view that LCC is a curriculum that supports diverse demand on individuals' time and learning style. Claudia and Marhta (2003) further point out that LCC proposes to create highly developed individuals, providing them with the skills to continue creating learning experiences, digesting current knowledge, and creating new knowledge within the curriculum itself.

A plethora of studies have indicated that teachers' inability to implement new curricula such as learner-centred curricula is largely because they use the traditional method of teaching to implement curricula that require the active participation of students in classroom discourse (e.g., Driver, Newton, & Osborne, 2000; Erduran, Simon, & Osborne, 2004; Jimenez-Aleixandre, Rodriques, & Duschle, 2000). According to Simon, Erduran, & Osborne (2006), LCC requires a radically different instructional approach compared to the traditional examination-oriented curricula. The message here is that, if LCC is to be implemented successfully in an educational setting, teachers need to use teaching strategies that are compatible with a learner-centred instruction. This is the focus of the sub-section below.

2.2.2 Learner-Centred Instruction (LCI)

The learner-centred instruction concept has long been in existence in education. Centuries ago, Plato had provided some ideas about a learner-centred instruction through questioning (Ozmon & Craver, 1995). Later on, in the 18th century a Swiss-born philosopher Jean Jacques Rousseau provided a more comprehensive picture of learner-centred ideas. In his emphasis on the idea of self-activity and discovery learning he admonished teachers to: "Let him [the learner] know nothing because you have told him, but because he has discovered it himself and furthermore "give your pupil no lesson in words; he must learn only from experience" (Rousseau, 1928, p.149).

In the 19th century, influenced by the progressive educational movement and the work of psychologists, some educators have largely replaced traditional curriculum approaches with hands-on activities and group work, in which students share their views with their classmates (Hammer, 1997; Warnich & Meyer, 2013). The underlining assumption of these educators, among others, was that for a meaningful learning to take place students need to participate actively in constructing their own learning. Theorists like John Dewey, Jean Piaget and Lev Vygotsky, whose collective work laid emphasis on how students learn, were mainly responsible for the move to learner-centred learning (Douglas & Jaquith, 2009). Century later (20th century) the principles underling learner-centred instruction continues to dominate education theory and practice globally (Deblois, 2002).

Learner-centred instruction is an instructional approach that inverts the traditional teacher-center understanding of the learning process by putting learners at the center of the learning process. It emphasises on learners learning rather than on what the teacher is doing (Wright, 2006) and focuses on improving the student’s learning and success rather than on transmitting information (Kaminski, 2010). That is why Kaminski (2010) further explicates that, in LCI, the balance of power shifts as the teacher’s role moves from the expert delivering the content toward facilitation of the student’s learning process. Therefore, LCI allows learners to actively participate in the discovery of the learning processes in learner-centred classrooms from an autonomous viewpoint (Armstrong, 2012). It follows that, learner-centred classrooms are educational settings where the norm of active learning is strongly encouraged (Lambert & McCombs, 2000). To Brown (2003) learner-centred classroom is a classroom which places students at the centre of classroom organization and respect their needs, strategies and styles. In learner-centred classrooms students are empowered to use prior knowledge to construct new learning. In the same line, McCombs and Miller (2007) and Fink (2003) describe the learner-centred classroom as a learning environment that encourages students to construct and reflect on their own learning, share their insights with their peers, and apply new learning to real-life and authentic experiences. Fink (2003) has extended this description by stating that through collaboration and cooperation with others, students engage in experiential learning which is authentic, holistic, and challenging. Brown (2008) describes learner-centred classrooms in learner-centred instruction as, “involving students in their own education- student-centred instruction is when the planning, teaching and assessment revolve around the needs and abilities of the students” (p. 1).

In the same vein, McCombs and Miller (2007) have identified five attributes of a learner-centred classroom. These include, the constructing of learning, meta-cognition, teacher-student partnership in learning, collaborative learning and meaningful assessment in real-world context. McCombs and Miller (2007) realize that creating a learner-centred classroom is not considered an easy task. One of the most complex factors in a learner-centred classroom is that of maintaining balance. A true learner-centred classroom offers a balance between each of these attributes. A balance of these attributes will empower learners to take control of their learning and create classroom teachers who are true facilitators of learning. In such classrooms, learners are encouraged to research materials and spend the entire class time constructing a new understanding of the material being learned in a proactive way. On the other hand, teachers are encouraged to use distinctive learning styles, such as, brainstorming, a problem-based, an inquiry-based or an argumentation-based instructional approach (Blumberg, 2008) to create a better environment for learners to learn. In addition, a variety of problem-based or task-based and hands-on activities have to be administered in order to promote successful learning. In order for a teacher to facilitate a learner-centred classroom, among others, he or she must be aware of the prior knowledge and experiences of his or her learners (Alsardary & Blumberg, 2009). The prominence given to learners' prior knowledge and experiences in helping learners to construct new meaning and knowledge is central to constructivist theory of learning.

2.3 Constructivist theories

Constructivism considers learning as construction of knowledge by individuals (Cakir, 2008; Carr et al., 1994) and recognizes that the construction of new knowledge is strongly influenced by prior knowledge (Ausubel as cited in Naidoo, 2005). Proponents of constructivist theory of learning believe that students do not come to the classroom as empty-vessels but come with lots of strongly formed ideas about how the natural world works. Driver, Asoko, Leach, Mortimer, and Scott (1994) add that constructivism sees learning as a dynamic and social process in which learners actively construct meaning from their experiences in connection with their prior understanding and the social setting. In the light of constructivists meaning is constructed as students interpret and re-interpret new events and new information through the lens of prior knowledge (Barnes, 1992; Berk & Winsler, 1995).

Constructivist theories of learning have exerted a powerful influence on educational policy and research (Stoddart, Connell, Stofflett, & Peck, 1993; Tobin, Tippins, & Gallard, 1994). Since 1980 the constructivist view of learning had noticeable psychological influence on the border perspectives of science education and curriculum thinking in science (Fensham, 1992). Influenced by the constructivist perspective, the current trends on science education are underpinned by the view that knowledge cannot be transmitted but must be constructed by the mental activity of the learner (Driver et al., 1994). Driver et al. (1994) further explicate that knowledge is built up by the learner individually through the learners' interaction with physical objects and events in their daily lives and/or through social processes that make different viewpoints available to other learners through discussions. The individual utilizes his/her present knowledge schemes to make sense of incoming information. In the process of integrating the new and the old, previous knowledge schemes may be modified. This idea of harmonizing and contextualizing knowledge as part of teaching and learning is based on the learner-centred psychological principles of moving from known to unknown.

Constructivist teaching and learning place the students at the centre of instruction, but this does not mean that in a classroom conceived as a community of learners, the teacher has the same role as the students (Cakir, 2008). On the contrary, the teacher should facilitate classroom interactions and direct the learning goals (Jimenez-Aleixandre, 2008). In this regard, Mortimer and Scott (2003) note that teacher's authority does not mean authoritarian stance, for these perspectives are explicitly anti-authoritarian, but being responsible for justifying why inadequate options are inadequate.

Dougiamas (1998) identified six faces of constructivism, namely, trivial constructivism, radical constructivism, social constructivism, cultural constructivism, critical constructivism and constructionism. Of the six faces outlined by Dougiamas (1998), this study focuses on social constructivism. On one hand, various educators and theorists (e.g., Dougiamas, 1998; Roesler, 2002) hold the view that LCE rely more on the theory of social constructivism, as social constructivism takes into account the social nature of the learning environment as a collaborative atmosphere between teachers and learners and among learners. Social constructivism is also believed to have many aspects that feature LCE (Henson, 2003). In addition, the new learner-centred curriculum in Eritrea, which is the central concern of this study, draws inspiration from constructivist theories of learning and extends the ideas of 'constructivism' into the 'social constructivism' (MOE, 2005). On the other hand, this branch of constructivism has been found to link well with the contemporary teaching and learning of science (Driver et al., 2000). In addition, learning science was believed to involve more than the individual making sense of their personal experiences (Wilson, 2000) because the knowledge constructed at a personal level is socially mediated as a result of experiences and interaction with others in that social context (Cobb, 1996). That is why proponents of social constructivist such as, Driver et al. (2000) construe scientific knowledge as a social construct. When science is construed in the socio-constructivist terms the gradual development of knowledge through discursive activities; especially argument is given a greater prominence (Driver et al., 2000).

Studies on students' argumentation, particularly on science related issues, show that social dimensions influence argumentation (Grace, 2005; Kolsto, 2006; Mercer, 2000). As rooted in the work of the Vygotsky, Luria and Leont'ev, social interaction is an essential component of cognitive development and learning (Cole & Engestrom, 1993). Jimenez-Aleixandre (2008, p. 94) agree that the role of social interaction in the development of higher thinking skills and the collective dimension of activity systems are relevant both for the design of learning environment to support argumentation and for the research about them.

In conclusion, the assertion that argumentation has social aspect (Jimenez-Aleixandre, 2008, p. 118.) coupled with the view that learning through dialogical argumentation (which is part of the goals of constructivist science classroom) is grounded on socio-constructivist view of learning (Jimenez-Aleixandre, 2008, p. 93); guided the current study to situate its theoretical framework within social constructivist theory and argumentation theory.

2.4 Argumentation

Argumentation has its roots in ancient times and is linked with the thoughts and teachings of the most influential ancient Greek philosophers such as Socrates, Plato and Aristotle. These philosophers posit that the generation of reasoned argument is central to the act of thinking (Erduran, Ardac, & Yakmaci-Guzel, 2006). Argument has been defined in a variety of ways. Philosophers construe argument as "an interdisciplinary study of how conclusions can be reached through logical reasoning (Wikipedia, 2012). For instance, Finocchiaro (2005) construes argument as an instance of reasoning that attempts to justify a conclusion by supporting it with reasons or defending it from objections. Similarly, Kuhn (1991) defines an argument as "an assertion with accompanying justification" (p. 12). Means and Voss (1996) describe an argument as "a conclusion supported by at least one reason" (p. 141). For Siegel (1989), argument is a rational process that relies on the rigorous application of knowledge evaluation criteria.

Generally argumentation is construed as a process of sharing distinct differences of viewpoints on a subject matter by two persons or parties. Argumentation requires the arguers to examine their claims in the light of the claims of others, which engage them in a social, context-bounded, and goal-oriented process (Leitao, 2000). The view of argumentation as underlining concept in current studies gives two distinct meanings to the word 'argument'. According to Billig (1987), argument has both an individual and a social meaning. The individual meaning refers to any piece of reasoned discourse which consists of something linguistically expressed through a set of statements of which at list one is offered as a justification for another. Whereas, the social meaning entails debate between people with contrasting views or people holding opposing sides of particular issue. In this perspective individuals who hold contrasting positions attempt to convince each other of the acceptability of their adopted opinion. The former is what Ogunniyi (2007a) calls intra-locutory argument and the latter dialogical argument. He extends this further to trans-arguments i.e. arguments across groups. In this regard, Driver, et al. (2000, pp. 290-291) support Ogunniyi's (2007a) position as well as that of Billig (1987). To them argumentation could take place as an individual activity, through thinking and writing, or as a social activity in a group; a negotiated social act within a specific community. On the other hand, Eemerson and Grootendorst (2004), focussing only on the social meaning of argument, view argument as a verbal, social and rational activity aimed at convincing a reasonable critic of the acceptable standpoint by putting forward a constellation of propositional justifying or refuting the proposition expressed in the standpoint.

Kuhn (1993) asserts that there is a link between the individual and the social meaning of argumentation. An argument can be either an inner chain of reasoning or a difference of positions between people. Both positions can be partly reconciled if, as Kuhn and Udell (2003) propose, the use of the term argument for the product, statement or piece of reasoned discourse and argumentation or argumentative discourse for social process or activity. The word "argument" in this study, upholds the individual and social meaning for two basic reasons. On one hand, Eritrean's new learner-centred curriculum, which is the central focus of this study, encourages learners to work individually, in pairs and in small groups on distinct tasks and projects, such that learners can make decisions using higher-order thinking skills (MOE, 2005). On the other hand, the argument-based tasks designed for the purpose of this study (see Appendices C and H) requires pre-service teachers and middle school students to construct reasoned arguments at individual (intra-), small-group (inter-) and whole-group levels.

In many instances people do normally engage themselves in the process of argumentation in their everyday life. However, this everyday form of argumentation differs from scientific argumentation. Cavagnetto (2010) and Tolumin, Ricke, and Janik (1984) describe scientific argument as a unique form of argument and have shown that it can be competitive (as two scientists advocate for their ideas) as well as collaborative (as two scientists construct valid arguments to support each other's idea). Cavagnetto (2010) further explains that scientists use arguments to scrutinize ideas as they work toward a common goal-which is advancement in scientific knowledge. This collaboration through critique is a process of negotiating meaning that distinguishes science from other disciplinary forms of arguments**.** In the same vein, Norris, Philips, and Osborne (2007) construe scientific argumentation as an attempt to establish or validate a conclusion on the basis of one or more reasons. To them conclusion is a conjecture, explanation, or other claim. The authors further elucidate that the word reason is a term used to describe the support that someone offers for a particular conclusion. Whereas, evidence is used to describe the reasons used by scientists, especially when a reason is based on empirical data or other observations. However, some reasons are more conclusive or persuasive than others in science and what counts as a good reason in science is different from what counts as a good reason within other ways of knowing (Sampson & Groom, 2009, p. 16). Jimenez-Aleixandre and Erduran's (2008, p. 13) view argumentation in a scientific discourse as "the connection between claims and data through justifications or the evaluation of knowledge claims in light of evidence, either empirical or theoretical." This view about scientific argumentation provides an apt summary for this section and concurs with the views of various science educators working in the area (e.g., Duschl, Ellenbogen, & Erduran, 1999; Kuhn, 1993).

2.5 Using argumentation as an instructional tool

In recent years, argumentation has emerged as a significant goal for teaching and learning of science. An emerging area of research in science education explores the effectiveness or otherwise of argumentation instruction in promoting teachers' and students' understanding of scientific concepts (e.g., Cross, Taasoobshirazi, Hendricks, & Hickey, 2008; Ogunniyi, 2007a & b; Venville & Dawson, 2010; Zohar & Nemet, 2002). For instance, a recent study conducted by Cross et al. (2008) has shown the positive impact of argumentation instruction on students' conceptual understanding of scientific concepts. Findings from this study proves that engaging students in argumentation results in "more secure understanding of pre-existing concepts, exposes them to new ideas, helps them to extend their prior knowledge, and possibly eliminate their misconceptions" (p. 842). Additionally, discourse analysis from a group of three students in the Cross et al (2008) study reveals that there is likely to be greater impact from involvement in argumentation on learning gains for students with more knowledge than those with less knowledge.

Venville and Dawson (2010) and Zohar and Nemet (2002) hold a similar view to the one above and affirm that students exposed to argumentation instruction improved their conceptual understanding of the genetics topics. The conclusions drawn from these studies indicate that: (a) integrating explicit teaching of argumentation into the teaching of human genetics enhanced performance in both biological knowledge and argumentation; and (b) improvements in argumentation skills could occur after a short intervention. Implications drawn from these studies suggest that the choice of socio-scientific issues should be carefully done by the teachers and the researchers to ensure that students have sufficient background knowledge to engage in argumentation. Studies conducted by Shemwell and Furtak (2010) and Von Aufschnaiter, Erduran, Osborne, and Simon (2008) have shown similar results. Findings from these studies have revealed the positive impact of argumentation in the quality of learning achieved by students after they have been exposed to argumentation instruction. Lewis and Leach (2006) support the view that high school students who have been involved in an argumentation intervention programme for a short period of time have developed the required content knowledge. In contrast, study conducted by Walker, Sampson, Grooms, Anderson, & Zimmerman (2010) indicates that those groups who are exposed to argumentation instruction did not significantly perform better than the control group students on a test that measured their conceptual understanding of key chemistry concepts. Conclusions drawn from this study reveal that argumentation instruction does not result in such significant learning gains for students.

I believe that effective implementation of argumentation instruction has the potential to promote learners' conceptual understanding of science. However, this does not imply that teachers' proficiency per se will result in effective implementation of argumentation instruction. Rather I suggest that teachers' argumentation proficiency is a pre-requisite for professional development in this area. Hence, it is noteworthy to indicate that effective teaching of argumentation required mastery of teacher's pedagogical content knowledge and practices of argumentation. That is why Lawson (2002) asserts that one premise of successfully implementing argumentation in the classroom is the science teachers' professional development.

In addition to the findings by various argumentation scholars Shemwell and Furtak (2010), Von Aufschnaiter et al. (2008), Bricker and Bell (2008) and Jimenez-Aleixandre and Erduran (2008) have also examined the relationship between argumentation and the epistemic nature of science. Results from these studies reveal that argumentation instruction enhances the quality of student learning because it engages students in public exercise of reasoning. Since argumentation provides learners the opportunity of externalizing their reasoning they are more likely to notice the inconsistencies in their reasoning. Kelly and Takao (2002) and Kuhn (1993, 2010) hold a similar view and affirm the positive impact of argumentation instruction on students' epistemic engagement with learning. In view of its importance, several science educators (e.g., Bricker & Bell, 2008; Jimenez-Aleixandre & Erduran, 2008; Venville & Dawson, 2010) have cited numerous studies in the area of argumentation to buttress their belief that argumentation instruction does engage students in dialogical reasoning and makes learning a social as well as a cognitive activity. Implications drawn from these studies suggest that in a dialogical learning environment students need to support each other in construction of evidence-based scientific explanations that pass the test of rationality and consistency.

Integrating argumentation instruction into the teaching and learning of science, however, can be difficult in a classroom setting. In order to engage students in argumentation, teachers must restructure classroom norms from traditional pedagogical approaches (e.g. lectures) to those that allow for the production and critical evaluation of scientific arguments. To help accomplish this transformation, I believe that we need to designed curricula and instructional models that teachers can use to promote and support scientific argumentation inside the classroom. This approach, in general, provides students more opportunities to construct and critique explanations or arguments of a natural phenomenon as part of the inquiry process. Moreover, as science educators we need to keep on asking fundamental questions such as, what are the major challenges that K-12 learners and university learners face with regard to the epistemic practice we would like them to become competent? What skills the learners need to acquire to successfully confront those challenges?

Although most studies reviewed above explore the effect of argumentation instruction on students' conceptual understand, Sadler's (2004) study is guided by the assumption that students' conceptual understanding has an impact on the quality and complexity of argumentation constructed. The findings reveal that increased knowledge may lead to a quantitative increase in the number of justifications students make in an argument. Sadler and Zeidler (2005b) hold a similar view and assert that students' content knowledge could influence the quality of their argumentation. Results from this study indicated that students with more advanced understanding of genetics were more likely to incorporate content knowledge in their reasoning than students with naive understandings of genetics. They also demonstrated fewer instances of reasoning flaws, such as lack of coherence and contradiction of reasoning within and between scenarios.

Other researchers have viewed the relationship between argumentation instruction and conceptual understanding in a slightly different manner. For instance, Venville and Dawson (2010) examined the relationship between argumentation and conceptual understanding and assert that such relationship could be thought of as being in two directions. One direction is that "a person's degree of understanding about a topic may influence the quality and complexity of the arguments they construct. Conversely, being involved in the process of argumentation may influence a person's understanding of the topic" (p. 953). In agreement with the view of Venville, and Dawson (2009), Von Aufschnaiter et al. (2008) contend that students involved in argumentation are more likely to be engaged with the subject matter and thus, ''it would be reasonable to expect enhanced student understanding'' (p. 127). The underlying assumption is that as an understanding of science is essential for students developing quality arguments, it is also assumed that student involvement in relevant, real-world argumentation is likely to contribute to understanding.

Sadler and Fowler (2006) viewed the relationship between skills of argumentation and conceptual understanding in a slightly different manner. Sadler and Fowler (2006) argue that the level of knowledge required for quality argumentation is out of reach of high school students. Rather it is equivalent to the experiences of college students majoring in a certain discipline. The tentative conclusion that could be drawn from the forgoing is that argumentation instruction might not have a significantly positive impact on students' learning of key scientific concepts in every context.

The findings of the studies indicated above reveal the importance of argumentation instruction in promoting students' conceptual understanding of science, although few of the studies showed otherwise. Benefiting from the above studies, the current study utilized argumentation instruction model as an instructional tool to train pre-service teachers to implement a learner-centred curriculum in science classrooms using ABIM. Such instructional model switches the role of the teacher to that of an experienced colleague or mentor, instead of a source of knowledge, which in turn empowers students to become independent learners (Reigosa & Jimenez-Aleixandre, 2007). A wider range of science education literature on argumentation framework has been based on Toulmin‘s (1958) Argumentation Pattern (TAP) (e.g., Erduran et al., 2004; Jimenez-Aleixandre & Erduran, 2008).

2.6 Toulmin's Argumentation Pattern (TAP)

Toulmin's work on argumentation framework has made substantial impact on how science educators have defined and used argument. His definition of argument has been applied as a methodological tool for the analysis of a wide range of science curricula and as a tool for assessing small and large group student discussions (e.g., Jimenez-Aleixandre, Rodrıguez & Duschl, 2000; Zohar & Nemet, 2002). TAP illustrates the structure of an argument (Figure 2.1) and encompasses the processing of data, warrant, backing, quantifier and rebuttals (Toulmin, 1958).

More specifically, in Toulmin's definition:

> A claim (C) is an assertion put forward publicly for general acceptance. Data (D) are the facts which provide the basis for the claim. Warrant(s) (W) are proposition(s) that are offered to justify the link between the data and claim. Backings (B) are generalizations making explicit the body of experience relied on to establish the trustworthiness of the ways of arguing applied in any particular case. Rebuttals (R) are the extraordinary or exceptional circumstances that might undermine the force of the supporting arguments.
>
> Toulmin further considers the role of qualifiers (Q) as phrases that show what kind of degree of reliance is to be placed on the conclusions, given the arguments available to support them. (Erduran et al., 2004, p. 918)

Toulmin (1958) proposes a model of argumentation (as depicted in figure 2.1). The model provides the essential elements of simple in comparison to a complex argument. Further, the model focuses on the functional relationships among elements of an argument.

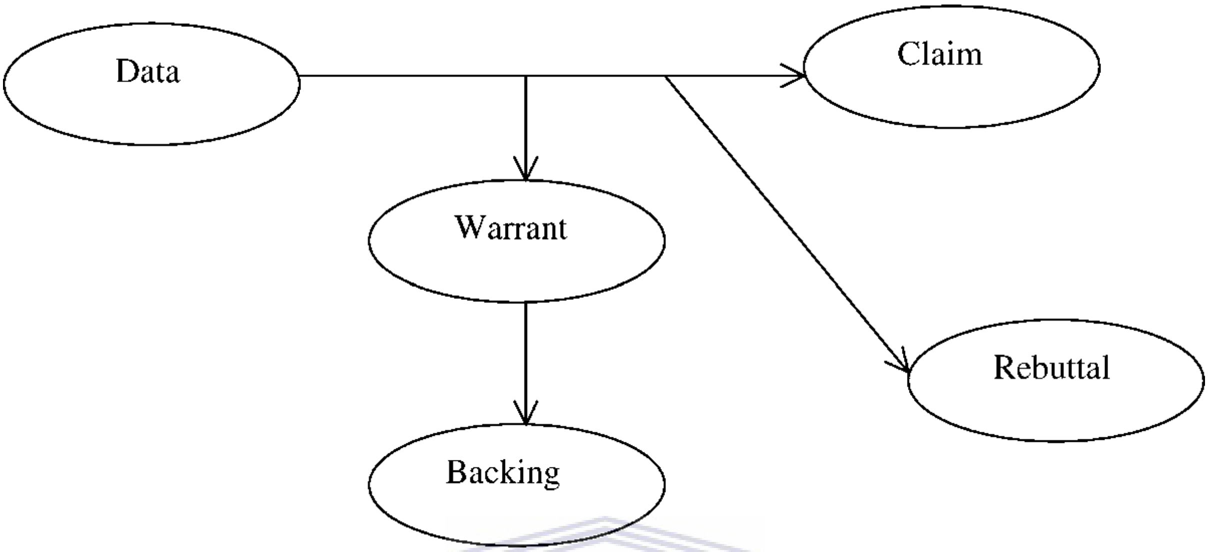

Figure 2.1 Toulmin's Argument Pattern (Toulmin, 1958).

As indicated in Fig. 2.1 above, Toulmin's model comprises of a set of six interconnected components which constitute an argument. Using these six components, Toulmin has outlined a pattern of analysing both simple and more complex arguments. An argument in its simplest form is represented by the following relationship.

D ⟶ so C

Since W

In this pattern, the facts which provide the grounds for the claim (D) are justified by propositions (W) which support the conclusion (C).

In more complex arguments, restrictions on the claim (Q) and conditions which would falsify the claim (R) are specified. Arguments of these forms are represented by the following relationship.

D ⟶ so Q, C

Since W Unless R

In addition to the above pattern, complex arguments may also include information which provides grounds for the warrant (B). Arguments of these forms are represented as indicated below.

D → So Q, C

Since W Unless R

On account of B below

Arguments which include a backing for the warrant are termed analytic if the backing implicitly or explicitly contains information communicated in the claim itself. If this information is not communicated in the claim, the argument is termed substantial.

This study adapted a modified form of TAP to evaluate the quality of arguments originated from small-group and whole-classroom discussions. I will allude to this later.

However, many science educators such as, Erduran (2008) asserts that despite its use as a framework for defining argument, the application of TAP to the analysis of small and whole class discussion was found to be difficult. The idea is consistent with the view of Simon, Osborne, and Erduran (2003) who indicated that nearly all researchers have found the application of Toulmin's schema problematic, as his criteria do not assist the ready resolution of data from warrants, nor warrants from backing resulting in poor reliability (Duschl, Ellenbogen, & Erduran, 1999; Kelly & Takao, 2002). In response to these difficulties, scholars have modified TAP analytical framework to obtain more robust units of analysis of classroom interactions (e.g., Clark & Sampson, 2008; Erduran, Simon, & Osborne 2004; Ogunniyi, 2004).

Erduran et al. (2004) have combined Toulmin's elements of argumentation namely, data, warrants and baking into a single category called grounds to sidestep many of the reliability and validity issues associated with Toulmin's framework. They have also outlined two methodological approaches that extend the use of Toulmin's model for tracing argumentation discourse in science classrooms. Both methodological tools measure the qualitative and quantitative outcomes of teaching and learning argumentation in whole class and small group discussion in science classrooms. In the first methodological tool Erduran et al. (2004) adapted TAP for the purpose of coding data that originate from the whole class conversation where successive implementations of lessons can be traced for their improved quality of argumentation. In the second methodological approach they developed a scheme and assessed argumentation in terms of levels of the quality of oppositions or rebuttals in the student's discussion in a small group setting. Table 2.1 below displays the analytical framework used by Erduran et al. (2004) to assess the quality of argumentation.

Table 2.1: Analytical framework used for assessing the quality of argumentation (Erduran et al., 2004, p. 928)

Level 1	Argumentation consists of arguments that are a simple claim versus a counter-claim or a claim versus a claim
Level 2	Argumentation has arguments consisting of claim versus a claim with either data, warrants, or backing but do not contain any rebuttals
Level 3	Argumentation has arguments with a serious of claims or counter-claims with either data, warrants, or backing with the occasional weak rebuttals
Level 4	Argumentation shows arguments with a claim with a clearly identification rebuttal. Such an argument may have several claims and counter claims
Level 5	Argumentation displays an extended argument with more than one rebuttal

Level 1 argument is the simplest, usually comprising a claim or an unjustified counter-claim in response to the claim under discussion. This is considered the lowest level of sophistication required in an argument in that it indicates learners with the lowest level of argumentation skills. On the other hand, level 5 is the most complex type comprising all of Toulmin's requirements for an argument-an extended argument with more than one rebuttal.

Other science educators (e.g., Clark & Sampson, 2008; Ogunniyi, 2007a & b) have further modified Erduran et al's (2004) framework (TAPping model) by classifying classroom discourse in terms of the complexity of the arguments involved such as: non-oppositional; arguments with claims or counterclaims with grounds but no rebuttals; arguments with claim or counterclaim with grounds but only single rebuttal, arguments with multiple rebuttals challenging the claim but no rebuttal; etc. Their framework characterizes the amount of conflict or level of opposition that takes place within an episode as outlined in the Table 2.2 below.

Table 2.2 Levels of argumentation (modified after Erduran, Simon & Osborne, 2004)

Quality	Characteristics of an argumentation discourse
Level 0	Non-oppositional
Level 1	Argument involves a simple claim versus counterclaim with no grounds or rebuttals.
Level 2	Argument involves claims or counterclaims with grounds but no rebuttals.
Level 3	Argument involves claims or counterclaims with grounds but only a single rebuttal challenging the claim.
Level 4	Argument involves multiple rebuttals challenging the claim but no rebuttal challenging the grounds (data, warrants and backing) supporting the claim.
Level 5	Argument involves multiple rebuttals and at least one rebuttal challenging the grounds
Level 6	Argument involves multiple rebuttals challenging the claim and/or grounds.

The framework above defines high-quality argumentation (oppositional level 5) as a discourse that emphasises the use of multiple rebuttals that challenge the interpretation of a phenomena and the validity of the grounds that are used to support this interpretation. On the other hand, low-quality argumentation is either non-oppositional (oppositional level 0) or consists of claims and counterclaims that do not attempt to challenge the validity of the other participants' interpretation of the phenomena (oppositional level 1).

Applicability of TAP in science lessons and in this study

Many science educators and researchers (e.g., Erduran et al., 2004; Simon et al., 2003, 2006) have adapted the methodological tools developed by Erduran et al. (2004) to evaluate the quality of argument discourses originated from classroom discussion. Others (e.g., Kelly & Bazerman, 2003) have used TAP to analyse learners' scientific reports. In the application of TAP (as modified by Erduran et al., 2004) to science lessons, researchers mainly focused on the description of arguments which were products of either individual or small-group discussions among participants. When researchers used TAP to analyse participants' argumentations, epistemic and argumentative operations adopted by the participants were compared with TAP's elements. Therefore, participants' reasoning functions and strategies for constructing valid arguments were analyzed in terms of specific features such as: the extent to which they made use of data, claims, warrants, backings, qualifiers and rebuttals; and the extent to which they engaged in claiming, justifying, and opposing the arguments (Erduran et al., 2004; Simon, Erduran & Osborne, 2006).

Erduran et al. (2004) extended the use of TAP to judge enhanced quality of argumentation and concluded that the inclusion of Toulmin's Argument Pattern in instructional practices enhanced both the teachers' and the students' reasoning and argumentation skills. In their study, Simon et al. (2006) used TAP to analyse secondary school science teacher discourse before and after they participated in a workshop about developing materials and strategies to support the teaching of argumentation in a science context. The authors indicated that using TAP as a methodological tool to analyse teachers' argument structures and reasoning functions enabled them to assess the quality of the teacher arguments. In addition, using TAP offered teachers a language for talking about science and understanding the epistemic nature of their own discipline (Simon et al., 2006). Studies which use varied application of Toulmin's Argument Model also include analysing teachers' instructional practices from a perspective of instructional decisions (Lee & Lin, 2005).

Kelly and Bazerman (2003) also used TAP to analyse learner's scientific reports and the tool that learners use in the process of writing scientific reports. Their study indicates that, students who were successful in their report writing were able to: adjust the epistemic level of their claims to accomplish different rhetorical goals, indicate specific data and methods to build theoretical arguments, introduce key concepts that served as anchors for subsequent conceptual development and tie multiple strands of empirical data to central constructs through aggregating sentences. Still others have used TAP as a heuristic for assessment of student work (e.g., Hart, 1998) as well as for supporting student learning (Andrews, 1995). For example, Mitchell (1996) successfully adapted TAP as a heuristic to scaffold university students' writing.

In conclusion, TAP is envisaged as a tool for analysing school science, and practical arguments that follow straight forward logical reasoning and non-controversial socio-scientific aspects of school science. This study, therefore, adapted units of analysis modified after Erduran et al. (2004) to evaluate the nature and level of arguments and argumentation generated in small group discussions and in the pre-service teachers' activity worksheets and writing frames. Qualitative comparison between arguments generated in successive argument-based tasks was also evaluated using the methodological tool modified after Erduran et al. (2004). In this regard, analysis of the quality of arguments constructed by the PTs focuses on the nature of rebuttals generated at individual, in small group and whole class discussion. Henceforth, the quality of argumentation was defined in terms of the presence and nature of rebuttals that were constructed by the pre-service teachers.

While TAP focused on the logical validity of claims in terms of deductive-inductive nature of school science, Ogunniyi (2007a) proposed an alternative argumentation framework compatible with or in addition to the inductive-deductive nature of science. This alternative view contends that very often arguments may carry connotative meanings that frame the intellectual apparatus of the arguer in a given context. This implies that an argumentation discourse may embrace both logical and non-logical aspects of human experience. In the light of its importance, the following section will discuss the premises of the contiguity argumentation theory (CAT) as espoused by Ogunniyi, and will highlight its units of analysis.

2.7 The Contiguity Argumentation Theory (CAT)

Ogunniyi (1995, 1996) proposed CAT to cater for the logical and non-logical but contextually valid arguments. 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. 2007a, 2011). CAT goes beyond the Platonic-Aristotelian association theory-a theory of the structure and organization of the mind which asserts that: (a) every mental state is resolvable into simple, discrete components and (b) the whole of mental life is explicable by the combination and recombination of these elemental states in conformity with the laws of association of ideas (Runes, 1975). It posits that these so-called simple elements are in reality inextricably interwoven and in a state of dynamic flux with the potential to change from one state to another depending on the arousal context in vogue (Ogunniyi, 2007a; Ogunniyi & Hewson, 2008).

Among other learning theories, CAT is a dialogical theoretical construct which depicts the way learners go about reconciling conflicting schemata which tend to arise between what learners believe and what they are taught in the science classroom. CAT suggests that:

> When two or more distinct worldviews come together in the mind, they either attract or repel each other depending on the context (Ogunniyi & Hewson, 2008) which may probably lead to cognitive conflict. In this regard, CAT is found to be an appropriate

frame work to resolve the incongruities that normally arise when two (sometimes multiple) competing thought systems (e.g. science, IKS and cultural beliefs, commonsensical, or intuitive notions) are placed side by side as in C2005" (p. 970).

The CAT proposes five types of dynamic adaptive cognitive outcomes that can occur when learners try to resolve the conflict between two different explanatory systems or ways of thinking, such as western science and Indigenous knowledge. These outcomes are:

Dominant: one idea has more cognitive power 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, 2007a).

Application of CAT to the study

As indicated earlier, TAP is only appropriate for analysing logical arguments. For this reason CAT was chosen as analytical framework to analyse explanations that do not fall readily under syllogistic reasoning on which TAP is based (Ogunniyi, 1997, 2004, 2007a). CAT was used to characterize the quality of argumentation discourses generated in the intervention programme, in the middle school science classrooms and in the argumentation activity worksheets. It was also used to describe the type of conceptual and perceptual changes that might have occurred as the result of pre-service teachers' exposure to the argumentation-based intervention training programme.

2.8 Rationale for introducing argumentation in science classrooms

An important goal of the science curriculum is for students to develop an understanding of the scientific view of the world and to be able to use scientific reasoning when a situation requires it (Sampson & Groom, 2009). Within this premises, science educators expect students to be involved in higher-order thinking skills in science classrooms. For instance, in their study, Dawson and Venville (2010) expected students to use their understanding of science to contribute to public debate and make informed and balanced decisions about socio-scientific issues that have impact on their lives**.** Similarly, Douglas and Victor (2007) expected students to know how new knowledge is generated and validated by scientists in order to understand science as a way of knowing. Still others expect students to understand that scientists use theories, laws, models and the conclusions of other investigations to design new investigations, to interpret empirical data, and to evaluate the validity or the acceptability of new explanations for puzzling phenomena (Sampson & Groom, 2009). Such expectations can only be attained if we change the focus and nature of classroom instruction. As Driver et al. (2000) succinctly put it, we need to emphases on a pedagogy that requires discursive activities, especially argument.

Over the past two decades, in an attempt to address the problem posed by the failure of the traditional method of instruction, science education researchers have explored the contribution of collaborative discourse and argumentation to learning science (e.g., Driver, et al., 2000; Newton, Driver & Osborne, 1999; Osborne, 2010). These studies have shown the importance of introducing argumentation in science classrooms. For instance, Newton, et al. (1999) provide convincing reasons for the explicit teaching of argumentation in science classrooms. First, argumentation is the process by which scientific knowledge is developed and verified. Second, by engaging in argumentation students actively participate in discussions and are able to talk about their emerging scientific understandings. Third, argumentation skills have value beyond science education. The ability of young people to reason, think critically, understand and present arguments in a logical and coherent way both orally and in writing allows them to fully participate in society, which is a desirable outcome of education in a democratic society. By the same token (Duschl & Osborne, 2002) assert that argumentation help students to: understand the nature and development of scientific knowledge, develop complex-reasoning and critical-thinking skills and improve their communication skills. Duschl (2008) seems to support the views of Newton et al. (1999) and Duschl & Osborne (2002). To him argumentation and debate are useful means to engage thinking and reasoning process in science classrooms and to mirror the discourse practice used in real life in the advancement of intellectual and scientific knowledge.

Lessons involving arguments necessitate that learners externalize their thinking (Billig, 1996; Kuhn, 1992). Such externalization requires a move from intra-psychological and rhetorical argument to the inter-psychological and dialogical argument (Ogunniyi, 2007a & b; Vygotsky, 1978). Similar views have been expressed by Quinn (1997). The author indicates that when learners engage in the process of argumentation, the interaction between the personal and the social dimension promote reflexivity, appropriation, and the development of knowledge, beliefs and values. In addition, students grasp the connection between evidence and claim, understand the relationship between claims and warrants and promote their ability to think critically in a scientific context. That is why (Billig, 1996; Kuhn, 1992) have seen the skill of 'learning to argue' as a core process of learning, both in thinking and in constructing new ideas.

Jimenez-Aleixandre and Erduran (2008) have conducted comprehensive analysis of extant literature on argumentation and summarized the importance of introducing argumentation in science classrooms as follows. Argumentation (a) is critical to meaningful learning as it enables participation in cognitive and metacognitive process, (b) develops students' communication skills, (c) promote students' critical reasoning skills, (d) supports students' understanding of scientific culture and practice, and (e) fosters scientific literacy.

In view of its importance, a number of studies are focusing on the analysis of argumentation discourse in science learning context (Driver, et al., 2000; Kelly & Takao, 2002; Zohar & Nemet, 2002). Erduran, et al. (2006) cite several studies on the analysis of the argumentation discourse in educational context. These studies have highlighted the importance of discourse in the acquisition of scientific knowledge. Similarly, Mercer, Dawes, Wegerif, and Sams (2004) have analysed argumentation discourses among students in a small group discussion. Results from these studies have shown improvement in conceptual learning when students engage in argumentation. Significant improvements were also produced in students nonverbal reasoning and understanding of science concepts. Jimenez-Aleixandre and Erduran, (2008, p. 3) noted that these works, among others, draw from two related frameworks. One framework is related to science studies highlighting the importance of discourse in the construction of scientific knowledge. The other framework is the sociocultural perspective which points to the role of social interaction in learning and thinking process and elaborates that higher thinking processes originate from socially mediated activities, particularly through the mediation of language. That is why Mason (1994) contends that argumentation needs to be appropriated by students and explicitly taught through suitable instruction, task structuring and modelling.

However, my long and rich work experience in the classroom practices indicates that Eritrean students have not been exposed to argumentation, discursive exploration of scientific ideas, their implications and their importance in science classrooms. Consequently, science students and graduate of science are unable to provide evidence and justification to some of their claims when discussing or critiquing ideas. Studies conducted in sub-Saharan Africa show similar findings. The result indicates the prevalence of 'traditional' and 'outmoded' styles of teaching in most classrooms (SMICT Study, 2005). That is why science educators (e.g., Bell & Linn, 2002; Sadler & Zeidler, 2005b) recommend that much work needs to be done in developing effective pedagogical approaches that pay particular attention to elementary, middle, and high school students' conceptual understanding of science content knowledge and the structure and function of sound argument.

The above discussions have shown the importance of the inclusion of explicit argumentation instruction in science classrooms. However, teaching science through argumentation has proved to be a challenging task for many teachers (McNeill & Knight, 2011; McNeill & Pimentel; Sampson, 2009; Sampson & Grooms, 2009). Hence, it is worthwhile to indicate the major barriers for implementing ABIM in science classroom.

2.9 Challenges of using argumentation in science classrooms

Extant literature in the area of argumentation identified several barriers to developing young people's skills of argumentation. Of these, lack of exposure to arguments and explicit instruction and practice in the skills of argumentation was found to be one of the major barriers (Larson, Britt, & Kurby, 2009; Osborne, Erduran, & Simon, 2004a; Takao & Kelly, 2003). Some of the challenges encountered by most teachers in the implementation process of argumentation in the science classroom (with respect to teachers and students ability, nature of curriculum and physical environment of the classrooms) include the following:

- Limitations of teachers' pedagogical repertoire to adapt argument-lesson and facilitate argumentation and their limited understanding of the nature of science (Driver et al., 2000). Bartholomew, Osborne and Ratcliffe (2004) hold similar views and reiterate that some science teachers were not familiar and others were not comfortable with argumentation-instructional approach and, therefore, encounter problems while adapting this approach in their teaching of science. Research conducted by (Duschl & Osborne, 2002) seems to support the above views. The result of the study indicates that most science teachers have difficulty in helping learners with the scientific inquiry practices such as argumentation.

- Teachers lack the required skills to use appropriate tasks and handle open-ended activities (Simon & Maloney, 2007). Also, they do not have the necessary skills to effectively organize group and class discussions and, hence, they lack confidence in their ability to successfully manage sessions devoted to argumentation and discussion in the classroom (Driver et al., 2000).

- Learners lack appropriate prior knowledge and experience language difficulties. They are also used to traditional forms of interaction (Brodie, 2004; Erduran, et al., 2006).

- Learners have difficulty in articulating and defending their knowledge claims (Sandler, 2004) and may fail to use appropriate evidence (Sandoval, 2003).

Similarly, studies conducted by (National Assessment of Educational progress, 1996, 1998; National Science Board, 2006) have shown that K-12 students are unable to understand, evaluate, or write arguments and do not have adequate understandings of NOS (e.g., Abd-El-Khalick & Lederman, 2000; Ryan & Aikenhead, 1992).

- The norms of scientific arguments, explanation and evaluation of evidence differ from the norms of students encounter in everyday life (National Research Council, 2007).

- Science teachers have the pressure to cover the National curriculum. In addition, content-leaden curriculum resulted in low time on task and examination-oriented teaching leave little room for teacher innovation (McCombs, 1997)

- Large class size, of which research has shown that overcrowding in many classrooms, makes it difficult to implement small group activity (e.g., Brodie, 2004) which is an essential process of argumentation.

Apart from the challenges indicated above, lack of the transformation of policy recommendations to educational practice is a major challenge to implementing argumentation in every day classrooms (Jimenez-Aleixandre & Erduran, 2008). To minimize the gap (e.g., Erduran, et al., 2004; Osborne, et al., 2004a; Simon, et al., 2006) organised an on-going school based research under the theme learning to teach argumentation for professional development of teachers through IDEAS project, which is the focus of the next section. McNeill and Knight (2011, 2013), Ogunniyi (2004, 2005, 2007a & b), Ogunniyi and Hewson (2008) and Zembal-Saul (2009) have also done the same with several cohorts of science teachers.

2.10 School-based research in argumentation

The renewed emphasis on scientific inquiry in contemporary reform efforts shifts the focus to science as argument and explanation (NRC, 2000, p. 113). The execution of argumentation in science classrooms, therefore, necessitates long-term and supportive professional development of science teachers. To this end, there has been considerable effort to improve science teachers' professional practice in organizing argumentation-based classroom discourses (e.g., Erduran, et al., 2004; Hall & Sampson, 2009; Simon, et al., 2006; Simon & Johnson, 2008; Skoumios & Hatzinikita, 2009). For instance, Erduran (2006), Erduran, et al. (2004), Osborne, et al. (2004a) and Simon, et al. (2006) conducted school-based research projects in secondary schools in the United Kingdom and elsewhere for two and half years for professional development of science teachers. Ogunniyi (2004, 2005, 2006, 2007a &b, 2008, 2011), as well as Ogunniyi and Hewson (2008) also conducted a similar research project in South Africa for the professional development of science teachers by integrating two presumably controversial and incompatible knowledge corpuses namely, science and indigenous knowledge in the classroom context.

Erduran, Simon, and Osborne (2004) and Osborne, Erduran, and Simon (2004a) organized research project funded by the Economic and Social Research Council (ESRC). The purpose of the research project was to investigate strategies and resources for promoting and sustaining argumentation in science classrooms. Twelve science teachers participated in the project for one year. The findings of the research project indicated that eight of the twelve teachers displayed significantly higher quality of argument in their lessons after one year of training. Also, they found out those children's skills of argumentation improved with practice. On the basis of their findings, the researchers concluded that it is possible to train teachers to adapt their teaching of placing more emphasis on construction of argument. Their findings also showed that if teachers get the required support, they can then produce helpful resource materials and instructional tools. It seems that the researchers have achieved the purpose of their study. They managed to develop training resources on argumentation and identified pedagogical strategies such as group discussion, presentation and posing questions that stimulate argumentation for enhancing argument in science classrooms.

Osborne, Erduran, and Simon (2004b) also worked in the Ideas, Evidence, and Argument in Science Education (IDEAS) project funded by Nuffield Foundation. The project was aimed at preparing pre-service and in-service teachers to teach science as an argument. The IDEAS pack was published in 2004 and reprinted in 2005. The pack contains:

- Resource materials on aspects of argument.
- Fifteen sample lessons which teachers are supposed to try out some or all of the approaches in the IDEAS Continue professional Development (CPD) sessions
- Twenty eight clips of ordinary teachers dealing with how to structure and approach the teaching of argument in science.

The IDEAS pack has been used in the training of both pre-service and in-service science teachers as part of the on-going school-based research in argumentation (e.g., Erduran, 2006; Erduran, Ardac, & Yakmaci-Guzel, 2006; Simon & Maloney, 2006).

Ogunniyi and associates (Ogunniyi, 2004, 2005, 2006, 2007a & b, 2011; Ogunniyi & Hewson, 2008; Mushayikwa & Ogunniyi, 2011) carried out a series of studies using an argumentation framework. While the above studies (e.g., Erduran, 2006; Erduran, Ardac, & Yakmaci-Guzel, 2006; Simon & Maloney, 2006) focused on the logical validity of claims in terms of deductive-inductive nature of school science. Ogunniyi (2004, 2007a & b) proposed an alternative argumentation framework compatible with or in addition to the inductive-deductive nature of science, which he calls it Contiguity Argumentation Theory (CAT). This alternative view contends that very often arguments may carry connotative meanings that frame the intellectual apparatus of the arguer in a given context. This implies that an argumentation discourse may embrace both logical and non-logical aspects of human experience. This will be clarified further on in subsequent chapters.

In recognition of the importance of professional development of teachers, many scholars (e.g. (Jiménex-Aleixandre & Erduran, 2008; Osborne, Erduran, & Simon, 2004a; Simon, Erduran, & Osborne, 2006) have organized argument-based intervention programs aimed at training pre-service and in-service science teachers. An interpretive summary of the work of some science educators will then be presented in the section that follows.

2.11 Pre-service science teacher development for argumentation instruction

As noted in the previous chapter, Ogunniyi contends that the most effective way to get teachers to be involved in the implementation of the new curriculum is to engage them in a long-term mentoring process which entails modelling for them dialogue, argumentation and explicitly reflective instructional approaches (Ogunniyi, 2005, 2006). In light of this, an overview of the research findings of some science educators (Erduran, 2006; Erduran, Ardac, & Yakmaci-Guzel, 2006; Ogunniyi & Hewson, 2010; Simon & Maloney, 2006) who have done commendable contributions in the professional development of science teachers in relation to classroom discourses is further highlighted. This study has focused on these science educators' works because they organized a number of training programmes for pre-service and in-service science teachers by introducing some argumentation protocols, essential to promoting argumentation, into the learning and instructional process within science classrooms.

Hence, the study reviewed seven school-based research projects on professional development of science teachers in argumentation. Two of these studies explore how pre-service and/or in-service teachers structure argument-based lessons (Erduran, Ardac, & Yakmaci-Guzel, 2006; Simon, Erduran, & Osborne, 2006). One study examines how trainee teachers worked collaboratively with their school-based mentors (Erduran, 2006). Four studies (Mushayikwa & Ogunniyi, 2011; Ogunniyi, 2006, 2011; Ogunniyi & Hewson, 2008) examine the effect of dialogical argumentation-based instruction on teachers' ability to integrate African IKS with natural science curricula in science classrooms.

As part of the school-based research project in argumentation, Erduran, Ardac, & Yakmaci-Guzel (2006) conducted a case study of pre-service secondary school chemistry teachers in Istanbul, Turkey. The purpose of the study was to illustrate how teachers structure lessons and implement argumentation in secondary school classrooms after a series of training sessions. Seventeen pre-service teachers were trained using the IDEAS pack over a six weeks period. The sessions took place as an integral part of the teaching practice in chemistry course. The course included some recommendations for encouraging students' use of evidence to support their claims as well as the video exemplars of good practice illustrated in the IDEAs video (Osborne et al., 2004). It requires pre-service teachers teach a minimum of three chemistry lessons during their field practice. The findings indicated that the trained teachers incorporate those features of pedagogical strategies (e.g., group discussion and presentation) targeted by the training. The findings of the research project proved that the intended purpose of the study has been achieved successfully. Also, the researchers noted that there is a need to further develop tools that would identify not only the structure but the content of argument.

Simon, Erduran, & Osborne (2006) also organized professional development programme for secondary school science teachers in great London for a period of one year. A group of volunteer teachers attended the preliminary workshop to develop resource materials, strategies and activities that support the teaching of argumentation in scientific contexts. Out of these, twelve teachers who were willing to practice teaching of argumentation were selected. The focus of the study was on developing argumentation skills of teachers and on examining how the target teachers enhance their practice over time. Data was collected at the beginning and end of the year. TAP was used as an analytical framework to provide a qualitative analysis of the extent to which teachers and students have made use of claims, data, warrants, backing, qualifiers and rebuttals and the extent and quality of argumentation facilitated by the teachers. Analysis of the data indicates that all teachers attempt to encourage a variety of processes involved in argumentation. The authors have also analysed transcripts of five teachers at a deeper level to identify teachers' oral contribution that facilitate and support argumentation. The findings revealed that three out of the five teachers show a significant change and the remaining did not.

Osborne et al. (2004a) used similar procedures to examine the quality of teachers' and students' argumentation in both scientific and socio-scientific contexts. The focus of their study was to enhance the quality of subjects' argumentation skills. The result from this study revealed that there is a positive development in the quality of argument of the targeted groups of teachers and students. Implication drawn from this study suggest that students need to be explicitly guided in developing and applying skills of argument in both scientific and socio-scientific contexts and that the application of relevant conceptual knowledge may be needed (particularly in science context) to ensure students are able to engage in argumentation effectively.

Erduran (2006) conducted a similar study on promoting ideas, evidence and argument in initial science teacher training. The aim of the study was to produce resources to support the teaching of ideas, evidence and arguments in the teacher training programme. The development of the materials built upon the knowledge gained through research-based initiatives such as IDEAS project (Osborne et al., 2004). The model of the training was based on a partnership between the school-based mentors and the trainee teachers. Both mentors and trainee teachers who attended the two workshops were introduced with the programme structure of the workshop and were allowed to reflect on their experiences with the lesson. Exemplary activity resources and feedback from trainee teachers and mentors were described. Erduran (2006) concluded that promoting ideas, evidence and argument in a science teaching is likely to engage both teachers and students in modes of thinking that characterize those of scientists.

In a nutshell, the three studies indicated above examined the effect of school-based professional development programme and highlighted the importance of argumentation-based intervention training programme on pre-service and/or in-service science teachers' ability to, (a) structure argument-based lessons in science classroom, and (b) develop strategies and resources to employ argumentation for their classes. Implications drawn from these studies suggest that science teachers need to understand the value of providing evidence to justify or refute a claim in science context. They also need to be aware and adapt the strategies required to facilitate the process of argumentation and move away from traditional approach of teaching.

As indicated above, Ogunniyi (2004, 2007a & b) proposed an alternative argumentation framework compatible with or in addition to the inductive-deductive nature of science. Using this framework Ogunniyi (2004, 2005, 2006, 2007a & b, 2011) conducted a research project in South Africa for the professional development of science teachers by integrating two presumably controversial and incompatible knowledge corpuses namely, science and indigenous knowledge in the classroom context. The author have trained several cohorts of science teachers who registered for post-graduate certificate in science education at University of Western Cape. The science teachers were exposed to a series of bi-weekly three-hour lectures, workshops and advanced seminars underpinned by the Tolumin's Argumentation Pattern (TAP) and Contiguity Argumentation Theory (CAT) on the Nature Of Science (NOS), Nature Of Indigenous Knowledge (NOIK) and the role of argumentation in scientific practice for over six months. Each lecture lasted for one and half hours followed by another hour for arguments and discussions. The participating teachers engaged in vigorous sessions of practice in argumentation, involving argument-based tasks, practical design of instructional materials and vigorous Science Ingenious Knowledge System (SIKS) research. The last 30 minutes was used for recapitulation and summary. The findings of these studies indicate that argumentation instruction did enhance the teachers' understanding as well as increase their awareness of the need to implement a Science-Indigenous Knowledge (IK) curriculum in their classrooms. The same studies further show that as a result of the teachers' involvement in argumentation instruction they become more sceptical of the notion that science is the only way of knowing or interpreting experiences.

Ogunniyi and Hewson (2008) also examined the effect of dialogical argumentation-based instruction on teachers' ability to integrate African Indigenous Knowledge System (IKS) with the existing natural science curricula in the South African science classrooms. In the study the authors investigated whether a curriculum involving argumentation would allow teachers to, develop a sense of acceptance of the new South African science curriculum, particularly the mandate to integrate IKS into the science curriculum; to differentiate science and indigenous knowledge and to select appropriate methods to integrate the two. Nine in-service, experienced teachers participated in the course for over a six-month period. The findings indicated that after participating in the course, the teachers were more willing to accept IKS as a potential legitimate aspect of a science curriculum. They were able to distinguish between science and indigenous knowledge than before the course. They were also able to select a number of appropriate pedagogical strategies to integrate IKS into their science classrooms. However, the strategy involving argumentation was ranked very low.

In a similar study, Mushayikwa and Ogunniyi (2011) explored the ability of in-service science teachers to integrate Indigenous knowledge Systems in their teaching of science concepts for grades two-twelve learners. Argumentation was used as the main strategy for this integration. Results from the study showed that the teachers did integrate the model into their teaching of science and that they found the experience to be beneficial to them and to their learners. However, teachers also reported serious impediments to the implementation of the model. The main concern was the apparent disjunction between the National Curriculum (NC) requirements and the statutory requirements needed to implement it. Other constraints pertained to the unpreparedness of the school, district and provincial authorities to implement IKS into the school system, despite its proven benefits.

From the foregoing, it seems that while a lot has been done to show the potential of argumentation instruction in facilitating classroom discourses there is still a lot to be done in the area. In view of this, the current study adapted the above strategies and protocols to train pre-service middle school science teachers to implement learner-centred curriculum using ABIM in Eritrean science classrooms. Resource materials (see Appendix G) and procedures adapted from these studies, which are used in the intervention training programme are presented in chapter three (see sub-section 3.8.2). The underlying assumption is that the outcome of the intervention programme would bring the required change in the instructional practices of the participating pre-service teachers involved in the study.

What seems obvious from the review of the above studies is that the implementation of the new curriculum has implications for teacher training, curriculum development and instructional practices. A curriculum innovation usually warrants that the teachers who would implement it agree with the philosophy of the curriculum and possess pedagogical skills for its implementation otherwise what is implemented would be a corruption of what was intended. Curriculum developers and other stakeholders e.g. teachers, learners, text book publishers, school administrators, heads of science department in the schools and others must have a say in the matter.

2.12 Conclusion

A number of issues related to argument in science teaching and learning emerged from the literature reviewed. The literature reviewed seems to come to one conclusion that science education programmes need to help students learn more about how new knowledge is generated, justified and evaluated by scientists and how to use such knowledge to engage in inquiry in a way that is consistent with the practices of scientific community (Hall & Sampson, 2009). There exists consistency in the literature reviewed which shows that to attain such a goal teachers need to change the nature of the typical classroom activity and discourse patterns and employ contemporary approaches of teaching such as argumentation in a learner-centred classroom. Such approaches provides opportunities to students to develop skills of argumentation, critical-thinking skills and scientific habits of mind that are needed to assess alternative ideas, weight evidence, evaluate the validity or acceptability of a scientific explanations.

The literature reviewed in this chapter has also consistently shown that many K-12 students are unable to understand, evaluate, or write well-structured arguments (National Assessment of Educational Progress, 1996, 1998; National Science Board, 2006). Moreover, the experience at the coal face of science classroom has identified major barriers to developing students' skills of argumentation (Osborne, Erduran, & Simon, 2004; Takao & Kelly, 2003). Central to the discussion is the limitations of teachers' pedagogical repertoire to adapt argument-based lessons and/or facilitate argumentation and their limited understanding of the nature of science (Driver et al., 2000, p. 309). The literature reviewed, however, does provide evidence that students' and teachers' skills of argumentation can be enhanced. These studies suggest direct, explicit instruction in argument as the preferred instructional method for developing argumentation skills. The discussion that centred on engaging science teachers in a long-term mentoring process in the form of dialogue, argumentation and explicit reflective instructional approaches (Ogunniyi, 2005, 2006) served to extend the general discussion from chapter one on the need to organize intervention programme in argumentation to pre-service science teachers in Eritrea.

In a nutshell, the discussion in this chapter suggests that well-trained and qualified science teachers could help students develop the ability to think dialogically and play an active role in resolving socio-scientific issues; thereby, contribute towards social transformation of their society. It is imperative that extensive classroom based research is required to determine the impact of classroom factors on students' and teachers' argumentation skills.

Although various attempts have been made to explicate issues surrounding the introduction of argumentation in science classrooms (e.g., Driver, et al., 2000; Duschl & Osborne 2002; Duschl, 2008; Newton, et al., 1999; Osborne, 2010) more empirical studies are needed to provide additional data and insight in the area. This study tried to corroborate the findings of earlier studies as well as provided additional evidence regarding the veracity or otherwise of argumentation protocols and argumentation theories that have been reviewed in this chapter. It is also hoped that the findings of the study would be found useful and informative for researchers in the area. The following chapter, chapter three, discusses the research design and methodology employed for this study. It also justifies the sampling size and sampling strategy, the research instruments developed as sources of data generation and audio and video transcripts as data collection method.

CHAPTER THREE

RESEARCH DESIGN AND METHODOLOGY

3.1 Introduction

The purpose of chapter two was to anchor the study within the on-going discourse on the conceptions of science learning as argument. It also examined the theoretical framework that guides this research. This chapter discusses the research design and methodology developed to address the purpose and the research questions of this study. It was aimed at providing justification for the research design employed in this study and explains how the data that was used to address the research questions was collected, analysed and interpreted.

The chapter begins with a description of the research design. It further outlines sampling and sampling strategies utilized. This chapter also provides a comprehensive description of the context of the study; including a profile of the participating pre-service teachers and the details of the argumentation based instructional intervention programme that was designed for the purpose of this study. Research instruments used in this study and phases of the study, as well as data collection techniques and analysis were discussed. The trustworthiness and ethical consideration in the study were also discussed. The chapter concludes with a summary of the research design.

3.2 Qualitative research design

This study was aimed at undertaking in-depth investigation of the effect of argumentation-based intervention training programme on pre-service teachers' ability to implement learner-centred curriculum in science classrooms. A qualitative research approach was viewed to be a suitable approach to address the complexity and fluidity of the issues raised in the study. A qualitative research approach helped to find meaning and gain more insight into factors and situations behind the numbers; a function which a quantitative approach might prove inappropriate for or ineffective to achieve (Asher, 1975; Cohen, Manion, & Morrison; 2001; Fraenkel & Wallen, 1996; Hart, 1998; Marshall & Rossman, 1999). This approach allowed the researcher to access rich, in depth information of a qualitative nature without requiring large sample (Lincoln & Guba, 1985; Sinkovics, Penz, & Ghauri, 2008; Sykes, 1990) and offers a clear and holistic view of the classroom context (Denzin & Lincoln, 1994; Ghauri & Grønhaug, 2005; Sinkovics, Penz, & Ghauri, 2008).

In line with the interpretivist research design the nature of the reality that emerged in this study was by and large based on the researcher's interpretation. Marshall and Rossman

(1999) elucidate that the interpretivist approach emphasizes more on watching, listing, asking, recording, reflecting and examining. These activists allowed the researcher to get closer and focus on individual pre-service teachers and on small groups in their naturalistic classroom setting (Lincoln & Guba, 1985; Van Rensburg, 2001). It also enabled an avid focus on the pre-service teachers' perceptions of learner-centred curriculum, argumentation and the factors that promotes and/or hinders them from using ABIM to implement learner-centred curriculum within their own classroom setting. Furthermore, the qualitative approach enabled the researcher to make sense of or to interpret phenomena in terms of the meaning pre-service teachers brought to their situation (McMillan & Schumacher, 1993; Terre Blanche, Durrheim, & Painter, 2004). Such an approach has further relevance in this study as it focuses on an issue about which very little is known (Schurink, 2003) namely, Eritrean pre-service teachers' perceptions about learner-centred curriculum, argumentation and their ability to use argumentation instruction to implement a learner-centred curriculum. This has been made possible by adopting a case study research approach.

Nisbet and Watt (as cited in Cohen, Manion, & Morrison, 2001) described case study as "a study of an instance in action in a bounded system, for example a child, a group, a class, a school, a community" (p.81). In this study, the case was a group of 25 pre-service teachers from the Department of science education, College of education, in Eritrea Institute of Technology (EIT), Eritrea. A case study can be approached from qualitative and quantitative research methods, as "it is defined by interest in individual cases, not by the methods of inquiry used" (Stake, 1994, p. 236). The choice of a case study approach was also congruent with the decision to use qualitative research methods. In addition, the case study method was considered useful for this study as it enabled the researcher to consider a particular case and study it narrowly (Babbie & Mouton, 2001) in order to know it well (Stake, 1995). In keeping with the view of Cohen, Manion, and Morrison (2001, p. 181), this methodological approach enabled the researcher to penetrate deep into situations in ways that are not always susceptible to numerical analysis.

When a number of cases are studied at the same time in order to investigate the same phenomena, Stake (2000, p. 437) calls this a collective case study. The design of this research study can therefore be described as a collective case study as it examined a group of twenty five pre-service teachers' individual cases. This study also adopted an instrumental case study. Instrumental case studies require that cases be selected for intensive study (Stake, 1994, p. 237). In this regard, Stake (1995) advised researchers to be very careful when choosing instrumental cases to provide an opportunity to maximize learning about the issue or problem to be investigated. In keeping with the above view, six instrumental cases out of the 25 collective cases were purposeful selected and examined at a deeper level (see section 3.3). Instrumental case study approach helped to investigate particular cases, and provided information that helped to answer the research questions, posed at the beginning of the study. The six pre-service teachers were selected (PT12, PT13, PT16, PT2, PT5 and PT23) as they represented a range of variation between pre-service teachers in terms of the quality of arguments they constructed when dealing with every day, socio-scientific and scientific argumentation scenarios (see Tables 4.4 - 4.9). While the data drawn from the 25 pre-service teachers' collective cases was used to represent a summary of the quantitative analysis, the six instrumental cases formed the core of the qualitative analysis.

Although the research design used in this study was not purely action research, to a certain extent, an attempt was made to utilize the elements of action research. The researcher adopted the stages of action research proposed by Kemmis and Mc Taggart's (1988a) namely, plan, act, observe and reflect to systematically organize the three reflective workshop sessions which took place after each round of classroom observation. Keeping the suggested stages, the researcher planned the reflective workshop session (planning), re-introduced some aspects of argumentation, encouraged the pre-service teachers to observe sample video lessons of their own and their peers' classroom practices and analysed them by emphasising on how the pre-service teachers structured and approached the teaching of argument in science classroom (act, observe). Finally, the researcher provided a platform for pre-service teachers to reflect and share their experiences (reflection).

The rationale for adopting the action research process was to help pre-service teachers to make progress in their teaching of argumentation by re-planning successive workshop sessions focusing on their existing pedagogical skills, understanding of Argumentation Based Instructional Model (ABIM) and on their aims of teaching and learning science. Another rationale for including the element of action research in this study was to examine the video lessons observed and to look for areas that needed consideration and improvement. Details of the reflective workshop sessions are discussed further on in this thesis. The sampling techniques used in this study are outlined below:

3.3 Sampling

3.3.1 The research sample

The participants in this study was a cohort of undergraduate middle school pre-service science teachers, enrolled in a teaching practice course during January of 2013, in the Department of Science, College of Education at the Eritrea institute of technology (EIT). The middle school pre-service teachers were chosen as they will be teaching in middle schools where the science concepts presented at that level are pivotal in laying the foundation to the biology, chemistry and physics concepts that are presented in successive levels of education.

The EIT is one of the nation's largest institutes of learning in Eritrea and offers **26** graduate and undergraduate degree and diploma programs to **6,000** students at a campus located in Mai- Nefhi, 28 kilometres away from Asmara, the capital city of Eritrea. Out of the **6,000** students, **1000** were education students, of which **150** were from the Department of science education. With the permission of the vice president of EIT as well as the approval of the Dean of the College of Education, I went to the classes and invited pre-service teachers to participate in the study. Out of the **150** students asked, a total of thirty middle school pre-service science teachers showed interest of participating in this study. This gives us a response rate of **20%.** They were provided with an information package indicating the purpose of the study, and the general procedures that will be followed during the three phases of the study, that is pre-intervention, actual-intervention and post-intervention phases. They were required to indicate their consent to participate in the study in writing, after reading and understanding the information included in the package.

While thirty of them consented to participate in the study only pre-service teachers who participated in all pre- and post-intervention data collection techniques were included in the analysis. This resulted in 25 pre-service teachers and became the case study participants in this study. The twenty five participating pre-service teachers were in their second year (final year) of study and have completed the core science content courses and education courses in the first semester of 2012/2013 academic year. During the study period (January 2013-June 2013) the pre-service teachers were completing the teaching practice course in selected middle schools to fulfil the requirements for graduation in science education. They all participated voluntarily in this study. None of them had taken any formal course work or workshops or seminars on argumentation before the intervention.

The pre-service teachers involved in this study were diverse in age, gender, socio-economic background, ethnic and religious groups. The majority of the PTs were in the **21-25** age range and they joined the diploma programme straight from high school. Eight of the pre-service teachers were matured, with their ages ranging between 29-39 years old. These eight pre-service teachers had received a one year teaching certificate from Asmara Teacher Training Institute (ATTI) and had nine to twelve years teaching experience in elementary schools in the country. About two third (16) of the participants were male teachers and the remaining nine were female teachers. The ethnic backgrounds of the pre-service teachers were similar; majority of them being of Tigrigna descent and few of Tigre, Bilene, Saho and Nara origin. Majority of them were Tigrigna language speaking and few were Tigre, Bilene, Saho and Nara language speaking. Yet, all pre-service teachers involved in this study can speak Tigrigna very well as it is an official language of the county. Majority of the pre-service teachers belong to the middle class socio-economic status and few were from the minority disadvantaged group. A critical glance at their university entrance matric results and cumulative grade points, in the three semesters at the institute, revealed that the 25 pre-service teachers were comparable with the current and last two years' cohorts of pre-service teachers' population that enrolled in the teaching practice course at the Department of science education at EIT.

Out of the cohort of 25 pre-service teachers, six pre-service teachers were selected for in-depth qualitative analysis using purposive sampling technique (Groenewald, 2004; Flyvbjerg, 2006) or a deliberately selected sample (Lester, 1999). The logic and power of purposeful sampling lies in selecting information-rich cases for in depth study (Patton, 1990). The author further described the information-rich cases as those cases where researchers can gather in-depth information about issues important for the purpose of the study. The selection criteria was primarily based on the quality of arguments constructed by individual pre-service teachers in the three tasks (see Tables 4.4 to 4.9) and their ability to participate in argumentation discourse during small group and whole classroom discussion (see episodes 1-9 of Appendix J) pre-service teachers' understanding of scientific argumentation, their teaching experience and gender were also taken into account. This selection criterion was used to examine whether pre-service teachers' understanding and skills of argumentation had an effect on their ability to use ABIM to promote and sustain argumentation in learner-centred science classroom. Although it is not the main concern of this study pre-service teachers' teaching experience and gender were also considered as a criteria to see their effect if any in their ability to use ABIM to implement learner-centred curriculum. To select the six cases, the quality of arguments constructed by all 25 pre-service teachers in all the three selected argument-based tasks (see Appendix C) administered during the intervention programme were analysed using the levels of argumentation developed after Erduran et al. (2004). Their participation in argumentation discourse and the quality of arguments constructed within their groups and in whole classroom discussion was also carefully scrutinized. Quality arguments as espoused by Erduran et al. (2004) are arguments which include one or more rebuttals (see Table 2.2). Finally, pre-service teachers understanding of scientific argumentation, participants profile such as, teaching experience, gender, and ethnicity were examined.

3.3.2 Choice of Schools

Before the commencement of the teaching practice course, the Teaching Practice Coordinator in the College of Education, EIT was contacted and informed about the purpose of the study and the general procedure that will be followed during the study period. The coordinator noted that all the PTs who were enrolled for the teaching practice course will be assigned to public middle schools located in Asmara, capital city of Eritrea. I was given the opportunity to choose four middle schools to which I can assign the 25 pre-service teachers. Then I chose schools within the shortest distance from the university hostel where the pre-service teachers stayed for a semester. The four selected schools were similar in size and type and were considered by the Ministry of Education as comparable with the other middle schools in the country. The demographics of the student population were of mixed gender, age, academic ability, and socio-economic background. According to the structure of Eritrean education system (MOE, 2001, 2005) middle schools comprise of grades six, seven and eight. In this study only grade seven was chosen because the grade is free from the stress of National examinations as such examinations could have an influence on the implementation of a curriculum. Being a permanent faculty member of the College of Education I was assigned as a teaching practice supervisor for all the 25 pre-service teachers for a period of four months; from March to June, 2013. Prior to the commencement of the teaching practice I contacted the school principals and sought permission to use a video camera during classroom observation sessions. The next section details the research instruments used in this study.

3.4 Research instruments

This study utilized several research instruments namely, 1) a questionnaire 2) an argument-based tasks 3) a classroom observation schedule 4) an interview 5) a reflective questionnaire/reflective interview 6) video-taped class lessons and field notes. This sub-section presents the primary data sources that provided evidence for the resultant analysis, interpretation, recommendations and implications that emerged during the period of this study. The section below is a detailed presentation of each of the research instruments used in this study.

3.4.1 Learner-centred Argumentation Instruction (LCAI) Questionnaire

The Learner-centred Argumentation Instruction (LCAI) Questionnaire was utilized to assess the pre-service teachers' pre and post views about learner-centred curriculum, learner-centred instruction and argumentation. It was administered twice before and after the intervention programme in order to assess the relative impact of the argument-based intervention training programme. The questionnaire was developed through a sequence of refinements; drawing from critiques from a group of science education experts, piloting and carrying out statistical analysis. The initial version of the questionnaire consists of 10 items. Five science education experts were asked to rate each item of the questionnaire in terms of relevance, clarity and simplicity of the language on a Likert scale of 1-5 (from a very poor item =1 to an excellent item = 5). Items rated less than 3 within a Likert scale of 1-5 were left out from the initial version of the questionnaire. The correlation of the ranking of two of the experts based on Spearman Rank Difference stood at 0.92, thus showing strong face, content and constructs validity. The items in the last version of the questionnaire were reduced from ten to eight. It was piloted with ten pre-service teachers from the College of Education, EIT, Eritrea. The final version of the questionnaire had three sections. The first section collected information on sample demographics and personal data. The second section, provided information on pre-service teachers' conceptions of learner-centred curriculum and the third, which is the instruction section sought to know their conceptions of argumentation (for details see Appendix B).

3.4.2 Argumentation-based tasks

A series of planned argumentation-based activity worksheets and writing frames were developed to assess pre-service teachers' argumentation skills. The argumentation-based activity worksheets were purposefully designed to encourage pre-service teachers' engagement in everyday, in scientific and socio-scientific argumentation tasks and guide them on how to argue effectively at different occasions. The tasks also went through a vigorous validation process. It was given to the same panel for face, content and constructs validation. Using the Spearman-Brown correlation reliability formula, the reliability coefficient of the argumentation-based activity worksheets and writing frames was 89**.**

Most of these tasks took the form of debates and were administered at different intervals of the intervention training sessions. Individual and group task were utilized during the administration of each task to allow pre-service teachers' to express and defend their claims and a whole class discussion was held at the conclusion of the task to further motivate them to examine their argument. Of the series of argument-based tasks administered during the intervention programme, data for analysis was drawn from three selected argument-based tasks. The scientific argumentation scenarios was sourced from a set of curriculum material that were developed to support the teaching of ideas, evidence and argument in school science education (Osborne et al., 2004b). The everyday and socio-scientific argumentation scenarios were purposefully developed for this study and the scenarios present issues that are currently debatable in Eritrean context. The rationale was to stimulate pre-service teachers' participation and engagement in classroom discourse and guide them on how to generate arguments and counter-arguments (See Appendix C for more details). The administration of these tasks is detailed in the intervention phases (see section 3.8.2).

3.4.3 Classroom observations

Classroom observation allows classroom activities that may have been taken-for-granted to be explored in greater details (Lasagabaster & Sierra, 2011). Classroom observations were carried out using a carefully developed set of steps and instruments. They are usually guided by a structured protocol. The protocol could take a variety of forms, ranging from the request for narrative describing events seen to a checklist or a rating scale of specific behaviours/activities that addresses the targeted research question of the study. For the purpose of this study, argumentation lesson classroom observation sheet was designed and it was used as a rating scale and checklist during classroom observation. The observation sheet allows the researcher to learn about things that the pre-service teachers may be unaware of or that they are unwilling or unable to discuss in an interview (Lasagabaster & Sierra, 2011; Schoenfeld, 2012). The observation sheet comprises of two sections. While section A of the classroom observation sheet was used as a rating scale, section B was used as checklist to describe events during classroom observation. A detail of each section is described below.

Section A of the observation sheet was used to rate the performance standards of pre-service teachers in relation to their ability to structure argument-based lessons using performance appraisal rubric. This section of the observation sheet was developed especially for this study. It consists of five domains and ten performance standards. These domains and performance standards were drawn from the Pedagogical Scheme for Implementing Dialogical Argumentation Instruction (Ogunniyi, 2009) (see Figure 3.1) and from IDEAS resources pack (Osborne et al., 2004). The Pedagogical Scheme for Implementing Dialogical Argumentation Instruction is a descriptive model emanated from a series of workshops and has been piloted successfully based on empirical evidence (Ogunniyi, 2007a & b). Likewise, the IDEAS resources pack has been used in the training of both pre-service and in-service science teachers as part of the on-going school-based research in argumentation (Erduran, 2006; Erduran, et al., 2006; Simon & Maloney, 2006) in UK and elsewhere and resulted in attainment of intended pedagogical and learning goals. Each standard was rated in a 3 level rating scale showing the degree of performances expected by participating pre-service teachers. [Level one- Poor (P), Level two- Intermediate (I) and Level three- Excellent (E)]. The description of each level for each performance standard was presented in performance appraisal rubrics (see Appendix K).

Section B of the observation sheet was designed in a form of a checklist and focuses on pre-service teachers' oral contributions that were oriented in the facilitation of argumentation. It was used to assess the occurrence of codes and categories of argumentation process as reflected in pre-service teachers' talk or utterance. In other words, it was used to examine which mechanism for facilitation of argumentation each pre-service teacher used in their science classrooms. Section B comprises of several codes clustered into eight categories of argumentation process. These codes and categories of argumentation process were adopted from Simon et al's (2006) framework developed for the same purpose (see Appendix L). The eight categories of argumentation process are, talking and listening; defining and modelling good argument; positioning; justifying with evidence; constructing arguments; evaluating arguments; counter-arguing and reflecting on argument process. It is noteworthy that this checklist was not developed to assess the frequency of occurrence of codes and categories, but to help the researcher narrate or describe the events/activities/behaviours observed in pre-service teachers teaching. More details about the argumentation lesson classroom observation sheet can be found in Appendix D.

The preliminary draft of argumentation lesson classroom observation sheet consists of 26 items. It went through a similar validation process and was given to the same panel for face, content and constructs validation. Items rated less than three within a Likert scale of 1-5 were then left out from the initial version of the argumentation lesson classroom observation sheet. The rating by the panel on each item were randomly grouped into two groups and the average score of one group was correlated with the other using the Spearman Rank Difference formula (Ogunniyi, 1992). The resulting correlation coefficients for the argumentation lesson classroom observation sheet stood at 0.91. Furthermore, based on the panels suggestions, (a) some items were merged, (b) 4 new item were added and (c) the items were further reorganised into two sections (Section A and B). The final version of the argumentation lesson classroom observation sheet comprises of two sections each consisting of 11and 14 items respectively.

The performance appraisal rubrics which was used to rate the performance indicators indicated in section A of the observation sheet was developed through a sequence of refinements, drawing from critiques from two science education experts. Their scores were then correlated using Spearman Rank Difference formula. The correlation stood at 0.94, which indicates a high correlation agreement between the two and suggests a strong face, content and constructs validity of their classification.

3.4.4 Interviews

Cohen and Manion (2002) describe interviews as a means of gathering information which has a direct bearing on the research objectives. For the purpose of this study, a semi-structured Interview was designed for pre-service science teachers. Hitchcock and Hughes (1995) describe Semi-structured interview as:

> a more flexible version of the structured interview. It is favoured by educational researchers since it allows depth to be achieved by providing the opportunity on the part of the interviewer to probe and expand the respondent’s responses...The interviewers ask certain major questions to all respondents, but each time they can alter the sequences in order to probe more deeply and overcome tendency for respondents to anticipate questions (p.157).

In keeping with the above view, in this study, semi-structured interview was utilized to better understand why the pre-service teachers teach the way they taught as it was not possible to understand all that was transpired in a lesson just from watching or observing it. The semi-structured interview provided the researcher with richer information by probing further with follow–up questions (McNiff, 1996). It also enabled her to probe for more information when the responses given by the interviewee lacked clarity (Cohen & Manion, 2002). In this study, the researcher used both informal and formal forms of interviews. The objective was to gain rich information from pre-service teachers' classroom experiences. I will allude to this later in more details.

The initial version of the formal semi-structured interview consists of 17 items. The interview questions went through successive revision for face, content and construct validation. Using the Spearman-Brown correlation reliability formula, the reliability coefficient of the interview questions was 93. The final interview protocol appears in Appendix E. The first seven item questions emphasize more on how pre-service teachers organize argumentation lesson. The next five item questions were based more on the process used by pre-service teachers to facilitate argumentation and the last two item questions focus on the major factors that promote or hinder pre-service teachers from using ABIM to implement learner-centred curriculum.

3.4.5 Reflective response questionnaire

For the purpose of this study reflective response questionnaire was designed to guide participating pre-service teachers in writing their reflective journals. It was adopted from a reflective diary questionnaire developed to examine science teacher educators' and teachers' perceptions on how Science and Indigenous Knowledge Systems Project (SIKSP) seminar-workshop series prepared them to use dialogical argumentation instruction to implement a Science-IK curriculum (Ogunniyi, 2013). This questionnaire includes six item questions that engendered a reflective diary of pre-service teachers' experiences of the intervention training programme and subsequent growth. More specifically, the questionnaire enquired pre-service teachers to reflect on their understanding of: (a) scientific argumentation and its role in science teaching and (b) the skills and techniques required to support and sustain argumentation. It also probes pre-service teachers to reflect on how the intervention programme prepared them to use ABIM to implement learner-centred curriculum in a science classroom. Finally, the questionnaire solicited pre-service teachers to reflect their teaching experiences in middle schools and indicate the factors that promoted and/or hindered them from using ABIM to implement learner-centred curriculum. The reflective questionnaire was passed through vigorous scrutiny and the inter-rater agreement stood at 90. See Appendix F for the final reflective questionnaire**.**

3.4.6 Video and audio recording

During the intervention programme video camera and audio tapes were used to capture information on pre-service teachers' engagement in small groups and whole class discussions in the three argument-based tasks. Video camera was also used to capture information on how the pre-service teachers structured the argument-based lessons and facilitated argumentation in their respective science classrooms. All the interviews were also recorded on audio and videotape for each interview being made.

The information obtained from the video and audio recordings formed one set of data for this study. Bottorf (2004) indicates that "video cameras are used to capture behaviour of interests...video recording provide a rich data source for studying interaction patterns..." (p. 753). Yet, it is noteworthy to indicate its limitation. For example, Erickson (1986) notes that video camera cannot capture nonverbal thoughts and feelings of teachers and students in the classrooms. Babbie and Moulton (2001) add "Even tape recorders and cameras cannot capture all the relevant aspects of social processes. Consequently, in both direct observation and interviewing, it is vital to make full and accurate notes of what goes on" (p.295). In view of the forgoing, in this study, video and audio recording was supplemented by field notes.

3.5 Development of training material on argumentation-based instructional model

Argumentation-based instructional material is a learning material developed for the purpose of training pre-service teachers to teach argumentation in science classroom. The material has been adapted from Ideas, Evidence and Argument in Science Education (IDEAS) resource pack designed by Osborne, Erduran, and Simon (2004b) for professional development of in-service science teachers and adapted by Erduran, Ardac, and Guzel to train chemistry pre-service teachers in Istanbul, Turkey (Erduran, Ardac, & Guzel, 2006) and elsewhere. The choice of the content and procedures stipulated in the IDEAS pack was based on the following aspects.

- The procedure is clear and well structured.
- The procedure has been used in many school-based research projects and resulted in attainment of intended pedagogical and learning goals.

- The IDEAS pack which was used for professional development of teachers elsewhere could be adapted in Eritrean context for the same purpose.
- The argument lessons drawn from the IDEAS pack could be adapted by pre-service science teachers to support the teaching of ideas and evidence in Eritrean science classrooms.

Nonetheless, slight modifications were made to the IDEAS resource pack on the basis of the following premises.

- The current study was set in an educational environment of a developing nation (Eritrea), whereas all previous studies took place in industrialized countries. The researcher believes that adapting the procedure and resource materials without considering differences in contexts could deter the effective implementation of the intervention programme. Thus, slight modifications were made in accordance with the topics stipulated in the middle school science curriculum, availability of teaching-learning resources and the physical environment of the Eritrean classrooms.

- The short duration of the study (about six months) was compensated for by organizing a series of reflection workshop sessions. In these sessions pre-service teachers were given an opportunity to share their experiences with their peers and to present examples of best practices. The researcher modelled argumentation instruction by presenting exemplary science lessons from the IDEAS pack and from middle school science syllabus during the intervention programme and during reflective workshop sessions. Moreover, the researcher worked closely with small group pre-service teachers on theoretical ideas and put this into practice in order to develop materials and strategies that can be adapted and owned by them. The objective was to give pre-service science teachers the opportunity to select topics and strategies that they find useful for their purpose in teaching an argument-based lesson.

The training material includes how to introduce an argument, how to manage small group discussions, how to teach argument, what resources can be used to support students' argumentation, how to evaluate arguments and how to model arguments for learners. Sample lessons along with activities in the form of worksheets were also developed.

3.6 Development of exemplary resource material to support the teaching of argument in middle school science

An exemplary instructional material was developed to support pre-service science teachers implementation of an argumentation-based instructional model in grade seven Eritrean middle school science classrooms. The material comprises of six sample lessons designed to support the process of argument in the science classroom and to expose students to the use of ideas and evidence in science. While lesson three (Phases of the moon) and lesson six (Snowmen activity) had been adapted from the IDEAS pack (Osborne, et al., 2004b), lessons one, two, four and five were modified in accordance with the topics stipulated in the Eritrean middle school science curriculum. Selection of topics such as ‘classification of matter’, ‘periodic table’, ‘mercury -metal or non-metal’….were chosen for use as a preliminary argument lesson topics. The lessons were selected on the basis of the following criteria:

- topics that would lend themselves to argumentation
- lessons that could easily be incorporated with the science topics presented in the Eritrean middle school General Science syllabus for grade seven.
- lesson that would agree with the topics scheduled for the second semester in the Eritrean middle school General Science syllabus for grade seven.

Argument-based activities in the form of worksheets were developed for each lesson. TAP as modified by Erduran et al. (2004) was infused into students’ argumentation worksheets. The activities included the aims, the instructional objectives of the activity, teaching points which highlight aspects of background knowledge or knowledge the students may need for the activity, a teaching sequence which suggests how the material might be implemented in the classroom and background notes for activities that require further elaboration on science background. A detailed sample lesson format for lesson one (Classification of matter: Elements) that includes aims of the activity, learning goals, teaching points and teaching sequence is presented in Appendix G. A brief summary of the other five lessons selected along with the argument-based activities are also presented in this Appendix.

3.7 Implementation of argumentation-based intervention training programme

An argumentation based intervention training programme was organized for 25 pre-service science teachers in EIT, Eritrea for a period of three weeks. The main purpose of the intervention was to equip pre-service science teachers with the required pedagogical knowledge and skills that will enable them to employ argumentation-based instructional model in a learner-centred science classrooms and, thereby, encourage their students to use evidence to support their claims. To achieve the intended purpose, the pre-service teachers were introduced to the concepts argument and were trained on how to encourage learners to use evidence or grounds to support their claims, counter-claims or rebuttals. Moreover, pre-service teachers were exposed to different strategies required for organizing group discussions. They also gained experiences on how to select a particular strategy to handle group work in their teaching. Pre-service teachers were further familiarized with Toulmin's (1958) Argumentation pattern (TAP), Ogunniyi's (2004, 2007a & b) Contiguity Argumentation Theory (CAT) and analytical tools that are used to evaluate the quality of arguments. In addition, an overview of aspects of learner-centred curriculum and learner-centred instruction and aspects of NOS were provided to the pre-service teachers as these concepts were found to be useful to teach science as an argument. Detailed training on the latter concepts was not provided as PTs have already taken formal courses on learner-centred curriculum and instruction in General Method of Teaching and aspects of NOS in Science Method course in their programme.

The sessions took place as an integral part of the teaching practice course that is offered during the second semester (final term) of the diploma programme. The training was conducted three times a week and each training session included a three hours' workshop based on a modified version of (IDEAS) workshop agenda (Osborne, Erduran, & Simon, 2004b). Such intensive schedule was set in order to cover the work planned within the limited time. The total hours allocated for the intervention training sessions was then 45 (i.e. 3hrs/session x 5 days) x 3weeks = 45hrs. The first 45 minutes block was in a form of a lecture accompanied by video show from the IDEAS resource pack. In this block the concept argument, strategies and techniques required to structure and facilitate argument-based lesson were introduced. An overview of aspects of learner-centred curriculum, learner-centred instruction and NOS were also discussed. The next one hour and 45 minutes was used for individual and group task (45 minutes), group presentation (30 minutes) and whole class discussion (30 minutes). The last 30 minutes of the three-hour block was used to round off the argument-lesson through evaluation and reflection.

Argumentation-based instructional model has been identified as a teaching strategy with potential to stimulate learner participation and engagement in structured discussion in science classrooms (Msimanga & Lelliott, 2010) (see section 2.5 of chapter two). Scholtz, Braund, Hodges, Koopman, & Lubben (2008) further explicate argumentation as "a learning method capitalizing on the requirement of discussions and group interaction" (p. 22). In agreement with the above views, argument-based instructional approach was explicitly implemented during the intervention training sessions by using the modified form of IDEAS resource pack (Osborne et al., 2004). As indicated above, these materials were specifically designed for professional development of pre-service and in-service science teachers in teaching of ideas, evidence and argument in school science. The pack was adapted by many science education researchers for a similar purpose (Erduran, et al., 2006, Simon et al., 2006) in many countries. In addition, other supplementary science education books were consulted to highlight aspects of learner-centred curriculum, learner-centred instruction and NOS.

During the intervention programme the pedagogical schema for enacting a dialogical argumentation-based discourse developed by Ogunniyi (2009) was adapted as an instructional approach (see Figure 3.1). The choice of this pedagogical schema is based on the following premises.

- The pedagogical schema is well structured and is suitable to hold different patterns of classroom interactions such as teacher- student(s), student-student and teacher-whole class interaction.
- The pedagogical schema would result in attainment of some level of cognitive harmonization as the schema provides a platform for PTs to generate their own arguments, listen and evaluate other's arguments and revise their previous views when the need arises.
- The pedagogical schema has been used in SIKSP for several years and resulted in attainment of intended pedagogical and learning goals (Ogunniyi, 2009).

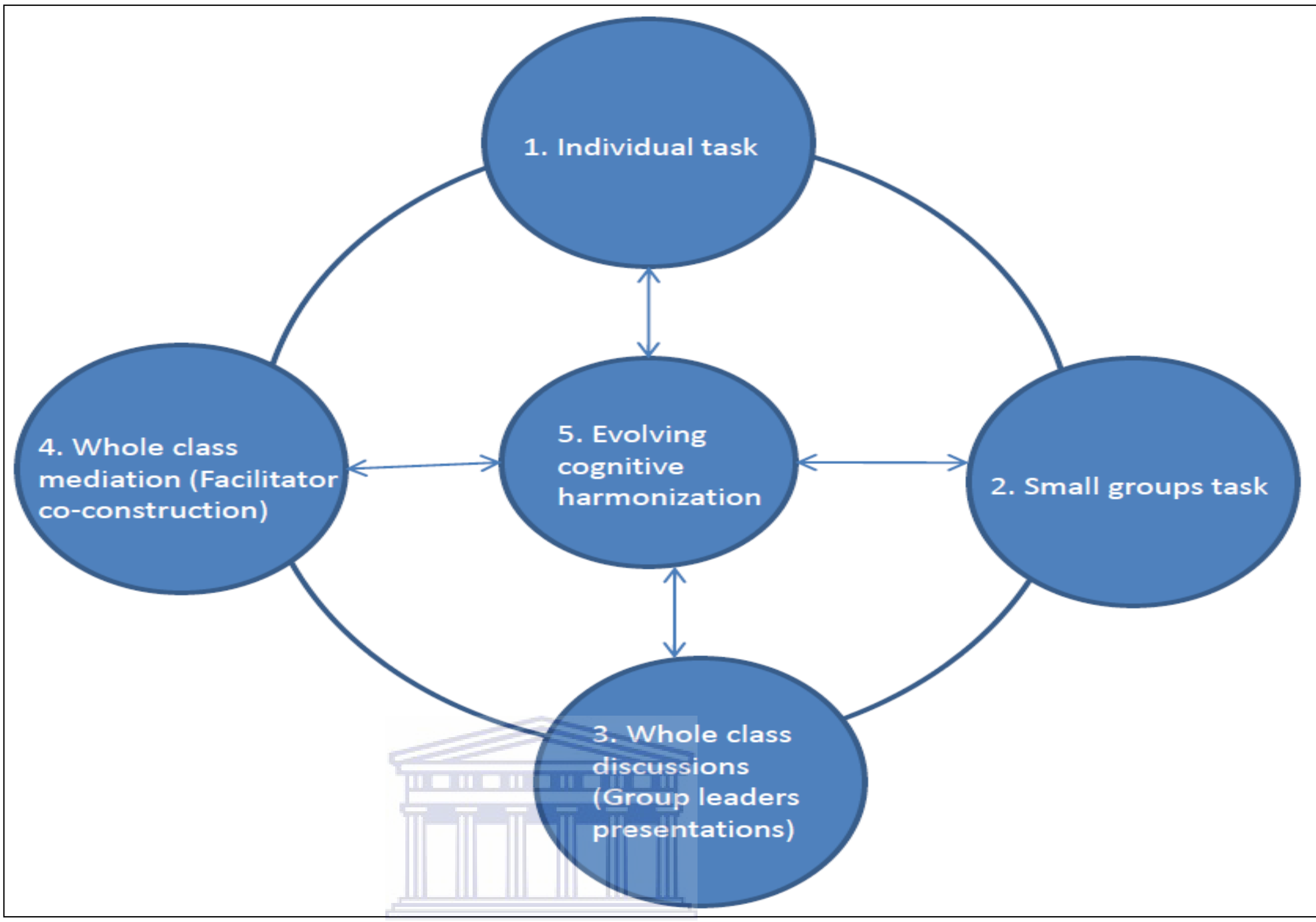

Figure 3.1 A Schema for Implementing Dialogical Argumentation Instruction

3.8 Data Collection procedures

This research study was conducted in three phases. Each of these phases will be described in the following sub-sections. A flow chart of the research procedure is provided in Figure 3.2.

3.8.1 Pre-intervention phase

Prior to the commencement of the intervention programme the following preliminary tasks were implemented.

- Submission of the ethical clearance application form to the Senate Research Committee of the University of the Western Cape (UWC). The Senate Research Committee of the university approved the methodology and ethics of my research project under the researcher's name (see Appendix A).
- Sought permission letter from the EIT to conduct both pilot study and the main research study (see Appendix A).
- Discussion with the Coordinator of the Teaching practice course about the purpose and procedure of this research.

- Conducted meetings with pre-service science teachers who were enrolled in the teaching practice course and invited them to participate in this study. During this meeting the pre-service teachers were informed about: the aims and nature of the research, the researcher's identity and contact details, estimated duration of the research study & what their participation in the research entails. Thirty pre-service teachers agreed to take part in the study.

- The 30 participating pre-service teachers were provided with information package including details of the study and consent form one week prior to the commencement of the intervention training programme.

- Conducted pilot study of the LCAI questionnaire and argumentation-based tasks.

Upon receipt of the consent form LCAI questionnaire was also administered to pre-service teachers at the pre intervention phase. The purpose was to collect baseline data on pre-service teachers' understanding of learner-centred curriculum, learner-centred instruction and argumentation.

3.8.2 Intervention phase

The intervention phase of the study involved the implementation of the intervention training programme. The purpose of the intervention programme and the instructional material adapted to implement it was already presented in section 3.7. Therefore it will not be repeated here. The programme was largely derived from argumentation theories discussed in chapter two. It also integrates aspects on learner-centred curriculum, learner-centred instruction and NOS. The intervention programme comprised of several lessons. The lessons were categorized into four parts, namely, overview of learner-centred curriculum and learner-centred instruction, overview of aspects of NOS, introducing the concept argument and learning to teach argument-based lessons. However, most of the sessions of the intervention programme were devoted to the last two parts. All the lessons were task-based. A summary of the lessons are presented in Appendix G.

As indicated above, the PTs were engaged in a series of argument-based tasks during the intervention training programme. In all the argument-based tasks pre-service teachers were asked to construct reasoned arguments at individual, small group and whole class level. Osborne (2010) argues that engaging in collaborative discourse and argumentation offers a means of enhancing students' conceptual understanding and their skills and capabilities with scientific reasoning. Benefiting from this view, the 25 participating PTs were grouped into four groups (Groups A, B, C and D) each consisting of six-seven members and were requested to engage in classroom discourse on the tasks provided on the worksheets. In deciding on the size of the group, the researcher was guided by Alexopoulou and Driver (1997) and Naylor, Keogh, and Downing (2007) views. Alexopoulou and Driver (1997) asserted that for students to support each other's learning, the groups must be large enough to permit this to happen but small enough to allow each member of the group to have an opportunity to engage in meaningful argumentation. In their study, Naylor, Keogh, and Downing (2007, p.35) confirmed that in groups of four, five or six students generally seemed to establish some kind of group identity and interaction freely. The pre-service teachers discussions were recorded with a video camera with a fixed microphone placed in the centre of the group (Osborne, et al., 2004a, p. 1004).

Preceding the intervention training programme, micro teaching was organized to participating pre-service teachers at EIT. Micro-teaching is one of the most powerful techniques for improving teaching and provides a basis for self-reflection and professional growth (Amobi, 2005). It makes teachers more aware of their own teaching style and helps them understand how to improve it (I'Anson, Rodrigues, & Wilson, 2003). The authors further explicate that micro-teaching is a laboratory approach to teaching development which was designed to help individuals develop and refine their teaching skills and to practice constructive criticism. In agreement with the above views, in this study, pre-service teachers were requested to design argument-based lesson from the topics included in grade seven General Science Textbook and deliver a 10-minute teaching segment to their fellow pre-service teachers. The lesson delivered during the micro-teaching period was videotaped for each pre-service teacher as a basis for self-reflection and on-going development of their teaching style.

Ambili (2013) and Deniz (2011) note that video feedback was an important part of the microteaching process for decades. For the same reason, each pre-service teacher was guided to view the video to analyse his or her success with the selected skills and techniques that are required to facilitate argumentation in science classrooms. In addition, pre-service teachers were asked to watch and analyse samples of the video lessons delivered by their peers. This was followed by a feedback period for the exchange of ideas and issues related to specific strategies and techniques used to facilitate argumentation instruction. Finally, some pre-service teachers were guided to restructure the lesson as needed and reteach it. However, due to time constraint the cycle of re-teaching and video analysis did not continue until the pre-service teachers' demonstrated mastery of the focus skill.

3.8.3 Post-intervention phase

The pre-intervention phase of the study involved: Administering questionnaire, formal and informal classroom observations, formal interview and reflective response questionnaire/reflective interview and reflective workshop.

3.8.3.1 Administering questionnaire

LCAI questionnaire was administered to pre-service teachers at the post intervention phase. The purpose was to determine PTs' post conceptions of learner-centred curriculum, learner-centred instruction and argumentation and to compare it with PTs' pre conceptions on this item.

3.8.3.2 Classroom observation

Classroom observation sheet was used to examine PTs' ability to use ABIM to implement a learner-centred curriculum. Video camera was also utilized to capture information on how the pre-service teachers structured the argument-based lessons and facilitated argumentation in their respective science classrooms. I will allude to this later.

Classroom Observation Schedule

McNiff (1996) suggests that researchers should check with the principals and managers before undertaking research that is connected with their organisation in order to reach a consensus about what they may and may not do. In compliance with the above suggestion, the researcher sought permission from officials of MOE and school directors of the four selected middle schools located in Asmara, capital city of Eritrea prior to the commencement of the classroom observation. Her discussions with the MOE officials and school directors led to the choice of grade seven (age 13-16) as the most suitable grade for this study as this would make pre-service teachers free from the constraint of National Examinations.

Before the start of the classroom observations pre-service teachers were provided with copies of exemplary argumentation-based learning material developed for the purpose of this study (see Appendix H) and teacher's guide. The respective schools also provided them with grade seven prescribed science textbook. The pre-service teachers started actual teaching on March 04, 2013 in their respective middle schools. Formal classroom observations started two weeks after in order to give them some time to familiarize themselves with the school environment and thereby build confidence in managing their classrooms.

To develop their pedagogical practice with argument the pre-service teachers were required to incorporate a series of six argument-based lessons, approximately one per two weeks over the course of the second semester. In the argumentation classes, the six argumentation lessons were incorporated into grade seven science syllabus and covered science topics on: ‘Classification of matter: Elements’, ‘Classification of matter: Mixtures and compounds’, ‘Revolution of the moon round the earth-Why does the moon have phases?’, ‘Introduction to chemical reaction and the periodic table: patterns in the periodic table’, ‘Introduction to chemical reaction and the periodic table: place of elements in a periodic table’ and, ‘Heat and temperature: Transfer of heat’.

As a non-participant observer, I carried out classroom observations during the second semester of 2012/2013 academic year for about three months starting from March 18, 2013 until May 31, 2013. Bottorf (2004) describes non-participant observation as a situation where “researchers focus primarily on the task of observation, while minimizing their participation in interactions in the setting” (p. 752). Similarly, A Dictionary of Sociology (1998) describes non-participant observation as a research technique whereby the researcher watches the subjects of his or her study, with their knowledge and skills, but without taking an active part in the situation under scrutiny. This approach is sometimes criticized on the grounds that the very fact of their being observed may lead people to behave differently, thus invalidating the data obtained. To overcome this, researchers normally observe a number of similar situations, over a period of time.

For the same reason, I conducted formal classroom observations of three different argumentation lessons of each of the 25 participating pre-service teacher on the specified period. The first, second and third lesson topics observed were “Revolution of the moon round the earth- “Phases of the moon -why does the moon have phases?”, “Mercury: Metal or non-metal” and “Transfer of heat” respectively (see Appendix C). In addition, as encouraged by (Barge, 2012) the researcher conducted several walkthroughs (frequent brief observations) of pre-service teachers focusing on certain pedagogical skills. The overarching goal of the follow up observations was to support the continuous growth and development of each pre-service teacher. Thus, in order to cover the work planned within the limited time the researcher had five to six observations per day. Formal observations were followed by individual and/or collective feedback discussions. During the feedback discussions pre-service teachers were provided the opportunity to express their experiences in preparing lesson plans and in teaching argumentation lessons and share their anxieties and problems.

Classroom Observation Procedures

As indicated above, during the course of the study the researcher conducted follow up classroom observations at different stages to assess the progress of PTs in using argumentation-based instructional model to implement learner-centred curriculum. The researcher used a video camera in the three lessons observed in order to capture maximum classroom activities and interactions of both the pre-service teacher and the students. The information obtained from the video formed one of the main sources of data in this study. Erickson (1992) gave a piece of advice to researchers who will be using video camera for data collection as noted below.

- Before taping, explain the purpose and get written or oral consent from those concerned.
- Be aware that people fear videotaping because it might blow their cover instantly.
- With audio-visual recording, confidentiality is the ethical issue that seems most conspicuous (p.212).

To avoid the possible problems that could be created the researcher, (a) sought permission from the school directors and their students to use video camera during classroom observation sessions, (b) explained the purpose of the study and (c) assured them that the information will only be used for research purposes. Pre-service teachers were also requested for the same and consented in writing that their teaching could be audio and video recorded.

As a non-participant observer, the researcher sat at the back of the classroom and took filed notes while the camera man recorded the events and interaction with a video camera. My classroom jottings focused on: introduction and outlining of the task, establishment of small groups and student’s interaction within the group, lesson organization, type of question posed, strategies used to help students generate scientific arguments, techniques used to evaluate the quality of arguments constructed by the student and strategies used to round off argumentation lesson. Events occurred during walkthrough were also recorded in the field notes. Field notes recorded during formal observation and walkthrough also availed data for this study.

Interview

As indicated above, in this study, I have used both informal and formal forms of interviews. All the pre-service teachers took part in both forms of interviews. While informal interviews were conducted after each classroom observation, formal interview was conducted at the end of the actual teaching practice period. During the first informal interview pre-service teachers were asked to indicate why they demonstrated or not demonstrated certain strategies that facilitated argumentation. For example if they encouraged group presentation then they were asked why and how they did so. On the other hand, if they failed to do so they were asked why they did not encourage the groups to present their work to the whole class. Additionally, they were also asked to indicate the major factors that hindered them from using ABIM to implement learner-centred curriculum. The second and third informal interviews were focused on certain aspects of argumentation where significant improvements were observed when compared with the earlier lessons. For instance, if the pre-service teacher improved from not been able to encourage counter-argument in his/her first lesson to demonstrating the goal of counterargument in his second lessons; then he/she was asked to explain why and how he/she improved his/her teaching. The formal interview further enquired pre-service teachers to elicit information on how they organized the lesson and what strategies and techniques they have used to facilitate argumentation. In-depth information was also sought from the pre-service teachers on the major factors that promoted and/or hindered them from using ABIM to implement learner-centred curriculum.

The pre-service teachers were notified to participate in the interview verbally and in written from. The interview questions were sent together with the notification memo for the interview prior to the date of interviews. They were also asked to indicate a convenient date and time for the interviews. Interviews were conducted individually by the researcher and took place in a private office in order to help make participants feel more at ease during the interview process. The problem with interviews is that they are unnatural interactions (Measor, 1985). To avoid this weakness the researcher attempted to build a relationship of trust with interviewees. Pre-service teachers were reminded of the purpose of the study and were also told that it was not possible to understand the overall teaching-learning processes just by conducting classroom observations. They were encouraged to ask for clarification at any time during the interview and to answer honestly. They were also encouraged to speak freely and even use their own mother tongue so that they could express themselves fully. Pre-service teachers were assured of the confidentiality of their responses. The formal interview lasted around 30 to 45 minutes and was audio and videotaped. In addition, the informal interviews lasted around 10 to 15 minutes and were jotted as field notes. The verbatim transcripts were later sent to each pre-service teacher to check the accuracy of his or her recorded comments. Silverman (2000) calls this process as respondent validation, which is a means to improve the validity of data.

Reflective response questionnaire

Towards the end of the study, each pre-service teacher was asked to write a reflective journal based on the six questions included in the reflective response questionnaire (see Appendix F). Preliminary analysis of some pre-service teachers' reflective journals revealed that the information obtained was not rich enough to answer the research questions of this study. In view of this, the researcher decided to administer reflective interviews with some pre-service teachers using the item questions of the reflective questionnaire and probed them again to reflect on each of the item question. It is worthy of note to indicate that separate instrument was not developed for the purpose of the reflective interview, rather the item questions of the reflective questionnaires were utilized.

Field Notes

Maykut and Morehouse (1994) describe qualitative researcher's field notes as "documents that contain what has been seen and heard by the researcher, without interpretation" (p.73). Patton (1990) further adds that qualitative field notes are "descriptive in nature and they should, therefore, be dated and recorded with basic information such as place of event, who was present, the physical settings, what social interactions took place, and what activities occurred" (p. 239). The author advised the researchers

> "not to trust anything to future recall... If it's important enough to be part of your consciousness as an observer, if it's information that has helped you understand the context, the setting, what went on, and so forth, then as soon as possible that information should be put into the field notes" (p.239).

In this study, the researcher took field notes to capture and describe important events and interactions right after each session of the intervention programme.

Emphasising the importance of field notes Patton (1990) argues that field notes should describe everything that the observer believes to be worth noting. For the same reason, the researcher tried to document every action and event that occurred during (a) micro-teaching sessions and (b) classroom observation and walkthroughs to help her understand what went well and what did not and suggested constructive feedback. The researcher also took field notes during formal and informal interviews with each pre-service teacher to help her better understand what was transpired in the classroom context. Field notes formed a very rich source of data to answer the research questions of this study.

Reflective workshop

Reinforced by the works of Dewey (1933) and Schon (1983), Pedro (2005) argues that the use of reflective practice encourages pre-service teachers to think critically about their practice. He further argued that reflective practice helps pre-service teachers develop their ability to examine their own concepts, theories and beliefs about teaching and subject matter (Posner, 2005). Borrowing the idea of Posner (2005), this study organized reflective workshops to pre-service teachers after each classroom visit round at EIT to enhance pre-service teachers' professional development. Dewey (1933) asserts that learning from experience is enriched by reflecting on experience. For the same reason, during the course of this study, three reflective workshop sessions were conducted to help pre-service teachers learn from their own and their peers' classroom practices and, thereby, improves their experiences in using ABIM to implement learner-centred curriculum. The reflective sessions provided a platform for pre-service teachers to examine and reflect on their own and their peers' classroom practices in light of the pedagogical knowledge and skills of argumentation instruction to which they have been exposed in the intervention training programme.

As a part of self-reflection activity, pre-service teachers were given access to view their own teaching videos lesson and reflect on their classroom practice. Pre-service teachers were also prompted to respond to structured questions that included, what went well, what did not and how are they going to improve their approach of teaching in the successive lessons. They were guided to write down a summary of it in their reflective journal and submit it towards the end of the study. Moreover, some of the pre-service teachers were given the opportunity to present their self-reflection during the reflective workshop sessions in order to share their experiences with their fellow pre-service teachers and received feedback from them.

To initiate peer-reflection, pre-service teachers were guided to view teaching video lessons of their peers in both reflective workshop one and two. The video lessons included samples of best and unsatisfactory classroom practices to help pre-service teachers identify the strength and the limitation of each of the video lessons viewed. Pre-service teachers were asked to analyse the video lessons in their respective groups and were solicited to respond to structured questions that included, how the pre-service teacher introduced the idea of argument to students, introduced a writing frame, utilized his/her utterance to facilitate the process of argumentation, provided feedback, evaluated students' understanding of scientific concepts, evaluated the quality of students' arguments and how the lesson was structured. Pre-service teachers were also given the opportunity to provide further comments. The groups presented their reflection to the whole class and this was followed by whole class general discussion. During these sessions pre-service teachers were also encouraged to: share their understanding of learner-centred curriculum, learner-centred instruction and argumentation, express their feelings, anxieties and problems encountered during the teaching practice period. Towards, the end of the reflective sessions the researcher provided general feedback about the sample video lessons observed and classroom observations conducted in the schools.

As indicated above a flow chart of the research procedure is provided in Figure 3.2 below.

Research procedure

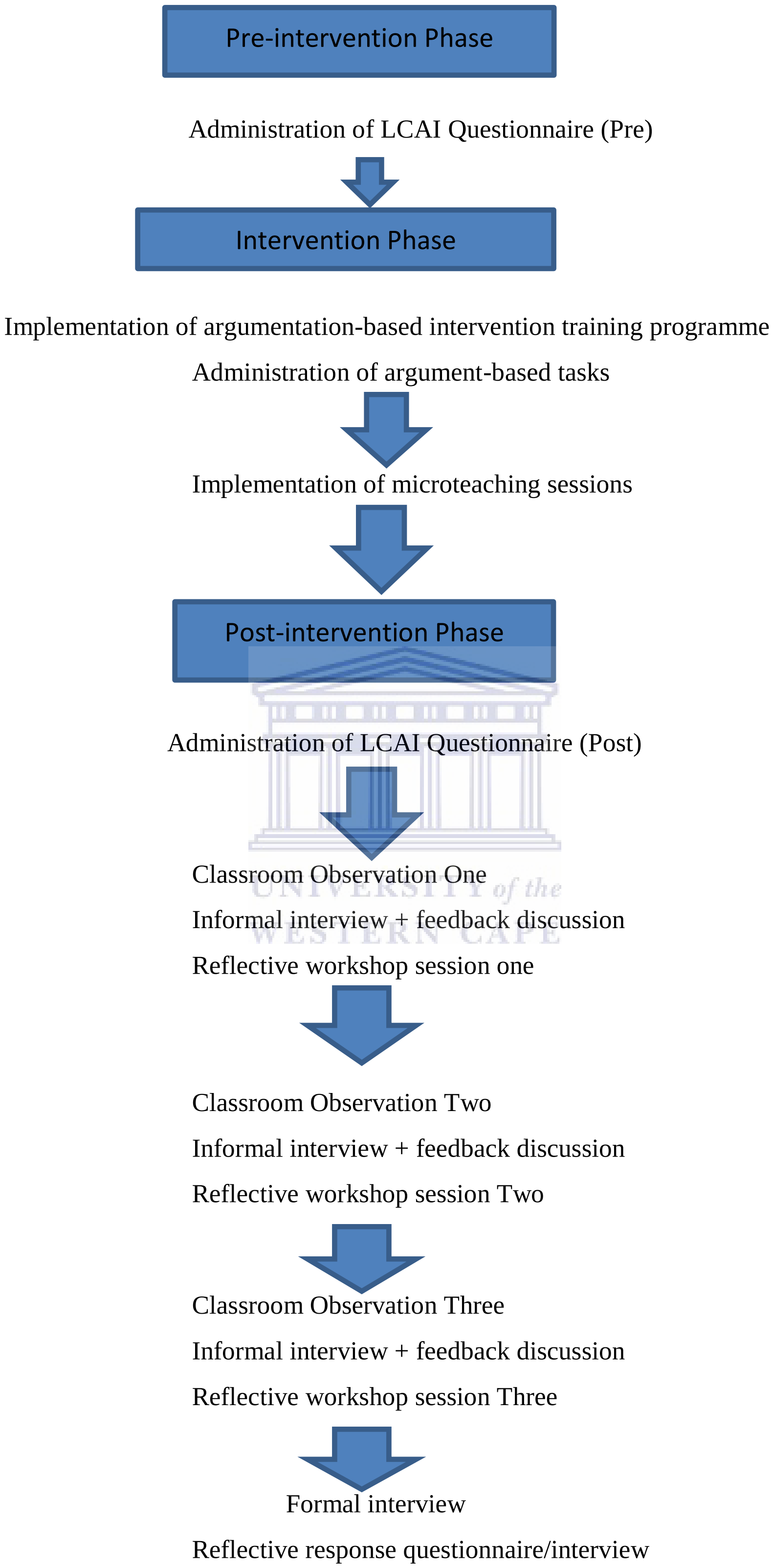

Fig 3.2 : Research procedure flow chart

3.9 Data analysis

3.9.1.General information

As alluded earlier, data for analysis was drawn from LCAI questionnaire, argument-based tasks, classroom observation, interview, reflective response questionnaire and reflective interview to examine the effect of argumentation-based intervention training programme on pre-service teachers' ability to use ABIM to implement learner centred curriculum. A predominantly qualitative research approach was used to gain insight into the pre-service teachers' understanding and practice of learner centred curriculum and argumentation and their ability to use ABIM in a learner-centred science classroom. An effort was made to borrowing the view of Patton (1986), thus the quantitative analysis summarized findings on the whole group (25 pre-service teachers) and the qualitative analysis focused only on a few number of the pre-service teachers to permit an in depth account of the outcomes of the study. The results were presented and analysed in terms of research questions and combined descriptive data with verbatim data. It also seeks to categorize data into themes as its primary basis for organizing and reporting results.

LCAI questionnaire responses, reflective questionnaire responses and individual pre-service teacher's written arguments were coded through careful reading and re-reading of the written texts. Interviews, classroom observations and reflective interviews were transcribed through careful listening and re-listening of the audio and video recorder.

3.9.1.1 *LCAI Questionnaire*

As alluded earlier, the open-ended questionnaire was administered before and after the intervention training programme to determine any change in the pre-service teachers' understanding of learner centred curriculum, learner centred instruction and argumentation as a result of the training to which they have been exposed. It addressed primarily the first critical question: "What conceptions of learner-centred curriculum/instruction and scientific argumentation did the pre-service teachers hold before and after being exposed to an argumentation-based instructional model?" The questionnaire data set was analysed qualitatively using open coding and the generation of major categories or themes (Strauss & Corbin, 1990). The major categories or themes were then ranked in descending order of occurrence and tabulated in two columns: Pre-test emerging themes and post-test emerging themes. Both pre and post-test emerging themes were summarised with frequencies and percentages. The Contiguity Argumentation Theory (CAT) categories developed by Ogunniyi

(2004, 2007a) were used as the unit of analysis to describe the type of changes that might have occurred.

3.9.1.2 *Interview*

As mentioned above, formal interview was administered to pre-service teachers at the end of the teaching practice period to: supplement the data obtained from classroom observation, get rich information about why the pre-service teachers teach the way they teach and ascertain the researcher's interpretation of the lessons observed. It addressed mainly the third and fourth critical questions: "To what extent do pre-service teachers structure and facilitate argumentation instruction in their lessons to implement learner-centred curriculum in accordance with argumentation-based instructional model to which they have been exposed?" and "What are the factors that promotes or hinders the pre-service teachers from using the argumentation-based instructional model to implement learner centred curriculum in their science classrooms?" respectively. All interviews were recorded on audio and videotape with simultaneous field notes of each interview being made. Audio and video recorded interviews were carefully listened to and re-listened to on different and separate occasions and were fully transcribed for interview verbatim. The data was then analysed qualitatively using open coding and the generation of categories or themes (Strauss & Corbin, 1990). Moreover, the written notes of each interview were all reviewed by the researcher in the process of completing this study. In this thesis, the findings from the interviews were exemplified with selected verbatim quotes.

3.9.1.3 *Argumentation-based tasks*

As alluded earlier, during the intervention programme a series of argument-based tasks were administered to pre-service teachers to develop their argumentation skills and to determine the quality of arguments constructed at individual, small group and whole class levels. It addressed mainly the second critical question: "To what extent are the pre-service teachers able to construct quality arguments and participate in an argumentation discourse?" Data drawn from small group's arguments and whole class discussions were audio and video recorded and transcribed for analysis. Transcribed verbatim of group's arguments and individual pre-service teacher's written arguments were analysed using the simplified form of TAP's analytical framework developed after Erduran et al. (2004), as shown in Table 2.2. This analytical framework has been employed in many previous studies in argumentation for the same purpose (Clark & Sampson, 2007; Simon et al., 2006; Venville, & Dawson, 2010;

vonAufschnaiter, et al., 2008). It was developed from Toulmin's (1958) argumentation pattern. According to this framework, the pre-service teachers' written and verbal expressions were coded into different levels representing different abilities of argumentation. This study also attempted to compare the quality of arguments constructed: (a) among groups in whole classroom discussions, (b) at individual and group level and (c) among the three dimensions: everyday argumentation, socio-scientific argumentation and scientific argumentation.

3.9.1.4 *Classroom observation*

A classroom observation sheet was developed to determine the participating pre-service teachers' ability to use ABIM to implement learner centred curriculum. Data collected from classroom observation addressed mainly the third and fourth critical questions. As indicated above, the classroom observation sheet comprises of two sections. While section A was designed to determine pre-service teachers' ability to structure argument lesson, section B was developed to assess how pre-service teachers' use their utterance to facilitate argumentation process. Three different argumentation lessons were observed and video recorded to determine what progress and development the pre-service teachers had over the course of the semester. The audio and video-recording were fully transcribed to capture all the pre-service teachers' oral contribution and interactions with students. The transcripts were used to code the data and to develop the coding schemes.

Data analysis of the lesson transcripts was done in two stages. In the first stage emphasis was given to pre-service teachers' ability to structure argument-based lessons in science classroom. This was made possible by referring to the items included in section A of the classroom observation sheet. The second stage of analysis focused on pre-service teachers' use of their oral contributions or talk that facilitated argumentation. At this stage the analysis was guided by the items included in section B of the classroom observation sheet. Details are presented below.

First stage analysis

PTs' ability to structure argument lessons in science classroom were analysed in terms of five domains and 10 performance standards (Table 12) using performance appraisal rubric with rating scales**.** Thus, the transcripts of each of the three lessons taught by each of the 25 PTs were analysed using the performance appraisal rubric. Barge (2012) describes performance appraisal rubric as a behavioural summary scale that guides evaluators in assessing how well a standard is performed. The rubric developed for the purpose of this study delineates/states the measure of performance expected of pre-service teachers and provides a qualitative description of performance at each level. The resulting performance appraisal rubric includes three levels poor (level 1), intermediate (level 2) and excellent (level 3) and provides a clearly delineated step-wise progression, moving from lowest (poor) to highest (excellent) levels of performance. The rubric is presented in Appendix K. It allowed the researcher to present the data into manageable form and also define the ideas to be displayed in the matrices (Miles & Huberman, 1994). The performance appraisal rubric also went through a vigorous validation process. Five science educator experts were asked to rate each item of the rubric on a scale of 1-5. The correlation of the ranking of two of the educators based on Spearman Rank Difference stood at 0.92, thus showing strong face, content and construct validity.

Second stage analysis

The second stage of analysis determined how pre-service teachers' use their utterance or talk to facilitate argumentation process. To study this aspect of pre-service teachers' progress and development requires more detailed qualitative analysis of the three lessons transcripts. Thus, decision was made to focus the analysis on a small number (six selected pre-service teachers) of contrasting cases. The selection criteria had been indicated in the sampling section of this chapter and will not be repeated here.

The transcripts of each of the three lessons taught by each of the six selected pre-service teachers were analysed using analytical framework developed by Simon and his team (Simon, et al., 2006). The framework focuses on the processes needed to facilitate argumentation. The lesson transcripts were then coded and further grouped into eight categories of argument processes. These are: talking and listening, defining and modelling good argument, positioning, justifying with evidence, constructing arguments, evaluating arguments, counter-arguing and reflecting on argument process. A summary of this analytical framework is presented in Appendix L.

3.9.1.5 *Reflective questionnaire/interview*

A six item reflective questionnaire was administered towards the end of the study to examine the changes in pre-service teachers' understanding of: learner centred curriculum, argumentation and strategies and techniques that are required to use ABIM to implement learner centred curriculum as the result of their exposure to argumentation based intervention training programme. The questionnaire also enquired pre-service teachers to indicate their perceptions on the factors that promotes or hinders the use of ABIM in science classrooms. It addressed mainly the first and fourth critical questions: “What conceptions of learner-centred curriculum/instruction and scientific argumentation did the pre-service teachers hold before and after being exposed to an argumentation-based instructional model?” and “What are the factors that promoted or hindered the pre-service teachers from using ABIM to implement a learner-centred curriculum in their science classrooms?” Reflective interviews were also administered to elicit more detailed responses in relation to the pre-service teachers’ written narratives on the open-ended reflective questionnaire. After a thorough reading of the written narratives of the questionnaire and listening interview transcripts, data was analysed qualitatively using open coding and the generation of categories or themes (Strauss & Corbin, 1990). The codes were further organised, into initial and latter knowledge and understandings, noting reported changes in knowledge, skills and attitudes/perceptions.

3.9.1.6 *Micro-teaching and reflective workshop sessions*

Micro-teaching sessions and reflective workshop sessions were organized to help pre-service teachers’ examine and reflect on their own and their peers’ classroom practices and thereby, progress in their teaching of argumentation. It addressed primarily the third critical question: “To what extent are the pre-service teachers able to use ABIM to implement a learner-centred curriculum?” While pre-service teacher’s reflections of their own classroom practices were obtained from the written summary included in their reflective journal/portfolio, pre-service teachers’ reflections of their peers’ practices was obtained from video recordings captured during micro-teaching sessions and reflective workshop sessions. A written summary of pre-service teachers own classroom practice and video recording of the transcripts were analysed in terms of how well the pre-service teachers assessed their own and their peers classroom practices in relation to the main pedagogical strategies that are required to facilitate ABIM in science classrooms.

3.10 The pilot study

In social science research a pilot study involves a “small scale version[s], or trial run[s] done in preparation for the major study” (Polit, Beck, & Hungler, 2001, p.467). A pilot study can also be “the pre-testing or ‘trying out’ of a particular research instrument” (Baker, 1994, pp. 182-183). In compliance with these descriptions, prior to the main data collection, a pilot testing of the LCAI questionnaire and the argument-based tasks was conducted during the second semester, January 2013 with 10 pre-service teachers enrolled in the teaching practice course. The pilot study took place in EIT where the intervention training programme was carried out and where some of the instruments were administered.

All the 10 participating pre-service teachers were from the department of science education, at the college of education, EIT. These pre-service teachers age range was between 21 and 32 years, and there were seven males and three females from a variety of ethnic groups, language, religions and socio economic background. Most of the participants were from Tigrigna ethnic group and they speak Tigrigna language. Before the pilot study was administered a permission letter was received from the EIT officials to undertake the pilot test with 10 pre-service teachers. The participating pre-service teachers were approached during their class time to elicit their permission to pilot test some of the instruments used for this study. Then meeting times were arranged to complete the questionnaire and argument-based tasks.

Peat, Mellis, Williams, and Xuan (2002, p. 123) suggested that pilot study procedures improve the internal validity of a questionnaire. In line with the suggestion, the questionnaire was administered to the 10 pre-service teachers in exactly the same way as it will be administered in the main study. After completion pre-service teachers were asked to identify ambiguities and difficult questions. Difficult words were then re-worded and ambiguous statements were rephrased. The researcher also checked whether all questions were answered and accordingly revised the questions that were not answered as expected. As for the argument-based tasks, the pre-service teachers were given each of the tasks in random order. They were asked to construct arguments individually and in small groups. Preliminary analysis of the arguments constructed ensured that these tasks could initiate discussions and arguments.

3.11 Trustworthiness

Lincoln and Guba (1985) posit that trustworthiness of a research study is an important ingredient for evaluating its worth. Guba and Lincoln (1989) proposed four criteria for judging trustworthiness or the soundness of qualitative research. They explicitly offered four criteria namely, credibility, transferability, dependability and confirmability, as an alternative to more traditional quantitatively-oriented criteria. To establish trustworthiness all the four criteria were used in this study because they were judged to better reflect the underlying assumptions involved in much qualitative research.

3.11.1. Credibility

Credibility was one of the trustworthiness criteria utilized in this study. To increase the credibility of this study prolonged, peer-debriefing, member checking, triangulation of data sources and inter-rater reliability were used in this study.

3.11.1a. Prolonged

Prolonged is obtained by engaging in considerable involvement in the setting in which the study is based (Lincoln & Guba, 1985). In this study, lengthy engagement was used to ensure a sense of rapport and trust with participating pre-service teachers and to minimize any possible distortion of information obtained from the pre-service teachers. It was attained by collecting data over a period of four months (full university semester), with a small group of participating pre-service teachers. The researcher conducted multiple data collection techniques, which included formal and informal interviews, feedback discussions and classroom observations of pre-service teachers on a biweekly basis. Reflective workshop sessions were also organized every month. During this period, a field note was developed which reported events that were worthy to be noted. This helped to supplement data collected by using the instruments earlier described. Detailed process undertaken to ensure credibility are hereby detailed.

3.11.1b. Peer debriefing

Peer debriefing was the second technique implemented to increase the credibility of this study. Guba and Lincoln (1989) described peer debriefing as 'a process of engaging, with a disinterested peer, in extended and extensive discussion of one's findings, conclusions, tentative analysis and occasionally filed stress" (p. 237). Borrowing the idea of Guba and Lincoln (1989), in this study the researcher conducted debriefing with her research supervisor to clarify the procedures used to analysis the data and to provide guidance for developing the subsequent stages of the study.

3.11.1c. Member checking

The third technique implemented to increase the credibility of this study was member checking. According to (Glesne, 1999, p. 32) member checking is a process of making sure that the researcher is representing the research participants and their ideas accurately. Emphasising on the purpose of member checking, Lincoln and Guba (1985) noted that "it provides an opportunity to assess intentionality" of the participants about how they interpreted the information that was provided. It also provides participants "an immediate opportunity to correct the errors" (p. 314) that might have been made during the interpretation of the data. In this study member checking technique was utilized during the interviews to ensure that the researcher correctly understood all that transpired in the observed lessons during the teaching practice period. The researcher asked for clarifications when needed to better understand how the pre-service teachers implemented ABIM in middle school science classrooms.

3.11.2. Transferability

Transferability was the second trustworthiness criterion utilized in this study. To Guba and Lincoln (1989) transferability is "an empirical process for checking the degree of similarity between sending and receiving context" (p. 241). Transferability is by and large enhanced through a technique of thick description (Geertz, 1973; Guba & Lincoln, 1989). Transferability was achieved in this study by doing a thorough job of describing the research context, the site, the research participants and the intervention programme (see sub-sections 3.3 and 3.7). Geertz (1973) and Guba and Lincoln (1989) further described transferability as the degree to which the results of qualitative research can be generalized or transferred to other contexts or settings. The thick description permit interested readers to make their own judgements about the transfer of the results of this study to a different context.

3.11.3. Dependability

The third trustworthiness criteria utilized in this study was dependability. It is associated with the traditional quantitative view of reliability, which is based on the assumption of replicability or repeatability. Guba and Lincoln (1989) associated dependability with the stability of the data over time. The idea of dependability emphasizes the need for the researcher to account for the ever-changing context within which research occurs. One of the characteristic of constructivist study is the shift in construction is a normal and expected features of development of an emergent design. The shifts in construction have to be traced and documented. In this study dependability was attained by tracking and documenting the implementation of the study.

3.11.4. Confirmability

The fourth and the last trustworthiness criterion used in this study is confirmability. It is associated with the traditional quantitative view of objectivity. In this study Confirmability was enhanced through a technique of confirmability audit and triangulation. Confirmability refers to the degree to which the results could be confirmed or corroborated by others. It is "concerned with assuring that data and interpretations are not simply figments of the evaluator's imagination, rather they are outcomes of inquiries that are rooted in context and in persons apart from the evaluator" (Guba & Lincoln, 1989, p. 243).

As such, the constructions which emerged during this study were traced back to their original sources. In this study, the procedures used to collect and analyse data, full transcripts of classroom interaction and interviews were documented for checking and rechecking the data throughout the study. The results sections of this thesis (chapter 4) incorporates verbatim quotes from pre-service teachers' video lessons transcripts, interview transcripts and reflective responses, in addition to the researcher's interpretations of the data drawn from classroom observations, interview and reflective responses.

3.11.4a Triangulation

The second technique used to increase the confirmability of this study was triangulation of the data sources. Denzin and Lincoln (1994) argue that methodological triangulation protocols increase confidence in the validity of the study. In the same vein, Lincoln and Guba (1985) indicated the importance of triangulation in measuring accuracy and credibility of the data. Glesne (1999) also noted the potential of triangulation in increasing the credibility and trustworthiness of the research data. Glesne (1999) proposed four different ways that data can be triangulated. These are multiple sources, methods, investigators, or theories to maximize opportunities to identify possible influences on the issue under examination. This study implemented multiple sources and methods to establish trustworthiness of the data. The researcher collected data through, questionnaire, argument-based tasks, interviews, classroom observations and reflective response questionnaire (multiple methods, multiple sources) to allow methodological triangulation to occur and to increase credibility and therefore trustworthiness.

3.11.4b Inter-rater reliability

In this study, inter-rater reliability was also utilized to establish trustworthiness of the data. Mays and Pope (1995) indicated that "the analysis of qualitative data can be enhanced by organizing an independent assessment of transcripts by additional skilled qualitative researchers and comparing agreement between the raters" (p.110). Lincoln and Guba (1985) described inter-rater reliability (or as referred peer debriefing) as "a process of exposing oneself to a disinterested peer in a manner paralleling an analytic session and for the purpose of exploring aspects of the inquiry that might otherwise remain only implicit within the inquirer's mind" (p. 308). Lincoln and Guba (1985) further elucidate that the researcher's peer should be a colleague who has considerable knowledge and understanding of "substantive area of the inquiry and the methodological issues" (p.308).

In compliance to their views, one-third of the data obtained from the three argument-based tasks was coded independently by a college of the researcher, who holds a PhD in Science Education and who had sound knowledge about qualitative and quantitative research method. Data obtained from the three argument-based tasks were purposefully selected to be analysed by the independent reviewer/reader. As indicated in the sampling procedure, the criteria used to select the six pre-service teachers for deeper analysis was primarily based on pre-service teachers' ability to construct quality arguments in the three argument-based tasks.

Before starting the coding process, the researcher explained the purpose of the study and provided information about the theoretical frameworks and the analytical tools utilized in this study to evaluate the quality of argument constructed in the statements produced by the pre-service teachers. Then independent raters analysed the selected data from argument-based tasks individually using the levels of argumentation developed after Erduran et al. (2004), which was also used by the researcher. Independent rater analysed a total of 24 arguments (about one-third of the total) constructed by eight different pre-service teachers for each of the tasks. The inter-rater reliability was calculated by dividing the number of agreements by the sum of number of agreements and number of disagreements. The initial inter-rater reliability was 75%. After the initial round of inter-rater reliability check the researcher and the independent rater discussed the disagreements in analysis. Disagreements between the researcher and the independent rater were resolved through discussion and further review of the disputed part of the data. After the discussion and further review, the researcher and the independent rater came to consensus on 87.5% of inter-rater reliability. A summary of inter-rater reliability of round one and two is displayed in Table 3.1 below.

Table 3.1: Summary of inter-rater reliability

Task	Round 1			Round 2		
	No. of agreement	No. of disagreement	Total	No. of agreement	No. of disagreement	Total
One	7	1	8	7	1	8
Two	6	2	8	7	1	8
Three	5	3	8	7	1	8
Sum total	18	6	24	21	3	24
Inter-rater reliability: 18/24x100= 75%				**Inter-rater reliability: 21/24x100= 87.5%**		

3.12 Ethical consideration

Ethical concerns need to be at the forefront of any research project and should continue through to the write-up and dissemination stages (Wellington, 2000, p. 3). In agreement with this assertion, institutions of Higher learning and Research Committee of Universities request researchers to follow the ethical codes of any professional association, educational institute or other external bodies with which they are associated, and abide by relevant legislation (CCCU, 2006). In view of this, this study made commendable efforts to comply with the ethical standards laid down by the Senate Research Committee of the University of the Western Cape. Apart from that, the researcher consulted basic principles stipulated in the international standard ethical practices, such as, ESRC guidelines 2006. This awareness helped the researcher to know what procedures and formalities to follow while collecting the data for the study.

In conformity with the ethical standards stipulated in the *Revised Ethical Guidelines for Educational Research (*BERA, 2004) the participating pre-service teachers were informed about: the aims and nature of the research, the researcher's identity and contact details, duration of research & what their participation in the research entails, who will have access to data, how data will be stored, the extent to which confidentiality and anonymity will be protected, their right to check the accuracy of their verbatim transcriptions. As an important component of ethical standard, psychologists respect the knowledge, insight, experience and expertise of potential participants (Department of Health, 2001, 2005, ESRC, 2005). This awareness helped the researcher to respect individual, cultural and role differences, including those involving age, sex, ethnicity, language, religion, family situation and socio-economic status of the participating PTs. Besides, the researcher did not explore sensitive issues before a good relationship has been established with the pre-service teachers.

The most important ethical issues for this study are related to pre-service science teachers and their institution; school directors, their learners and the selected middle schools in which the research was conducted. The researcher made conscious effort to protect the integrity, autonomy, privacy and dignity of the above research participants who were directly or indirectly involved in this study. To achieve such a purpose, this study adopted the guidelines stipulated in "The Human Rights act of 1998" (Committee on Medical Ethics, British Medical Association, 2000; ESRC guidelines (2006) and related literature to safeguard the rights of research participants. Emphasis was given to three essential components: minimising risks, ensuring informed consent, privacy and confidentiality.

Minimizing risk

The Human Rights act of 1998 (Committee on Medical Ethics, British Medical Association, 2000) stated that all research studies should be undertaken under the basic principle that it does not cause harm, allow harm to be inflicted, or otherwise damage the interests of any involved parties. The ESRC guidelines (2006) further explicate that researchers need to be alert to the ways in which their research affects the work of other people, and should respect the rights and reputations of others. In the light of this assertion, participating pre-service teachers were assured that the data collected will not be of any highly sensitive nature politically, socially, physically or otherwise. Furthermore, all stakeholders were assured that the study will not create negative image about the Eritrean Education System in general and the new learner-centred curriculum in particular. The researcher respected the physical, personal and psychological autonomy of participants who were directly or indirectly affected by this study. They were assured that the researcher will take care of any adverse effect her work may have on them.

A code of information consent

Any participation in a research project should normally take place in the context of a clear and unambiguous agreement between researcher and participant. In projects which carry some risk for participants, this should normally take the form of written consent by the participant(s), with written information provided giving explicit details of any eventualities that may result from the investigation (Marian, 1996). Hence, a code of informed consent guided the involvement of pre-service science teachers and their institution. Participants were given clear and unambiguous information relating to the activities in which they will be involved as failure to fully inform participants of any known relevant factor may make consent invalid (ESRC, 2001). Moreover, before the commencement of the study the researcher sought permission of all the stakeholders including, MOE officials, school directors, pre-service teachers and middle school learners.

A code of confidentiality

Researchers need to respect confidentiality and ensure that information or data collected about individuals are appropriately anonymised and cannot be traced back to them by other parties, even if the participants themselves are not troubled by a potential loss of confidentiality (ESRC, 2005; CCCU, 2006). In line with this assertion, this study gave due attention to the issue of confidentially as the participants who were involved in this study could be at risk if any disclosure is made about their perceptions and insights on the nature of the learner centred curriculum and the teaching-learning process employed in classrooms. In this study, therefore, considerable efforts were made to respect the privacy of individuals and to ensure that individuals are not personally identifiable. They were assured that they have the right to decline or to withdraw at any time, without penalty if any of their rights was not respected. All the interviews were strictly confidential and a confidentiality letter was written to the participating pre-service teachers. Moreover, pre-service teachers' questionnaire was anonymous and the name of the selected schools was kept anonymous and no information about the schools or learners was divulged to any person. The data collected was only used for research purpose and only the researcher and her supervisor have access to it.

3.13 Conclusion

This study adopted a case study approach grounded in the interpretive research paradigm as it was based on the researcher's interpretations of the pre-service teachers' ability to understand learner centred curriculum, argumentation and to use ABIM to implement a learner-centred curriculum. Multiple data sources and research instruments were utilized to collect the data that were necessary to answer the research questions of the study. This research took place in three major phases. The pre-intervention phase of the study incorporated, the development of argumentation based intervention training instructional material, and the development of exemplary argumentation based instructional material for middle school students, the administration of LCAI questionnaire and other preliminary activities. The intervention phase of the study implemented the intervention programme, administered argument-based tasks and employed micro teaching. The post-intervention phase of the study administered LCAI questionnaire, classroom observations, reflective workshops, interviews and reflective questionnaire/reflective interview. A simplified form of TAP's model developed after Erduran et al. (2004) and CAT (Ogunniyi, 2004, 2007) were used as units of analysis for the data collected. This study adopted trustworthiness criteria proposed by Lincoln and Guba (1985) to ensure that the interpretations and the findings of this study are valid. The findings of the study are presented and discussed in chapter 4.

CHAPTER FOUR

DATA PRESENTATION, ANALYSIS AND DISCUSSION

4.1 Introduction

This chapter presents the results of the qualitative and quantitative analysis of the data obtained from participating pre-service teachers' in response to the following research questions:

1. What conceptions of learner-centred curriculum and argumentation did the pre-service teachers hold before and after being exposed to ABIM?

2. To what extent are the pre-service teachers able to construct quality arguments and participate in an argumentation discourse?

3. To what extent are the pre-service teachers able to use ABIM to implement a learner-centred curriculum?

4. What are the factors that promoted or hindered the pre-service teachers from using ABIM to implement a learner-centred curriculum in their science classrooms?

Quantitative data were presented using frequency and percentages in a tabular form and in colour coded stack bar charts (Pietersen & Maree, 2007, p.184). Qualitative data were organized by categorising data into categories and response themes (Strauss & Corbin, 1990) and were presented in the form of text. The data was then analysed using theoretical and analytical frameworks that were found to be useful for this study. These include modified form of Toulmin's Argumentation Patter (TAP) (Toulmin, 1958) and Contiguity argumentation theory (CAT) (Ogunniyi, 2008b). The findings of the results were then discussed in relation to extant literature using the theoretical frameworks adapted for the purpose of this study. The results were analysed and discussed using the four research questions as subheadings.

The chapter commences with a critical examination of pre-service teachers' (PTs') pre- and post-intervention conceptions of a learner-centred curriculum and argumentation. This was followed by a discussion of pre-service teachers' ability to construct arguments and participate in argumentation discourse. Pre-service teachers' ability to use argumentation-based instructional approach to implement a learner-centred curriculum in selected Eritrean middle school science classrooms and their progress overtime was then examined and discussed. Factors that promoted or hindered the implementation of argumentation instruction in science classrooms were also identified and examined. The chapter ended with a summary of the major findings for each research question.

4.2 Conception of Learner-Centred Curriculum/instruction and of argumentation

This section looks at the pre-service teachers' understandings of a learner-centred curriculum and instruction before and after their involvement in the argumentation-based intervention training programme and after their participation in the reflective workshop sessions organized for the purpose of this study. The section that follows explores the PT's responses to the first question: "What conceptions of a learner-centred curriculum/instruction and argumentation did the pre-service teachers hold before and after being exposed to an argumentation-based instructional model"?

4.2.1 Pre-service Teachers' pre-post conceptions of a Learner-Centred Curriculum and Instruction (LCCI)

The section presents the analyses and discusses of the data set which was derived from the pre-service science teachers' responses to the Learner-centred Argumentation Instruction Questionnaire (LCAIQ) and to the reflective response questionnaire/ reflective interview.

4.2.1.1: Results from the questionnaire soliciting for pre-service teachers' conceptions of a learner-centred curriculum and instruction

As indicated in chapter three, an eight item open-ended questionnaire was administered before and after the intervention programme *(See Appendix B for details on this questionnaire)* to obtain the PTs' conceptions of a learner-centred curriculum, a learner-centred instruction and argumentation. This sub-section only looks at PTs' responses to items one and two of the questionnaire, which states thus: "What is your understanding of learner-centred curriculum and learner-centred instruction?" Pre-service teachers' responses were analysed using open coding and the generation of categories. The process of open coding began with the collection of raw data from the LCAI questionnaire responses. The intent of open coding was to break down the data into segments in order to interpret them. Detailed word-by-word and line-by-line analysis was conducted by the researcher asking what is going on. The researcher identified, defined and develops as many ideas and concepts as possible without concern for how they will ultimately be used. The relationship between the issues and themes within the data was systematically assessed after the multitude of ideas and concepts have been uncovered. The development of such concepts provided the opportunity for the researcher to classify similar phenomena together, ordering and reducing the data.

Data segments were, therefore, compared so that they may be grouped together as examples of the same concept or differentiated to form new ones. Coded responses were then ranked in descending order of occurrence. The emerging response themes are depicted in Table 4.1.

Table 4.1: Emerging response themes of pre-service teachers' understanding of a learner-centred curriculum and instruction

Pre-test emerging response themes	**F (%)**	**Post-test emerging response themes**	**F (%)**
Encourages active students involvement	22(27)	Encourages active students involvement	25 (13)
emphasizes learning by doing and by understanding	18(22)	emphasizes on learning by doing and by understanding	22(12)
Students construct knowledge through gathering and synthesizing information	16 (19)	Students construct knowledge through gathering and synthesizing information	21 (11)
Intends to develops critical thinking, problem solving and communication skill	14(17)	Intends to develops critical thinking, problem solving and communication skill	19(10)
Teacher's role is to coach and facilitate	13(16)	Teacher's role is to coach and facilitate	19 (10)
		Gives importance to students'' prior knowledge	18 (10)
		Emphasis is on using and communicating knowledge effectively to address problems in real-life contexts	17(9)
		Emphasis is on generating better questions and learning from errors	17(9)
		Assessment is used to promote and diagnose learning	15(8)
		The nature of the learning environment is cooperative, collaborative, and supportive	13(7)
Total	**83**	**Total**	**186**

Ranked and coded in descending order. Figures in parenthesis indicate percentages.

A critical glance of the data displayed in Table 4.1 shows that some PTs provided more than one response themes. Therefore, the percentages were calculated based on the total number of responses across all the identified themes not on the total number of participating PTs (N=25). The above table also shows that compared to post-test, only a relatively small number of response themes emerged from the participating pre-service teachers at the pre-test stage. Eighty three (83) of the response themes at the pre-test relate to their understanding of a learner-centred curriculum and instruction. From these response themes: 22 responses deal with how a learner-centred instruction (LCCI) encourages active students involvement; 18

relate to learning by doing and understanding; 16 relate to students' knowledge construction through data collection and analysis and 14 to higher-order thinking skills such as critical thinking, problem solving and communication skill and 13 to the role of the teacher in learner-centred classrooms.

From the post-test responses, it seems that PTs had more comprehensive understanding of LCCI than they had at the pre-test stage. At the post-test they were able to describe salient features of a learner-centred curriculum and instruction which did not feature in their pre-test responses. Among others, PTs' responses seem to show an awareness of the fact that the emphasis of LCCI is to guide students to learn how to use the concepts stipulated in the science textbooks to address problems in day-to-day life. The pre-service teachers were also able to appreciate the need to start with students' prior knowledge, the purpose and procedures of assessment in the lenses of LCC as well as the cooperative and collaborative nature of a learner-centred learning environment.

From the foregoing analysis, it is evident that the PTs had basic knowledge and understanding of a learner-centred curriculum and instruction before the intervention. Although the pre-service teachers were not able to elaborate, some aspect of LCCI related to assessment and nature of the learning environment, their views are well documented in the extant literature (e.g., Blumberg, 2004; Lambert & McCombs, 2000; Weimer, 2002; Wright, 2006). For instance, Blumberg (2004) notes that LCCI emphasizes active student involvement and focuses more on student learning than on what the teacher is doing. In a similar vein, Weimer (2002) argues that LCC gives emphasis to learning by doing and understanding and considers learning as construction of knowledge by individuals. The major observation that can be deduced from the above analysis is that LCCI was not a new concept to the participating pre-service teachers. Nonetheless, there is sufficient evidence that PTs indicated more features of a learner-centred curriculum and instruction in the post-test than in the pre-test, which could mean that they became more knowledgeable after their involvement in the intervention programme. One can conclude that the intervention programme must have been effective to some extent in broadening and advancing pre-service teachers' understanding of LCCI. Such advancement or progress seems to link well with the emergent category of CAT (Ogunniyi, 2004, 2007a, 2008b), where new ideas about LCCI were added to the old ones. The sub-section that follows further examines pre-service teachers' understandings of a learner-centred curriculum and instruction on reflection.

4.2.1.2 Pre-service teachers' pre-post understanding of a learner-centred curriculum and instruction on reflection

As indicated in chapter three, towards the end of the study, each pre-service teacher was asked to write a reflective journal based on the six questions included in the reflective response questionnaire. Initial analysis of some pre-service teachers' reflective journals revealed that the information obtained was not rich enough to determine the PTs' pre-post understanding of a learner-centred curriculum and instruction. Therefore, reflective interviews were administered with some pre-service teachers using the item questions of the reflective questionnaire to probe them again to reflect on each of the item question.

The first item of the Reflective Response Questionnaire (RRQ)/ reflective response interview asked the participating pre-service teachers to reflect on and express their views about a learner-centred curriculum and instruction before and after their involvement in the intervention programme and in the reflective sessions (See Appendix F for details) Exemplary responses of some of the pre-service teachers are displayed in Table 4.2 and will be discussed in detail. The other responses are highlighted in a combined fashion because they either reiterate or reinforce what the detailed responses disclose.

Table 4.2: Pre-service teachers' pre-post understanding of a learner-centred curriculum and instruction on reflection

PTs' identity	**Aspects/elements of LCC**	**Pre-test views**	**Post-test views**
PT13	Relate knowledge to real life	Before the intervention I was aware that LCCI aims at relating the new information with students' prior knowledge and experiences. Starting lessons with students' prior knowledge was my usual practice in my earlier teaching days. **(PT12) echoes** the same sentiments when she says "Initially, I was cognisant that LCCI values existing knowledge and experiences of students"	The intervention programme ***enlightened my understanding*** of LCCI. …I now realized that LCCI aspires to relate lesson content and classroom activities to students' real-life needs. PT13 express his earlier teaching experience in this regard "In my earlier teaching days I never attempt to help students to use the knowledge they learnt in the science classroom to address the problems encountered in their day-to day practices". ***Now I am confidence to apply it in my class.*** **(PT12) echoes** the same sentiments when she says "My participation in the intervention and reflection sessions enabled me to ***realize the importance of***

			anchoring the science lessons with students' life experience
PT18	Method of instructions	Before the intervention I was aware that LCC encourages students to construct their own knowledge and emphasises on active student involvement. Yet ***I had limited knowledge*** of the instructional strategies that are appropriate to achieve this goal. **(PT5)** echoes the same sentiments when she says " Before the intervention 'group work activities' and 'discussion' were the only learner-centred teaching strategies which I was familiar. ….It is an indication that I was aware of ***narrow range of instructional strategies.***	The intervention ***increased my awareness of the various methods of instruction*** that are appropriate to implement LCC. Moreover, I was able to frequently employ contemporary approaches of teaching such as, argumentation-based instruction in my science classroom **(PT5)** hold similar view. She said "After the intervention I was ***familiar with diverse instructional strategies*** that are used to implement LCC. Among others, I am aware that argumentation instruction approach, problem-based approach, discussion approach are appropriate instruction approaches to implement LCC
PT8	**Assessment**	Before the intervention I thought that the purpose of assessment is ***only*** to determine the performance of students….Frankly speaking I equate assessment with exams.	The intervention equipped me ***to define the purpose of assessment more clearly and comprehensively****. I now know that in LCC* assessment is used to promote and diagnose learning. The experiences emanated from the reflective workshop sessions ***empowered me to use*** assessment as an integral part of the teaching-learning process with ease and confidence.
PT17	learning environment	Before the intervention ***I was not aware*** that LCI requires specific learning environment. Honestly I had limited understanding on how classroom environment influences students' learning…	The intervention, the reflective sessions and feedback discussions ***helped me to realize that*** LCCI fosters active, participatory or interactive and learner-centred learning environment
PT 16	Type of question	Before the intervention I was conversant that the LCCI encourages teachers to use open- ended questions although I was not able to rationalize the importance of providing open-ended questions. **(PT 3)** echoed similar view when he said "I was familiar that LCCI inquires teachers to utilize open-ended questions, but I did not consider its importance in students' learning".	The intervention ***helped me to justify*** why LCCI recommend open-ended questions or problem-based activities. It also helped me to better explain how open-ended questions develop higher-order thinking skills. **(PT 3)** echoed similar view when he said ' After the intervention I was aware that the emphasis of LCCI is not to get the right answer for the given open-

		PT8 express his earlier teaching experience in this regard "In my earlier teaching days I frequently use close-ended questions as my emphasis was on how to help students to get the correct answer to the questions posed"	ended questions but learn from each other and to learn from errors
Respons es from other PTs	General views	Before the intervention I was familiar that LCCI emphasis on active student involvement(PT23), teachers are facilitators of the teaching learning process (PT10), fostered to meet the diverse needs of students(PT9), value students' prior experience(PT2)	The intervention ***opened my eyes to realize*** that: the purpose of assessment is to diagnose learning(PT23) LCCI fosters cooperative learning environment(PT10) LCCI encourages the use of diverse interaction modes to meet the diverse needs of students (PT9) LCCI values socio-cultural background of students(PT2)

*The numbers in brackets are other PTs' identities.

Table 4.2 portrays that before the intervention PTs had a reasonably good knowledge and understanding of a learner-centred curriculum and instruction. However, it can be said that they seem to be more conversant with the major aspects or elements of LCCI at the end of the intervention programme than before the programme. To mention just a few, at the post-test level, the majority of the pre-service teachers indicated that LCCI focuses on active student involvement and promotes participatory and collaborative learning environment. These PTs have also pointed that LCCI encouraged teachers to employ teaching strategies that initiate discussion. Their views, at this stage are well documented in the extant literature (e.g. Blumberg, 2004; Blumberg, 2008; Lambert & McCombs, 2000, Wright, 2006). In terms of CAT, a more cohesive understanding of the aspects of a learner-centred curriculum and instruction was gradually assimilated and new concepts emerged. This seems to suggest that there was no well-formed prior knowledge or understanding of the concepts.

The major observations from the data derived from the reflective response questionnaire/ reflective response interview (see Table 4.2) seem to reinforce the main observations derived from the LCAI questionnaire (see sub-section 4.2.1.1). In addition, the data obtained from the reflective response questionnaire/ reflective response interview (see Table 4.2) provides more vivid information about pre-service teachers' understanding of LCCI that emanated from their experiences in the intervention programme, reflective sessions and their subsequent growth. Thus, more detailed analysis of the data displayed in Table 4.2 will follow.

The results displayed in Table 4.2 indicate that there are several phrases within the PTs' reflective responses to the questionnaire and the interviews that suggest the revision of stances, evidence of growth or improvement in their understanding of a learner centred curriculum (LCC) as a result of their exposure to the intervention programme, teaching practice and reflective workshop sessions. For example, "*enlightened me ", "I now feel confident", "to define more clearly", "empowered me"* and "*opened my eyes to realize***"** just to mention but a few. For instance, a 38 year male pre-service teacher (PT13) with 11 years teaching experience made the following statement:

> *In my earlier teaching days, that is, before I joined the College of Education I often associate the new lesson with learners' prior knowledge. The intervention programme and the reflective sessions have played a great role in enriching my understanding of learner-centred curriculum and instruction. Among others,* ***I was able to help students on how to use the knowledge they learnt in the science classroom to address the problems encountered in their day-to day practices.*** *To do so, I frequently used activity-based tasks that address socio-scientific issues….* ***I Now feel confident to apply it in my class.***

Although PT12's view is not too different from that of PT13, she is more succinct about her experience in the intervention and reflection sessions, as the following excerpt shows:

> *Before the intervention, I was aware that learner-centred curriculum and instruction considers students' existing knowledge and experience as an important aspect in learning new knowledge. The intervention and reflection sessions heightened my understanding of learner-centred curriculum and instruction. My participation in the intervention and reflection sessions enabled me to* ***realize the need of anchoring the lessons with students' day-to-day life.***

Like PT13, PT18 stated that the intervention programme and the reflective sessions were instrumental in broadening her understanding of LCCI. More specifically, she indicated that the intervention helped her to increase her awareness *of the methods of instruction* that are useful to implement a learner-centred curriculum, as the following excerpt indicates:

> *Initially, I was aware that a learner-centred curriculum and instruction intends to attend to individual student's needs and aspires to develop student's problem solving and critical thinking skills. The intervention opened my eyes to realize that successful implementation of the learning goals of learner-centred curriculum requires the use of different repertoires of teaching strategies. The intervention programme also helped me to select appropriate instructional approaches to implement learner-centred curriculum in science classrooms. In my teaching practice period I was able to use argumentation as a teaching strategy to promote students' higher-level cognitive thinking skills.*

It seems that PT13’s and PT18’s engagement in the intervention and reflective sessions had not only helped them to become more knowledgeable about LCCI at the post-test stage, but also influenced their instructional practice.

The views expressed by PT8 and PT17 on the intervention programme seem to corroborate those of PT13 and PT12. For instance, before the intervention programme PT8 noted that he had limited understanding of certain aspects of LCCI. For example, he thought that the purpose of assessment is only to determine the performance of students, but after the intervention he was able to realize that the purpose of assessment is to promote and diagnose learning. It is important to note that PT8’s view is echoed by many other pre-service teachers. PT17’s view focuses on the effect of learning environment in promoting learning. She indicated that before the intervention she did not have a clear understanding of the effect and relevance of learning environment in the teaching-learning process. However, after the intervention she was able to understand how a learning environment influences students’ learning. Her realization that LCCI supports cooperative and interactive learning is of great importance.

From the forgoing analysis, one can conclude that the PTs involved in this study benefited considerably from the intervention programme and the reflective sessions in terms of increased understanding and awareness about the value of LCCI. Looking at the data displayed in Table 4.2, there is sufficient evidence to show increased understanding among the pre-service teachers about the importance of a LCC as a result of their involvement in the argumentation instructional model (including the experiences they garnered from the reflective workshop sessions). This implies that the explicit reflective argumentation-based instructional approach employed in the intervention programme and in the reflective sessions enhanced their understanding of a learner-centred curriculum and instruction. This finding is resonant with the general assertion that shows the potential of argumentation instruction in knowledge building, belief revision, and in enhancing their conceptual development and overall awareness about the value of argumentation instruction (e.g., Leitao, 2000; Venville & Dawson, 2010; Zohar & Nemet, 2002).

Sub-section summary

The major observation that can be deduced from the analysis of the data displayed in Tables 4.1.and 4.2 is the pre-service teachers involved in the study had more comprehensive understandings of a learner-centred curriculum and instruction after their exposure to the intervention programme and reflective workshop sessions than was previously the case.

Having presented the pre-service teachers' views about a learner-centred curriculum and instruction, the section that follows will examine their pre- and post- understandings of argumentation. Specifically, the section will explore their views about the usefulness of argumentation or otherwise of a learner-centred curriculum and instruction.

4.2.2 Pre-service teachers' pre-post conceptions of argumentation

As indicated earlier, the pre-service teachers' responses to the LCAI questionnaire (see Appendix B for details on this questionnaire) and to the reflective response questionnaire/reflective interview (for details see Appendix F) provided the data set for this item.

The pre- and post- LCAI questionnaires requested the pre-service teachers to express their views about (a) argumentation, (b) the differences between scientific and every day argumentation and (c) the role of argumentation in science education and/or science teaching before and after undertaking the intervention training programme. They were also asked to indicate the pedagogical knowledge and skills required to: facilitate argumentation discourse, keep argument going and evaluate the quality of arguments. The last item of the questionnaire solicits the pre-service teachers to express their views on the possibility of introducing argumentation-based instruction model (ABIM) in Eritrean classrooms.

As indicated in chapter 3 the reflective response questionnaire/reflective interview was administered towards the end of the study period. The second and third item of the reflective response questionnaire/interview (See Appendix F) asked the pre-service teachers to narrate their understanding of (a) scientific argumentation and its role in science teaching/science education and (b) the skills and techniques required to support and sustain argumentation in science lessons at the time they started participating in the intervention, at the end of the intervention and after their involvement in the teaching practice session.

LCAI questionnaire responses and reflective responses were analysed using open coding and the generation of categories. A more detailed description of the coding process was presented in sub-heading 4.2.1.1. Thus, it will not be repeated here. The coded responses in each response theme were then ranked in descending order of occurrence. A broad summary of the results obtained from the LCAI questionnaire and reflective response questionnaire/interview are illustrated in the table below (Table 4.3) and discussed in detail.

Table 4.3: Pre-service teachers' pre-post views about argumentation

Response themes	**Pre-test** **Codes**	**No. of references (%)**	**Post-test** **Codes**	**No. of referenc es(%)**
Understan ding of argumenta tion	…a discussion or debate ..a dialog but rather in a quarrel form *to win the argument*	16(60)	Supporting or refuting a claim by giving reasons	16(38)
	presenting an idea using concrete example	9(32)	Debate and negotiation to reach mutually acceptable conclusion through logical and non-logical reasoning	12 (29)
	To discuss about an issue by reasoning or proofing it on the basis of evidences	2(8)	Attending critically to others argument	10(24)
			It is a form of discussion	4 (10)
Sub-total		**27(100)**		**42(100)**
Difference between scientific and everyday argumenta tion	No, both reach to a common point or conclusion	15(60)	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	14(56)
	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 most arguers are emotional and defensive rather than providing reasons for their claim; whereas in scientific argumentation arguers attempt to provide evidence to justifying the claim or conclusion made	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 theories which are	4(16)	No, in both forms the arguers try to reach into consensus	5(20)

	absolute			
Sub-total		**25(100)**		**25(100**
Role of argumentation	No, … argumentation doesn't have any role in science because scientific knowledge is absolute	17(68)	Yes, scientific argumentation has a significant role in science teaching, particlarly in scientifc knowedge construction.	17(37)
	No, because scientific knowledge is synthesized by logical reasoning	8(32)	Yes, scientific argumentation promote conceptual understanding of scientific concepts	12(27)
			Yes, scientific argumentation develop students' critical thinking and communication skills,	8(18)
			I still don't see the role argumentation in science teaching…	7 (16%)
Sub-total		**25(100)**		**44(100)**
Skills and techniques required to support and keep argumentation going	Provide open-ended tasks	19 (39)	Pose argument prompt questions and playing devils advocacy	18(32)
	Guide and initiate discussion	16(33)	Establish norms of argumentation	15(27)
	Facilitate group work and presentation	14(28)	Employ strategies such as: classification activity, computing theory, concept cartoon, predict observe explain, /analysis and interpreting	13(23)
			Facilitate group work and presentation	6 (11)
			Introduce the lesson by summarizing the previous lesson, ask questions at the end of the lesson to assess the performance of the students	4(7)

Sub-total		**49 (100)**		**56(100)**
Quality of arguments	My focuses is on the appropriateness of the final answer	18(62)	I would examining the overall structure of the argument using TAP model	22(58)
	I would consider those ideas which are related with my opinion/views, and reject those ideas that are different from mine	8(28)	I would focus on the presence or absence of rebuttals	11(29)
	I have no idea on how to evaluate the quality of argument	3(100	I will focus on the final answer	5(13)
Sub-total		**29(100)**		**38(100)**

***** Ranked and coded in descending order. Numbers in parenthesis indicate percentages. These percentages were calculated based on the total number of responses in each response theme.

Pre-service teachers' understanding of argumentation

Before the intervention, the participating pre-service teachers described argumentation in various ways. The codes that received the highest percentage of responses 16 (60%) were the "discussion/debate/dialog" code. This indicates that the majority of the PTs had limited understanding of argumentation before the intervention. The table further discloses that slightly more than one third (32%) of the responses associated argumentation with concrete examples. This shows that some of these pre-service teachers had misconceptions about the meaning of argumentation at that time. The following expressed views are representative of the PTs' understanding of argumentation.

A 21 year female pre-service teacher with no teaching experience associated the process of argumentation with provision of *concrete examples*, as the following excerpt shows:

I think argumentation is a process of presenting ideas or information using concrete examples from our daily life (PT5).

A pre-service teacher with 12 years teaching experience described argumentation in a different way, as follows:

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).

The same sentiments were echoed by many other participating pre-service teachers who said 'argumentation is disagreement between people to win the battle'. The views of this group of pre-service teachers seem to reflect Bricker and Bell's (2008) observation. In their study, they indicated that young people equate argument with social dispute and consider quarrelling as genuine ways to win an argument.

The statements above show that although the views of PT5 and PT8 are different at the pre-test stage there is an indication that both of them have a naïve understanding of argumentation. On the other hand, very few responses of the pre-service teachers seem to show good understanding of argumentation before the intervention. For example, a 23 year male pre-service teachers with no teaching experienced described argumentation as indicated in the excerpt below.

> *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 (PT16).*

The view of PT16 at the pre-test accords with the view espoused by Finocchiaro's (2005) construal of argumentation as an instance of reasoning that attempts to justify a conclusion by supporting or opposing it with reasons.

After the intervention, however, the majority of the responses of the pre-service teachers (90%) showed a reasonably good understanding of argumentation. Some defined argumentation as a means of supporting or refuting a claim by giving logical and non-logical reasons. Others have also defined it as to debate and negotiate to reach mutually acceptable conclusions through plausible reasoning. Still others described it as assessing critically other people's argument and expressing one view or another about it. The understanding of these group of pre-service teachers at the post-test agreed with the view of many science educators working in the area (e.g., Driver et al., 2000; Finocchiaro, 2005; Kuhn, 1993, Means & Voss, 1996**).** These scholars define argumentation as an assertion with accompanying justification or an instance of reasoning that attempts to justify a conclusion by supporting or opposing it with reasons.

PT5 and PT8 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 once claim. (PT5 at post-test)*
>
> *Argumentation is an activity where individuals who hold contrasting positions attempt to convince each other's claim using evidence (PT8* at post-test)

It is notable that PT8s' response to the reflective response questionnaire in relation to this item was that the intervention programme and reflective workshop sessions helped him to change his view about argumentation. He opined as follows:

> *Initially, I thought that argumentation is a debate in a form of quarrel between two or more people to win an argument. After my involvement in the intervention programme I was able to understand that argumentation is more than to debate to win an argument. ...I have learnt that in argumentation arguers have to thinking 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''. ...My engagement in the open discussions that took place in the reflective sessions further improved my understanding of argumentation. I now came to understand that scientists constructed scientific knowledge about the natural phenomena through critic and debate, which I believe is one process of scientific argumentation.*

A critical analysis of the above excerpt reveals that PT8 made a noticeable perceptual shift or developed an emergent view in terms of the contiguity argumentation Theory (CAT) from his view at post-test reflective response. At the pre-test he saw argumentation as a debate to win the argument. However, at the post-test he construed argument as a means of justifying a claim using plausible evidence. This is seen as the major observation for this aspect of the research. In addition, the final statement of PT8 accords with the view of Osborne (2010) who contends that "Critique is not, therefore, some peripheral feature of science, but rather it is core to its practice, and without it, the construction of reliable knowledge would be impossible", (p.465).

PTs' understanding of everyday argumentation and scientific argumentation

The pre-service teachers' understanding of scientific argumentation was also probed by inviting them to describe the difference between everyday argumentation and scientific argumentation. Initially, slightly more than half of the responses 15(60%) showed that PTs belief that there is no difference between scientific and everyday argumentation *as both intend to reach at a common point or at a conclusion*. This serves to illustrate that more than half of the participating pre-service teachers were not aware of the unique form of scientific argumentation.

The rest of the responses 10(40%) indicated that pre-service teachers seem to be aware of the differences between scientific argumentation and everyday argumentation. However, there were sufficient evidences to show that they had misconceptions of the two forms of argumentation. The following excerpts derived from the questionnaire responses of some of the pre-service teachers are representative:

For example, PT16, a 23 year male pre-service teacher responded by stating that:

> *In Everyday argumentation arguers argue on the basis of their experience; whereas in scientific argumentation the arguers or debaters elaborate their view based on scientific knowledge*

A pre-service teacher (PT13) with 11 years teaching experience in elementary schools noted that:

> *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 into consensus; whereas in scientific argumentation arguers never disagree because they all provide reasons with reference to scientific theories which are absolute.*

At this stage, the views expressed by PT16 and PT13 are contrary to the views of Venville and Dawson (2010) who contend that "while the term argument, in an everyday sense, may conjure up images of people in conflicting and angry dialog, within the context of socio-scientific issues, argument may be used to reason about challenging and multi-layered problems", (p. 954). Additionally, PT10's view is in sharp contrast with the view of Cavagnetto (2010) and Tolumin, Ricke and Janik (1984) who have shown that scientific argumentation can be competitive (when two scientists advocate their ideas) as well as collaborative.

However, after the intervention, an overwhelming majority of the responses 20 (80%) showed that the pre-service teachers made a clear distinction between the two forms of argument. For instance, slightly more than half of the responses 14 (56%) indicated that in everyday argumentation conclusions are not validated by legitimate reasons; whereas in scientific argumentation arguers attempt to construct and validate a conclusion on the basis of multiple evidences. Six (24%) of the responses emphasise on the role of evidence in justifying a conclusion. It seems that the majority of the pre-service teachers abandoned their previous belief and showed a more informed view about the notion of scientific argumentation and its unique form. At this stage their views concur with many science educators (e.g., Driver et al., 2000; Norris, Philips, & Osborne, 2007; Venville & Dawson, 2010) who posited that scientific argumentation is an attempt to establish or validate a conclusion on the basis of one or more reasons. This was concisely articulated by PT13 who stated that:

> *Before the intervention I was aware that scientific argumentation is different from everyday argumentation. However, I had misconceptions between the two forms of argumentation… After the intervention, I was able to realize that in everyday argumentation most arguers are emotional and defensive and often don't attempt to provide reasons to back up or validate their claims whereas; in scientific argumentation arguers attempt to provide evidence to construct and validate their claim using plausible evidence. I also came to learn that scientific argumentation has a unique structure.*

Like PT13, the view a PT16 on the reflective response diary on this item revealed that the intervention programme helped him to realize the difference between the two forms of argumentation and to describe scientific argumentation more clearly than was the case before.

> *Initially, I was aware that the two forms of argumentation are not the same. Yet, I had vague conceptions 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 inquires arguers to generate adequate explanations and validate them using appropriate evidence and reasoning. As the study progresses I was able to master the unique forms of scientific argumentation and practiced it with my students in my class. (PT16)*

This implies that after their involvement in the intervention training programme an overwhelming majority of the pre-service teachers became more knowledgeable about scientific argumentation. In terms of CAT new concepts emerged and were gradually assimilated as there was no well-formed prior knowledge or understanding of the concepts, in this case scientific argumentation. This findings corroborates with the findings of Cross, Taasoobshirazi, Hendricks, and Hickey (2008) who have proven that engaging students in argumentation results in more secure understanding of pre-existing concepts, exposes them to new ideas, helps them to extend their prior knowledge, and possibly eliminate their misconceptions. However, five pre-service teachers expressed views, at the post-test level, which suggests that they still had limited understanding of scientific argumentation. PT2's statement succinctly articulates this.

> *There is no difference between every day and scientific argumentation. In both forms the arguers attempt to reach a consensus*.

While the foregoing responses emanating from the PTs, to some extent, show some emergent valid views about argumentation, they seem to present a rosy picture of scientific argumentation they do not present an accurate situation of things. The extant literature shows on the contrary that argumentation discourses whether in common day-to-day conversation or scientific context range in tempo from the pleasant to unpleasant and sometimes nasty dialogues. Popper (1968) describes the scientific enterprise as a body of conjectures and refutations. Ziman (2000) goes further by stating that:

> The notion that academic scientists have to be *humble* and disinterested seem to contradict all our impressions of the research world. Scientists are usually passionate advocates of their own ideas, and often extremely vain…Peer review keeps the official scientific literature reasonably honest and factually reliable. It favours precise, thorough and cogent argumentation and sets high benchmarks for technical performance. But it does not pretend to eliminate error, nor does it guarantee certainty or truth. On the contrary, it is often the occasion of fierce disputes that illustrate graphically the uncertainties, arbitrary assumptions and half-truths of scientific knowledge. In the *social* system of academic science, this is where the *intellectual* action is-and *vice versa*. (pp. 38 & 43)

The role of argumentation in science education and science teaching

When the pre-service teachers (PTs) were asked whether or not scientific argumentation has any role to play in science education all of them indicated that they were not aware of such a role before participating in the study. The two major reasons given for their lack of awareness were that: (1) science tells us the truth about the world, which implies that there was no need to argue or negotiate to find out the truth; and (2) scientific knowledge is constructed by the well-established and logically sound inductive and deductive forms of reasoning.

A 29 year male pre-service teacher with nine years teaching experience stated that:

> *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 at pre-test).*
>
> *After the intervnetion, I realized that argumetnation played a great role in science teaching and science education. It has a potential in knowledge builidng and in promoting understanding of scietific concepts. It is also a useful mechanism in devloping communciation skill of studetns (PT21 at post-test).*

A 22 year female pre-service teacher with no teaching experience expressed a similar view to PT21 by asserting that:

> *Argumentation is not applicable in science because scientific knowledge is constructed by inductive and deductive process not by discussion (PT12 at pre-test).*
>
> *Argumentaion has a vital role in science education and science teaching. It supports students in scientific knowedge construction at all levles (PT12 at post-test).*

When asked to further narrate their understanding of the role of argumentation in science teaching and science education before and after the intervention at the reflective response questionnaire/interview PT12 said:

> *Initially, I thought that argumentation could play a great role in social science areas, such as in philosophy or related courses. The ancient philosophers such as Socrates and Plot who were primarily interested in the study of thinking made use of argumentation to impart and advocate their philosophical perspectives to the world. Even at present Philosophers and politicians make use of argumentation to advocate and persuade their views. But 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. My awareness in this regard was further developed when I began to use argumentation instruction in my class during the teaching practice period.*

From the forgoing, the result of the pre-test seems to be consistent with the findings of a recent study (Xie & Mui SO, 2012) which shows that most of the participating pre-service science teachers had never heard of the word argumentation in the area of science education and were unaware of the role of argumentation in science education. It is worthy of note to indicate that PT21 had possibly taught science as a subject that tells us the truth about the world for nine years. Similar responses were also given by other pre-service teachers who had teaching experiences before participating in the study. Their responses could probably be influenced by the way they have been trained in the teacher education programme. It seems clear that training and support is an integral part of eliciting change in people's conceptions, attitudes, values and practices (Ball & Cohen, 1999; Wilson & Berne, 1999).

In contrast, it seems that majority of the participating pre-service teachers made a noticeable perceptual shift from their initial stances at the pre-test, where they considered that argumentation has no role to play in science education/teaching to their post-test stance where they reached to a state of acknowledging the benefits of argumentation in science teaching and in science education. This is indicated more explicitly in PT21's and PT12's pre-post-test responses. This finding seems to be consistent with the results of previous studies that show the potential of argumentation in knowledge building and in enhancing students' and teachers' conceptual understanding of scientific concepts (Clark & Sampson, 2007; Driver et al., 2000; Erduran, et al., 2004; Jimenez-Aleixandre & Erduran; 2008, Lawson, 2002; Leitao, 2000; Osborne, et al., 2004; Simon & Maloney, 2006; Venville & Dawson, 2010; Zohar & Nemet, 2002). The role of argumentation has also being regarded by many other science educators as central in scientific practice and in scientists' work (see Brick & Bell, 2008; Driver et al., 2000; Kuhn, 1993). That is why McNeill and Pimentel (2010) asserted that argumentation is an essential goal of science education.

Also, after the intervention, these group of pre-service teachers seem to accept the tentative nature of science as opposed to their previous belief that tells the absoulte truth about nature (e.g. Abd-El Khalick, 2004; Lederman, 1992; Ogunniyi, 1988, 2004, 2007a & b; Schwab, 1962). A very good example of this observation is noted in the reflective response diary of PT12, here presented:

> *It was only after the intervnetion that I became aware that science is concerned with a probabilistic truth….I no longer believe in absoulte truth because things do change and we have proof that things change. I think the provision of evidence results in the production of scientific knolwedge but not always absoulte truth (PT12).*

The shift in PT12's view from perceiving science as a discipline that tells us the truth about the world at the pre-test, to that of construing science as being concerned with probabilistic truth is evident in her response during the post-test. At the post-test, she had begun to realize that scientific concepts and principles are by no means permanent but could change as more knowledge accrues about a given phenomenon. This is important for these PTS because it is likely to influence the way they present science in their classrooms. Her view at the post-test corroborates the views of many science educators working in the area of the nature of science (NOS) (e.g. Abd-El-khalick, 2004 & 2005, Abd-El-khalick & Lederman, 2000; Ogunniyi, 2004). In terms of CAT category it could be said that her pre-test positivist view of NOS has become suppressed while social constructivist view has become more dominant at the post-test. However, it is worthy of note to indicate that seven 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:

> *PT23: 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 (Post-test).

PT23 perceived the goals of teaching and learning science in the light of positivist's view. As indicated earlier, positivists view science as a school subject that emphasizes on factual recall of information with confirmatory experiments (Driver et al., 2000).

Techniques and resources that are required to support argumentation and keep argumentation going in science classrooms

When the PTs were solicited to go further and consider the techniques and resources required to support argumentation and keep argumentation going in science classroom, they suggested various skills and techniques required to keep argumentation going in science classroom. The provision of open-ended tasks received the highest percentage (39%) of responses. Guiding and initiating discussion as well as promoting social interaction were also very frequently mentioned (33% and 28% respectively). This suggests that the PTs had preliminary knowledge about the skills and techniques required to facilitate argumentation or any other teaching strategy categorized under a learner-centred approach. Their views at the pre-test reinforce the views of Osborne et al. (2004) who assert that open-ended questions have been regarded as crucial to the initiation of argumentation in science classrooms. This is evidenced in the fact that majority of the pre-service teachers indicated that providing open-ended tasks could facilitate argumentation. The implication of this finding is that the pre-service teachers had some knowledge and skills on how to facilitate argumentation before they were exposed to the intervention programme. The "General Methods of Teaching" course, offered to all education students could probably be the source of such skills. Yet the specific advanced skills and techniques necessary to sustain argumentation and keep argumentation going in an argument-based lesson did not merge in their responses.

After the intervention, 93% of the responses seem to show that an overwhelming majority of the pre-service teachers who lacked sufficient cognitive knowledge and pedagogical skills have exhibited considerable improvements. Almost all of the participating pre-service teachers were able to mention and describe some of the specific skills (e.g., establishing the norms of argumentation, playing devils advocacy, posing argumentation prompt question) required to keep argument going. They also indicated some of the frameworks and strategies necessary to keep argument going. Among others, pre-service teachers considered classification activity, computing theory, concept cartoon, predict observe explain, as essential strategies to support and sustain argumentation. The following excerpts were derived from the questionnaire response of some of the pre-service teachers as representative. A 21 year female pre-service teacher (PT6) stated that:

> *I think providing open-ended task to students is essential as it probes students understanding of certain scientific concepts which are abstract for most students. (PT6 at pre-test)*
>
> *Playing devils advocacy, posing argumentation prompt question are necessary skills to stimulate further justification of argument and keep argument going. Computing theories and concept cartoons are also frameworks that are used to support and sustain argumentation. These frameworks provide alternative theories and ask students to choose one of the two theories and justify their choice using evidence (PT6 at post-test)*

Her view at the reflective response questionnaire on this item was that:

> *Before the intervention I had limited knowledge and skills on how to engage students in a discussion. The intervention equipped me with the necessary skills and strategies that will enable me to sustain and keep argumentation going in science lessons. The intervention heightened my understanding on how establishing the norms of argumentation, posing argument prompt and playing devils advocacy promotes the process of argumentation in science lessons. I now feel confident to establish the norms of argumentation in my classes by highlighting the significance of why it is important to provide justification for our knowledge claim. I have also used argument promote questions to encourage students to take position and to justify it using evidence.*

From the above excerpts, it is evident that PT12 not only became knowledgeable about the strategies required to support and sustain argumentation discourse after the intervention, but also attempted to employ certain skills that support argumentation in her classroom.

A 38 year male pre-service teacher (PT13) with 11 years of teaching experience at elementary schools responded that:

> *I have been teaching science in elementary school for 11 years. Although the MOE instructed us to implement learner-centred approach, in most case my teaching was dominated by teacher-centred approach. In recent years I tried to engage my students in a discussion by providing them group tasks. Nonetheless, my emphasis was not to promote students' conceptual understanding of scientific concepts; rather it was to help them get the right answer. I can confidently say that the intervention programme opened my eyes to realize that there are different skills and techniques that can be used to engage students in reasoned argument…. In my teaching practice period I attempted to enhance scientific argumentation by posing argument promotes such as: what is your evidence? Why do think that? Can you think of another argument for your view? I have also played devil's advocate to help students stimulate further*

justification. I feel that such intervention programmes should be given to all science teachers.

According to the CAT, these pre-service teachers have developed an emergent view having been exposed and having developed new pedagogical knowledge and skills on argumentation of which they had no prior experience.

Very few pre-service teachers (7%) seemed not to have adequate knowledge about the skills and strategies required to support and promote argumentation after the intervention. This is articulated in the following excerpt:

In my view the skills that are required to facilitate argumentation are: posing questions in the first five minutes of the day's lesson to initiate discussion, providing an overview of the lesson and finally rounding off the lesson by asking other set of questions (PT5 at post-test).

Pre-service teachers' views on how to evaluate the quality of written and spoken argument

Pre-service teachers were also asked to express their view on how they would evaluate the quality of written argument constructed during the group discussion. Initially, 18(62%) of the responses showed that pre-service teachers would focus on the appropriateness of the final answer, including its organization and eight (28%) of the responses indicated that pre-service teachers would evaluate the quality of arguments with reference to their own views. Only three (10%) of the responses showed that they have no idea on how to evaluate the quality of argument.

At the end of the intervention programme, however, a good number of responses seemed to indicate that pre-service teachers have a reasonably good understanding about the specific analytical tools that are used to evaluate the quality of arguments. While 22(58%) of the responses showed that pre-service teachers would evaluate the quality of argument by examining the overall structure of the argument, 11(29%) of the responses indicated that pre-service teachers would focus on presence or absence of rebuttals as an indicator to quality argument. The remaining responses five (13%) showed that few pre-service teachers were yet to be familiar with the strategies and techniques required to evaluate the quality of arguments even after their exposure to the intervention programme.

The following excerpts show the responses of some pre-service teachers. A 35 year male pre-service teacher with 11 years teaching experience stated that:

I would consider those ideas which are related with my opinion, but if it is different from my suggestions I reject it or I consider it as low-level argumentation (PT9 at pre-test).

I would identify the components of TAP (claim, ground and rebuttal) included in students' arguments and evaluate the quality of arguments using the levels of TAP's arguments modified after Erduran et al. (2004) (PT9 at post-test).

A 23 year female pre-service teacher with no teaching experience said:

I would check whether the final answer is correct or not as the ultimate goal of learning is to equip students with appropriate new knowledge and skills. I would also consider the organization of the argument (PT18 at pre-test).

I would use two steps to evaluate the quality of students' argument. In the first place I would determine the structure of arguments constructed during small group discussion using TAP model. Then after I would examine the presence or absence of rebuttals in the structure of the argument as it is an indicator to quality argument. (PT18 at post-test).

PT18 narrated the effect of the intervention on her understanding and ability to evaluate the quality of argument on the reflective response questionnaire/interview, as shown below:

Initially, I thought that I could use the general criteria that are recommended to assess the quality of an essay with the understanding that writing an essay and constructing an argument are the same. The criteria which I consider them essential were: appropriateness of the final answer, whether the argument has introduction, body/content and conclusion, and finally whether the argument is well organized. During the intervention I have learnt that there are specific tools for assessing the quality of arguments. My understanding was further developed during the reflective sessions and I was able to realize 'what makes a good argument'…. Overtime, I developed confidence to adapt the elements of TAP and levels of arguments to assess the quality of students' arguments during the teaching practice period.

From the forgoing, it is evident that before the intervention both PT9 and PT18 were not familiar with the methodological tools that are used to evaluate the quality of arguments.

At this stage the researcher did not expect the pre-service teachers to indicate analytical tools that are used to evaluate the quality of arguments because these tools were not included in any of the courses they have been exposed before. Yet the researcher expected the participating pre-service teachers to indicate the presence of absence of logic, reason or justification as a criterion to assess the quality of argumentation. A critical glance at the data exposed two important points: (a) pre-service teachers seemed to give more value to the appropriateness of the final answer rather than the quality of the arguments constructed; and (b) pre-service teachers seemed to perceive that teachers' views should not be questioned or have to be accepted and respected by the virtue of the fact that they presumably possess a better understanding of the subject matter than their students. Such a view could probably be attributed to the nature of education system of the country in general and the teacher education programs in particular. That is why Zohar (2008) argues that to implement argumentation in science classrooms, science teachers need to experience a fundamental shift in their pedagogical understanding and practice.

After the intervention, however, both PT9 and PT18 made a significant perceptual shift from their initial stances. At this stage, PT9 and PT18 seemed to give more credit to the quality of the arguments constructed rather than to the appropriateness of the final answer.

The findings show that the intervention programme enhanced the pre-service teachers' understanding on how to evaluate the quality of arguments. Yet, it is important to note that the intervention did not bring significant learning gain for a very few PTs (13%). This is succinctly indicated in the excerpt below.

> *I would evaluate the quality of arguments by considering the degree of correctness of students' final answer or response (PT2)*

Section summary

An analysis of the pre-service teachers' pre-post conceptions of argumentation has shown that the participating pre-service teachers' understanding of argumentation improved considerably as a result of their exposure to the argumentation-based instructional model and reflective workshop sessions. The following is a summary of the subsequent growth made by the pre-service teachers in terms of their understanding of argumentation before and after the intervention programme.

By the end of the intervention programme, an overwhelming majority of the pre-service teachers had a reasonably good understanding of argumentation. They seem to have shifted from seeing argumentation as a debate to win a case to that of a process where people dialogue and negotiate to reach a mutually acceptable conclusion. The majority of the pre-service teachers seemed to realize the difference between scientific and everyday argumentation. The percentage of responses which claimed that there is no difference between scientific and everyday argumentation dropped from 15 (60%) at the pre-test to five (20%) post-test. Similarly, the percentage of PTs responses asserting that argumentation has no role in science education dropped drastically from 25 (100%) at the pre-test to seven

(16%) at the post-test. This is an indication that the majority of the pre-service teachers have accepted the central role of argumentation in science education.

A shift in the perceptions of the pre-service teachers about the conception of scientific argumentation and its centrality in science education as an instance of belief revision (Leitao, 2000) accords CAT's notion of an emergent cognitive state (Ogunniyi, 2007a & b; Ogunniyi & Hewson, 2008). There is also sufficient evidence that at the end of the intervention period virtually all participating pre-service teachers seemed to have acquired the necessary skills and strategies on how to support and sustain argumentation in their classrooms. In addition, the majority of the pre-service teachers seemed to understand that there are specific methodological/analytical tools that are used to assess the quality of argumentation discourses after the intervention. Further study is required to examine the pre-service teachers' pre-post conceptions of argumentation to see whether the pre-service teachers' gender, age and teaching experience differences had any visible effect on their understanding of argumentation.

4.3 Pre-service teachers' construction of an argument

In this section three scenarios regarded as everyday argumentation, socio-scientific argumentation and scientific argumentation given to the PTs as tasks, are presented. The claim given in each task will henceforth be referred to as the task-claim one, two or three for the three tasks respectively, (see Appendix C). These tasks were used to examine PTs' argumentation skills at individual level (intra-argument), group level (inter-argument) and whole class level (trans-argument). Individuals PT's written arguments and transcribed small and whole group's arguments were analysed using levels of arguments modified after Erduran et al. (2004) (see Table 2.2). According to this analytical framework:

Level 1 argument comprises of a claim or an unjustified counter-claim versus counterclaim with no grounds or rebuttals.

Level 2 argument comprises of claims or counterclaims with grounds but no rebuttals.

Level 3 argument comprises of claims or counterclaims with grounds but only a single rebuttal challenging the claim.

Level 4 argument comprises of multiple rebuttals challenging the claim but no rebuttal challenging the grounds.

Level 5 argument comprises of multiple rebuttals and at least one rebuttal challenging the grounds.

Level 6 argument comprises of multiple rebuttals challenging the claim and/or grounds.

The classification of the PTs levels of argument were done by the researcher and a senior science educator independently (see Table 3.1 in section 3.11).

4.3.1 Every day argumentation scenario: Task One

Task One (everyday argumentation) took place during the second week of the intervention programme, after PTs were introduced to the concept of argumentation. At this time, the structure (Toulmin, 1958) and levels of argumentation (Osborne et al., 2004) were not yet clarified. This task was aimed at introducing the concept of, "evidence" to the pre-service teachers as it is an essential component of an argument (Tolumin, 1958).They were confronted with the controversial subject of using corporal punishment to attain discipline. They were confronted with the question: "Is punishment an appropriate mechanism to control students' behaviour in a school setting?" The PTs were asked first to individually write down the kind of reasoned argument that they have used to support or refute the claim and then discuss it in small groups.

i) Individual argumentation

The individual argumentation exercise outlined below (Tables 4.4 and 4.5) is presented in this section, highlighting their levels of argument. Individual pre-service teacher's written arguments within groups A and C respectively are designated as male (M) or female (F), PT1, PT2 and so on.

Table 4.4: Group A's individual written argument

PT's identity	Claims	Evidence	Warrants	Rebuttal	Comment
*PT3(M) **(Leader)**	I am against it. Punishment cannot control the discipline of students in a school setting	Because punishment has negative consequences	..if punished students may not be productive citizens'	-	Claim supported with evidence and warrant
PT1(M)	I am against it. Punishment is not an appropriate mechanism to control the discipline of students	Because punishment has adverse consequences	It may cause mental, social and physical impact'	-	Claim supported with evidence and warrant
PT5 (F)	I am against it. It is not an appropriate means to control the discipline of students			-	Claim not supported with evidence
PT6 (F)	I am against it. It is not a proper strategy to control the discipline of students in a school setting	Because it increases dropout rate of students	, Because it reduces students interest		Claim supported with evidence and warrant
*PT23 (M)	I am against it. Punishment is not an appropriate mechanism to control the discipline of students in a school setting		--		Claim not supported with evidence
PT18(F)	I am against it. Punishment is not an appropriate mechanism to control the discipline of students	Because punishment create psychological problem,	psychological problem could also causes low self-esteem, low confidence,		Claim supported with evidence and warrant

*PTs who had teaching experience before

Table 4.5: Group C's individual written argument

PT's identity	Claims	Evidence	Warrants	Rebuttals	Comment
* PT13(M): Leader	I am for it. Punishment is an appropriate mechanism to control the discipline of students in a school setting	Punishment is used to decrease the occurrence of behaviour that is undesirable".	So it maintains school discipline		Claim supported with evidence and warrant
PT2(M)	I am for it. Punishment is an appropriate mechanism to control the discipline of students in a school setting	it reduce the number of misbehaved students	This will make the school an exemplary school in terms of discipline.		Claim supported with evidence and warrant
PT12(F)	I am for it. It is a proper strategy to control the discipline of students in a school setting	Because it corrects misbehaving students. What is inapposite is physical punishment	this will make the school environment more appealing to teachers and learners		Claim supported with evidence and warrant
PT19 (F)	I am against it. It is not an appropriate means to control the discipline of students in a school setting	Students will develop negative attitude towards the punisher, the subject matter and even to the school compound.	Consequently, students will withdraw from school.		Claim supported with evidence and warrant
PT16(M)	I am strongly against it. Punishment is not an effective means	Because punishment create psychological problem	The psychological problem in turn could also cause low self-esteem, low confidence,	Punishment may correct bad behaviour under specific condition, It cannot helps students to develop good behaviour, thus it is not an effective means	Claim with rebuttal
***PT9 (M)**	I am against it. Punishment is not an appropriate mechanism to control the discipline of students in a school setting	Because punishment has negative consequences	punishment increases dropout rate of students,		Claim supported with evidence and warrant

*PTs who had teaching experience before

In terms of TAP, Tables 4.4 and 4.5 shows that all the 12 PTs seem to take a stance about the issue of using punishment to achieve classroom control. Of the 12 PTs, four pre-service teachers from Group A and all the six from Group C were able to offer evidence or reason for their claim and connect their claim with evidence (warrant) although, some of the evidences were not well linked with the claim made. Yet, none of them provided multiple reasons. The arguments generated by the 10 pre-service teachers from both groups are level 2 arguments. The other two pre-service teachers from group A were not able to support their claim with evidence or reason; hence, these arguments are level 1. On the other hand, of the six pre-service teachers from group C, one pre-service teacher (PT16) was able to use rebuttals to a certain extent to nullify certain claims; therefore his argument is classified as level 3.

ii) Group argumentation

The 25 PTs involved in the study were grouped into four groups each consisting of six –seven members. However space limitation would not allow me to present the findings of all four groups. Therefore, the argumentative discourses in only two namely, A and C was presented in this report:

(a) The critical analysis of the transcribed small group verbatim discussions reveals that while all the members of Groups A, B, and D held the same stance in their respective groups, Group C members differed in their stances in all the three tasks.

(b) Among groups A, B and D, Group A was chosen because of the rich argumentation skills displayed by majority of the individual members within the group. The sub-section below reports on the arguments presented by individual pre-service teacher's during their (Groups A and C) small group arguments and whole class argument.

This section reports on the discussion within groups A and C for task 1 (see Appendix J, episodes 1 and 2). These episodes are the contributions made by individual members within the specified groups.

It was found that Group A came to a consensus about their position against the claim, which is "punishment is an appropriate mechanism to control the discipline of students in a school setting". They provided multiple reasons to support their stance. After the discussions, the group generated the argument that, "*punishment cannot ensure school discipline at all. It is better to use another mechanism such as negative reinforcement to develop good behaviour and thereby, maintain students' discipline".* This level of argumentation shows that the group attempted to back up their argument with a weak rebuttal; probably because they anticipated oppositions from their opponents. Yet there were no explicit oppositions in the discourse with a clearly identifiable rebuttal. The group's interaction (see episode 1) is categorized as level three, because a series of claims or counter-claims with warrants, and occasional weak rebuttals were presented.

Looking at episode 2 it was discovered that several claims and counter-claims were constructed with evidence and warrant. Towards the end of the discussion one of the members (PT16) generated a rebuttal against the task-claim, "*punishment is not an effective means to control school discipline*" noting that *"although punishment may correct bad behaviour under specific condition it cannot helps students to develop good behaviour. Thus punishment is not an effective means to maintain school discipline".* Group C's argument (see Appendix J, Episode 2) is a typical example of a level 4 argument, because it was backed with a claim and identifiable rebuttal.

It is notable that, the level of discussion in the groups, shows that some pre-service teachers have improved their argumentation skills as a result of their engagement in the group discussion. This is evident in PT23's (Group A) contribution. At individual level, he did not offer evidence or reason for his claim. During small group discussions (see Appendix J, episode 1), PT23 supported his claim with evidence. He moved from level 1, to level 2. In contrast, few of the PTs struggled to actively participate in the group discussion. For instance, (PT5F) and (PT2M) were unable to provide additional evidence or elaborate on what others said. Instead, they simply agreed with other members' contributions. They made statements like, "well, you are right"; "Yes, yes …." (Appendix J, episode 1), Emm… (Appendix J, episode 2). The possible reasons could be that, (a) they might be dominated by some group members who had a better argumentation skill, (b) they felt scared by the arguments articulated by their discussion partners or they felt shy to express their view or lack the basic skills of argumentation.

In addition, some pre-service teachers ignored the arguments of their opponents. For example, PT12 (F) was confronted with her opponent's statement, "I have tried punishment for several years with my students but it didn't work out ….". She ignored her peer's concept that, "punishment did not work out"; but, she responded with her own opinion saying, "I am also against corporal punishment because it may create physical damage or injury. This contribution is one that leaves the opponent's argument intact, but tenders a personal opinion (see Appendix J, episode 2).

iii) Whole class argumentation

During whole class discussion, group leaders presented their group's argument to the whole class. In all the four groups arguments and counter arguments were made. I used some prompt questions to scaffold the discussion during the group presentations, thereby playing the devils advocacy to elicit more quality arguments. This is because the focus here is to identify whether the PTs have developed to a stage in which they can present rebuttals, counterclaims against one another's' claims or evidences. It was found that the groups successfully generated extended arguments with more than one rebuttal. More arguments classified at level 4 or 5 were identified (Appendix J, episode 3).

4.3.2 Socio-scientific argumentation scenario: Task two

During the third week of the intervention programme, after pre-service teachers have become familiar with TAP (Toulmin, 1958), a second task was presented to them using a socio-scientific scenario. The PTs had to discuss the task-claim 2, which was, "Do you believe that plastic bags should be banned in your community?" **(adapted from** http://www.en.wikipedia.org/wiki/Phase_out_of_lightweight_plastic_bags) (for details see Appendix C). The purpose of task 2 was to expose the pre-service teachers to a situation where they construct stronger arguments using all the elements of TAP, including rebuttals. PTs were expected first to construct individual written arguments in support of their position. Then the same process as before was followed, where they carry out group argumentation and then whole class argumentation. Just as in task one the quality of arguments constructed during whole class discussions was assessed.

i) Individual argumentation

Individual PT's (in groups A and C) written constructions of arguments to support or refute the task claim two, "the *use of plastics bags should be banned'* are presented in Tables 4.6 and 4.7.

Table 4.6: Group A's individual written argument

PT's identity	Claims	Evidence	Warrants	Rebuttal	Comment
*PT3(M) **(Leader)**	Plastics bags should be prohibited	-plastics make our environment dirty -if eaten by animals it may poison them	Because they are made up of harmful chemicals	-	Claim supported with evidence and warrant
PT1(M)	I support the prohibition of the use of plastic bags	because they pollute our environment dirty.	This will have a negative effect on our health	-	Claim supported with evidence and warrant
PT5 (F)	Plastics bags should be prohibited	because they make our environment dirty.	So the best way to keep our environment clean is just by banning plastic bags in our community	-	Claim supported with evidence and warrant
PT6 (F)	Plastic bags should be banned from our community	because they are harmful to the live of humans and animals	-	Plastic bags are not the only means to carry our staff. Instead we can use paper bags or baskets	Claim with rebuttal
*PT23 (M)	Plastic bags should be banned from our community	Plastic bags are too destructive in humans and animals health			Claim supported with evidence, evidence not linked with claim
PT18(F)	Plastics bags should be prohibited from our community	People throw Plastic bags everywhere because they are very thin, short lived and also cheap	Consequently, plastics pollute the environment, if eaten by animals they will kill them		Claim supported with evidence and warrant

*PTs who had teaching experience before

Table 4.7: Group C's individual written argument

PT's identity	Claims	Evidence	Warrants	Rebuttals	Comments
PT13(M): Leader*	Plastic bags should be banned from our community	Many people do not have the experience to reuse plastic bags instead they throw them after use. This makes the environment dirty	If our environment is not clean it will affect our health greatly		Claim supported with evidence and warrant
PT2(M)	Plastic bags should be banned from our community	Plastics bags pollute our environment	Because plastics bags are made up harmful chemicals		Claim supported with evidence and warrant
PT12(F)	Plastic bags should not be banned from our community	Plastics bags are beneficial. We can make our environment clean by collecting the bags and by reusing them or recycling them Plastic bags are not the only staff which make the environment dirty	They are easy to handle and are more comfortable to carry our staff. What is required is to raise the consciousness of the community on how to use plastics	Plastics do pollute our environment if they are not used carefully. If we raise the awareness of people on how to use them, We can use plastics for our-day to day activity without polluting and making our environment dirty.	Claim with rebuttal
PT19 (F)	Plastic bags should be banned from our community	Many people throw plastic bags after use because they are cheap. So if animals eat plastics either they die or had digestive problems	Because plastic bags don't decompose easily		Claim supported with evidence and warrant
PT16(M)	Plastic bags should not be banned from our community	Plastic bags are useful in our day-to-day life They are easy and manageable to carry staff	It is only when plastics are not used properly that can cause pollution or affect the lives of human and animals.	plastics bags would rather serve us to collect waste material	Claim with rebuttal
*PT9 (M)	Plastic bags should not be banned from our community	plastic bags are easy to handle and are more comfortable to carry our staff.			Claim supported with evidence, evidence not linked with claim

*PTs who had teaching experience before

All the members of groups A and C (12PTs) support their claim with evidence and connect the evidence with the claim (warrant). Nine pre-service teachers from both groups produced level two arguments. However, only three PTs, PT6F (a group A member), PT12 and PT16 (Group C members) were able to generate rebuttals. These three provided not only evidence for their claims but also rebuttals to refute anticipated oppositions from their peers. Therefore the three pre-service teachers have gained ability to provide level 3 or 4 arguments. Looking at the data displayed in Tables 4.4, 4.5, 4.6 and 4.7 it was found that the individual pre-service teachers' in Groups A and B constructed better arguments in task two than in task one. What can be deduced from this analysis is that the pre-service teachers in both the groups (Group A and C) seem to develop their argumentation skills as the study progresses. For example PT5F and PT23M (Group A member) have made progress from simply stating knowledge claim without any evidence, to stating knowledge claims with evidence. Similarly, PT6 (Group A member) and PT12 (Group C member) have progressed from stating claim with some form of "evidence", without any rebuttal, to stating claims with evidence followed by some rebuttals. This finding corroborates Kuhn's (2010) view when he argued that argumentation, like conceptual knowledge, has its own progressions. Nonetheless, it is important to note that although majority of the pre-service teachers attempted to link the evidence with the claim using warrant, there were some pre-service teachers, such as PT23M (a Group A member) and PT9 (a Group C member) who encountered difficulty in explaining the relationship between the evidence to the claim made (warrant).

ii) Group argumentation

This section presents, the analysis and discussion of the level of arguments constructed within groups A and C for task 2 (see Appendix J, episodes 4 and 5). It was discovered that groups A and B provided grounds for all their claims. Later, they provided not only evidences to support their claims but also used rebuttals to a certain extent to nullify certain claims. This is an indication of the ability to construct high level arguments (Erduran et al., 2004). The arguments generated by both the groups are categorized as level 4. Findings emerging from the analysis of Tables 4.6 and 4.7 and episodes 4 and 5 (task two) corroborate with the findings obtained from task one (see Table 4.4 and 4.5 and episodes 1 and 2). The findings attest that group arguments were relatively stronger than the individual argument as provision of multiple reasons surfaced more during the discussion.

A close examination of group C argumentation reveals that there was a lot of disagreement or controversy amongst the PTs within the group. For instance, opposing the claim "plastic bags have to be banned from our community", PT16 argued saying, "*I don't agree. Plastic bags are useful in our day-to-day life. It is only when plastics are not used properly that can cause pollution or affect the lives of human and animals".* He was then confronted with opponent's counterargument that: "*I don't understand why you are defensive. Plastic bags are not the only means to carry our staff. Instead we can use paper bags or baskets"* However, towards the end of the discussion two of the PTs, (PT12 and PT16) seemed to have had an influence on the final group's position and arguments by throwing the following counter-arguments*: "plastics would rather serve us to collect waste material*" and "*what is needed is to raise the awareness of people on how to use plastic bags".* This implies that some members of Group C have changed their earlier position or knowledge claims and accepted new ideas when they were confronted with persuasive evidence, or evidence which they found to be more rational than their own (Leitao, 2000, p. 342) The following statements are excellent examples: *"If we use plastics properly we can use them in our daily life"(PT13); "Yes, we only need to know how to use them for our benefit" (PT2).*

iii) Whole class argumentation

Just as in task 1, the group leaders presented their group's argument to the whole class. Prompt questions and devils advocacy were employed to facilitate the whole class discussion. The four groups constructed arguments and counterarguments at each other. For example:

> *"Many people do not have the experience to reuse plastic bags instead they throw them after use. This will pollute our environment and will make it dirty. If animals eat plastics either they die or had digestive problems because Plastic bags don't decompose easily"* was met with *"Plastic bags are useful in our day-to-day life. It is only when plastics are not used properly that can cause pollution or affect the lives of human and animals"; " Plastic bags are not the only means to carry our staff. Instead we can use paper bags or baskets"* was met *with "plastic bags are easy to handle and are more comfortable to carry our staff"; "plastics would rather serve us to collect waste material. What is required to raise the awareness of people on how to use plastic bags"* was met with *"Developing awareness of community members will take time. The easiest and simplest is to restrict plastic bags and use alternative means such as paper bag"*

The major observations made during the whole class discussion/debate are as follows:

- Whole class discussion was the contribution of the individual group's arguments.
- New knowledge or argument was not generated during the whole class discussion as the groups repeated the same arguments which were expressed during the small

group discussion

- It seems that most of this group of pre-service teachers were able to supply counter-arguments or alternative arguments with rebuttals to weaken the opponent's arguments. According to Erduran et al. (2004), this group of pre-service teachers demonstrate a high level of capability with argumentation, which to the authors, rebuttals are essential elements of better quality arguments. This finding is consistent with earlier studies (Felton & Kuhn, 2001; Felton, 2004) who examined adults' developmental level of argumentation skills. In their studies they found that adult demonstrated three major component skills - producing justifications, producing, and counter-arguments and rebutting.

- The majority of the pre-service teachers have reached a level of listening to each other's argument and directly attending to each other's argument. According to Kuhn (2010) at this stage, this group of pre-service teachers have reached a high level of argumentation. In addition, this group of pre-service teachers seemed to understand that in dialectical argumentation opposition between views are not necessarily between individuals" (Leitao, 2000, p. 342). This finding is one of the significant observations recorded in this research question.

4.3.3 Scientific argumentation scenario: Task three

Towards the end of the intervention programme the idea of 'written arguments' (Osborne et al., 2004, p. 4.5) was introduced to help pre-service teachers to be more thoughtful about articulating their claims and evidences and structure their arguments more effectively. Pre-service teachers were provided with scientific argumentation scenario to provide a context for pre-service teachers to construct a written argument using writing frames to support one side of the argument and counter the other side. This activity was aimed at preparing pre-service teachers to help their students write arguments in a similar manner in a classroom context. Their task was to read the statements constructed by Fred and Birt and, "decide which snowman (-one wearing a coat and another not wearing a coat) will melt first. This third task (scientific argumentation scenario) was adapted from IDEAS pack (Osborne et al., 2004) and took place after pre-service teachers were familiarized with Toulmin's Argument Pattern (Toulmin, 1958) and different writing frame formats that guided them to write a complete argument (Osborne et al., 2004). Pre-service teachers were asked first to individually write down their decision and then discuss it in pair and finally in small groups.

The sub-section below reports on the individual pre-service teacher's arguments, discussions of two groups (Groups A and C) which are representative of the discussions that took place and whole class discussion. As reported in sub-sections 4.3.1and 4.3.2, this sub-section will also highlight the effect of small and whole class discussion in constructing better arguments.

i) Individual argumentation

Individual PT's (in groups A and C) written constructions of arguments to support or refute task claim three, "Fred (wearing a coat) or Birt (not wearing a coat) will melt first" are summarized in Tables 4.8 and 4.9.

Table 4.8: Group A's individual written argument

PT's identity	Claims	Evidence	Warrants	Rebuttal	Comment
*PT3(M) **(Leader)**	Fred will melt first	Because he is exposed to heat energy. That is heat energy can heat him directly	because he is unprotected and the sun radiation can penetrate easily to Fred. This makes Fred to melt first		Claim supported with evidence and warrant
PT1(M)	I think Fred will melt first	Fred is directly exposed to heat energy because he is not covered	so the sun radiation can penetrate easily to Fred and will make him to melt first		Claim supported with evidence and warrant
PT5 (F)	I think Fred will melt first	Because Fred is not wearing a coat			Claim supported with evidence, evidence not linked with claim
PT6 (F)	Fred will melt first	Because Fred is not wearing a coat	So Fred is getting direct heat energy from the sun through convection and radiation while Birt gets heat energy by conduction. This makes Fred to melt first		Claim supported with evidence and warrant
*PT23 (M)	Fred will melt first	Radiation of the sun can penetrate directly to Fred because he is not protected.	This will make him to melt first. In contrast, Birt will take longer time to melt because he is wearing a coat		Claim supported with evidence and warrant
PT18(F)	Fred will melt first	Because Fred gets heat energy by convection and radiation	So Fred will melt first		Claim supported with evidence and warrant

*PTs who had teaching experience before; Pre-service teacher =PT

Table 4.9: Group C's individual written argument

PT's identity	Claims	Evidence	Warrants	Rebuttals	Comment
* PT13(M): Leader	Birt will melt first	Because the coat and the hat will trap all the heat	This makes the ice of Birt to melt fast.		Claim supported with evidence and warrant
PT2(M)	Fred will melt first	Fred is not wearing a coat and hat	Fred get direct heat energy from the sun and this reaction will make him to melt first		Claim supported with evidence and warrant
PT12(F)	Fred will melt first	Because he is getting direct heat energy from the sun through convection and radiation.	This will make him melt quicker		Claim supported with evidence and warrant
PT19 (F)	Birt will melt first	Birt's coat absorb heat energy from the sun and melts the ice quickly than the Fred without coat.[W].	So Birt will melt first		Claim supported with evidence and warrant
PT16(M)	Fred will melt first	Fred is not wearing a coat and a hut	Fred will get heat energy form the sun directly. In the case of Birt first the heat energy will fall into the coat and then transferred to Birt. Which slows down the melting process of ice	-	Claim supported with evidence and warrant
*PT9 (M)	I think Birt will melt first	Because Birt will get heat from the sun radiation and from the coat, while Fred will get heat only from the sun	This makes Birt to melt first.	-	Claim supported with evidence and warrant

*PTs who had teaching experience before Pre-service teacher =PT

The individual pre-service teacher's within groups A and C constructed claims and provided grounds in an attempt to support their claims with evidence and warrant. Some of these pre-service teachers had also attempted to a certain extent to back up their arguments by providing scientific explanations that shows how the warrant links the data to the claim. Nonetheless, unlike in the previous two tasks, in this task none of the pre-service teachers provided rebuttals anticipating opponents from others. The arguments generated by these PTs are at level 2 of TAP. The implication is that it seems that these pre-service teachers demonstrated lower level of argumentation in scientific scenarios compared with their daily and socio-scientific argumentation. I will allude to this later.

ii) Group argumentation

This section presents, the analysis and discussion of the level of arguments constructed within groups A and C for task 3 (see Appendix J, episodes 7 and 8). Both groups were able to construct complex arguments comprising almost all components of TAP, including rebuttal.

A critical glance of Appendix J of episode 7 showed that the members in group A held similar stances: “Fred will melt first”. They offered evidence to support their claim “*Fred is not wearing a coat and hat*” and provided warrant “ *So the radiation of the sun can penetrate directly to Fred and will make him to melt first*” to connected the evidence with the claim. The group supplied evidence “*Fred is getting direct heat energy from the sun through convection and radiation while Birt gets heat energy by conduction”.* To substantiate the claim they provided warrant “*this will make Fred to melt first”* supplied backing *“The coat and a hat that Birt is wearing will insulate him and will reduce the heat energy transfer* and rebuttal “*It is the reverse of human wearing a coat to stop heat escape from their bodies”.* The arguments generated by this group is categorized as level 4, which is an evidence of construction of high level arguments according to Erduran and her team (Erduran et al., 2004).

An examination of Appendix J of episode 8 revealed that there were a number of explicit opposition among the members of group C which is an indication that there were heated arguments among the members. This could be attributed to the fact that the members in Group C had different stances. Some of them argued that “Fred will melt first” and others argued otherwise: “*Birt will melt first*” and did not reach into consensus till the end of the discussion. For instance, the group who were in favour of: “Birt will melt first” provided evidence “*because Birt gets extra heat from the coat*”, linked the evidence with the claim (warrant) “*This will make him to melt first*” and generated weak rebuttal “*it is the same like wearing a jacket to make us worm*”. The other group who supported the claim “Fred will melt first” provided counterarguments to weaken their opponents’ arguments: we don’t agree, It is the reverse of human wearing a coat to stop heat escape from their bodies. This group of pre-service teachers have used rebuttals to a certain extent to nullify certain claims; therefore the group’s argument is classified as level 3 or 4. From the above analysis one can easily see that the members who hold similar stance tend to support each other to weaken their opponents’ arguments within the same group (group C) (see Appendix J, episode 8).

iii) Whole class argumentation

Similar patterns described in tasks one and two was used to facilitate whole class discussion. The quality of arguments constructed was assessed by focussing on the presence or absence of rebuttals as illustrated in Appendix J of episode 9. Episode 9 shows that there were a number of explicit oppositions across the four groups. Towards the end of the discussion, some pre-service teachers from group C (e.g., PT 13 and PT15) had changed their original stance. Initially, these pre-service teachers had explicitly claimed that '*Birt will melt first*" and supported their claim by offering evidence "*unlike Fred, Birt gets extra heat from the coat*" and provided warrant "*this will make him to melt first*" to connect the evidence with the claim. Later they shifted their position in light of new evidence supplied from groups A, B and D and were finally convinced that "Fred will melt first" which to me is a high level of argumentation. At this stage this group of pre-service teachers seemed to accept Leitao's assertion (Leitao, 2000). In this regard, Leitao (2000) asserted that when people are confronted with new evidence they could choose to reject or accept the evidence based on the strength of the advanced evidence. They could also choose to conciliate or compromise their original positions for interpersonal goals such as maintaining their relationships. CAT placed this perceptual shift or the new position for group C as emergent category. According to CAT (Ogunniyi, 2008b) an emergent category refers to a condition where a new knowledge claim emerges as the individual is exposed to more convincing information or concept.

The majority of pre-service teachers within the groups constructed claims and provided grounds in an attempt to support their claims with evidence and warrant. Some of them constructed complex arguments consisting of almost all components of TAP, including rebuttal (see Appendix J, Episode 9). These arguments are classified as level 4 arguments, because the arguments were backed with a claim and identifiable rebuttal.

In summary, the major observations made from a critical analysis of the arguments constructed at the individual level (Tables 4.4 -4.9) and arguments constructed at group level (Appendix J, episodes 1, 2, 4,5, 7 and 8) are:

(a) Group's arguments are the result of the contributions made by individual members within the group. The collective arguments of both the groups reflect a more convincing reasoned argument than the individual arguments. In other words, the contribution of individual group members within the group resulted in generation of multiple reasons/evidences that are more plausible. This finding is resonant with the general assertion that showed that social collaboration with a partner in constructing responses to the opposition supports metacognitive reflection on the dialogic interchange (Kuhn, 2010).

(b) While examining the contributions made by the individuals in groups A and C the main processes identified in all the six episodes (1, 2, 4,5, 7 and 8) were opposing claims by others, elaboration of an earlier ideas, reinforcement of claim with data, warrant and advancing claims. What emerges out of the analysis from these debating episodes is that in group A (episodes 1, 4 and 7) there were no explicit oppositions among the discussion partners. Put in other words, the members did not attempt to challenge the knowledge claims and evidences of each other's, as their views were presented as parallel claims, data and warrant (ground) right from the start of the debate. They rather attempted to reinforce their claims with additional data and warrant. The argument of the group is a typical example of inclusive communication as there were no counter-claims and rebuttals. In contrast, in group C episodes 2, 5 and 8 clearly show that the discussion partners held very different views on the issues raised and provided evidence to support themselves. Put in other words, there was a lot of critique expressed by the discussion partners in the three tasks. Critique in science is considered as vital by many science educators. For example, Osborn (2010) contend that "critique is not, therefore, some peripheral feature of science, but rather it is core to its practice, and without it, the construction of reliable knowledge would be impossible" (p. 465). From the forgoing there is an indication that the members in group C developed clear argumentation division lines and seem to realize that contrasting views are part of argumentation. Such analysis helps to identify the features of the interactions and the nature of engagement among the discussion partners.

So far the pre-service teachers' ability to argue at individual levels, in small groups and during whole class discussions, were analysed and discussed. The tables below (Tables 4.10 and 4. 11) present a summary of individual pre-service teacher's and group's ability to argue across the three tasks respectively.

Table 4.10: Levels of individual pre-service teacher's arguments across the three tasks

Pattern of arguments	NO. of PTs		NO. of PTs		NO. of PTs		Level of argument
	Task one: Everyday argument		Task two: Socio-scientific argument		Task three: Scientific argument		
	Group A	Group C	Group A	Group C	Group A	Group C	
[C]	**2**	-	-	-	-	-	**1**
[C-D]	-	-	-	1	1	-	2
[C-D-W]	4	5	5	3	5	6	2
[C-D-R]	-	-	1	-	-	-	3
[C-D-W-R]	-	1	-	2	-	-	3 or 4
Total							

Key: C =Claim not supported with evidence; C-D = Claim supported with evidence; C-D-W = Claim supported with evidence and warrant; C-D-R=Claim supported with evidence and rebuttal; C-D-W-R= Claim supported with evidence, warrant and rebuttal.

Table 4.10 above depicts the patterns and levels of arguments articulated by individual pre-service teachers across three tasks. Looking at the data displayed in the table above two important points seems to have emerged. On the one hand, it seems that as the study progressed some pre-service teachers have relatively improved their skills of argumentation. The following are excellent examples

- Two PTs who were not able to provide evidence or reason for their knowledge claim in task one were able to offer evidence to support their knowledge claim in the subsequent two tasks, that is, task two and three. These pre-service teachers displayed a move from level 1, where a knowledge claim is not accompanied with data or evidence to level 2 where a claim is supported with evidence.

- The number of pre-service teachers who constructed arguments with rebuttals increased from one in task one (everyday-argumentation scenario) to three in task two (on Scio-scientific scenario). These pre-service teachers have reached level 3 or 4 arguments where there is a rebuttal that challenges the thesis of a claim, which is an indication that they demonstrated relatively high level of argumentation.

On the other hand, the number of pre-service teachers who constructed arguments with rebuttals dropped from three in task two (on Scio-scientific scenario) to zero in task three (on scientific scenario). As the study progressed, the researcher expected an increase in the number of pre-service teachers who could construct arguments with rebuttals. Nonetheless, the number of PTs dropped to zero. As indicated earlier, it seems that these pre-service teachers demonstrated mainly the lower levels of argumentation in scientific scenarios compared with their daily and socio-scientific argumentation. This finding corroborates previous findings in similar studies (e.g., Durant, Evans & Thomas, 1989; Xie & Mui SO, 2012). These earlier studies also show that pre-service science teachers demonstrating low levels of argumentation in scientific scenarios compared with their daily argumentation.

Table 4.11: Levels of group's arguments for the three tasks

Group	**Level of argumentation**		
	Everyday argumentation (Task one	**Socio-scientific argumentation (Task two**	**Scientific argumentation (Task three)**
Group A	**3**	**4**	**4**
Group C	**4**	**4**	**3**

Table 4.11 displays levels of group A's and Group C's arguments across the three tasks. A close examination of Table 11 has shown that the PTs in Groups A and C have the basic skills of constructing every day, socio-scientific and scientific argumentation. In all the three tasks, they were able to: (1) provide evidence (data) to support their claims; (2) connecting the data with the claim (warrant); and (3) use rebuttals to a certain extent to nullify certain claims i.e. level 3 and 4 of argumentation. A perusal of Table 4.11 also reveals that the level of argumentation in Group A rose from level 3 in task one (everyday-argumentation) to level 4 in task two (on Scio-scientific scenario) and in task three (on Scio-scientific scenario). In contrast, the level of argumentation in Group C dropped from level 4 in task one (everyday-argumentation) and in task two (on Scio-scientific scenario) to level 3 in task three (on Scio-scientific scenario).

What can be deduced from the above analysis is that as the study progresses the quality of arguments constructed by Group A showed improvements; whereas the quality of arguments constructed by Group C showed a decline to some extent. This finding suggests that the two groups followed slightly different patterns in their mastery of argumentation skills. One can argue that the quality of arguments constructed by Group C in scientific scenario could possibly be influenced by their level of conceptual understanding about the topic "heat transfer". Venville & Dawson's (2009) study seem to support this argument. In their study they found that "a person's degree of understanding about a topic may influence the quality and complexity of the arguments they construct. Conversely, being involved in the process of argumentation may influence a person's understanding of the topic" (p. 953).

Another important point to note is that working in a group provides additional opportunities for the individual members to sharpen their arguments, clear their misgivings and revise their views in the strive to attain collaborative consensus or cognitive harmonization (e.g. Erduran, et al., 2004; Leitao, 2000; Ogunniyi, 2007a & b, 2011; Simon & Johnson, 2008). Another important observation which is not depicted in both Tables 4.10 and 4.11 is that PTs' understanding of scientific argumentation seems to have an effect in their ability to construct quality arguments. More specifically, the PTs who had reasonably good understanding of scientific argumentation (see section 4.2.2) at the post-test were able to construct more complex arguments comprising almost all components of TAP, including rebuttal (see Tables 4.4-4.9). These PTs (e.g., PT6, PT12, PT13, PT16, and PT18) were also observed to participate actively in argumentation discourses during small and whole class discussion (see episodes 1-9 in Appendix J).

In contrast, PTs who had limited understanding of scientific argumentation at the post-test (see section 4.2.2) constructed low level arguments-i.e. arguments with no rebuttals (see Tables 4.4-4.9). These PTs (e.g., PT2, PT5, PT9, and PT23) have also shown little engagement in argumentation discourses during small and whole class discussion (see episodes 1-9 in Appendix J). It is for the same reason that science educators (e.g., Erduran, 2006; Erduran et al., 2004, McNeill & Knight, 2011, 2013; Osborne et al., 2004; Simon et al., 2003, 2006) made commendable efforts to develop pre-service and in-service science teachers' pedagogical content knowledge on argumentation through continuing professional development programmes.

Section summary

From the forgoing, it seems that argumentation-based instructional model used in the study has been effective to some extent in equipping the PTs with the necessary argumentation skills that will enable them to take part in a meaningful discourse. The findings have shown that the majority of the participating PTs have the basic skills of constructing every day, socio-scientific and scientific argumentation. In the three tasks, they were able to: (1) provide evidence (data) to support their claims; (2) connect the data with the claim (warrant). This finding is important for this study and for this research question. At individual level, very few PTs were able to generate rebuttals to nullify certain claims in tasks one and two but, in task three (the scientific scenario), none of them constructed arguments with rebuttals. The findings seemed to indicate that these PTs showed lower level of argumentation in scientific scenarios compared with their daily and socio-scientific argumentation.

Results obtained from the three selected argument-based activities show that the PTs' ability to argue improved significantly as they went through many discursive activities. The major observations are:

- Some PTs who did not offer evidence for their knowledge claim at the initial stage of the study were able to substantiate their knowledge claim with evidence and connect the evidence with the claim as the study progressed. Additionally, few PTs demonstrated greater skill in generating rebuttal.

- Initially, during small group and whole class discussion the groups focused entirely on their own argument and failed to attend critically to the opponent's arguments. Later on, most of the PTs were able to listen at each other's argument and respond directly to each other's arguments to weaken their opponent's argument. Put in other words, they demonstrated greater skill in generating rebuttal.

- It was also observed that the group members who hold oppositional views made no attempt to dominate the discussion; rather, they provided appropriate evidence to justify their claim and attempted to use persuasive language to convince the group members who initially argued against the claim. As a result, some of the group members who initially argued against a particular claim were able to change their mind. The implication is that overtime PTs began to understand that opposition between the views of arguers during argumentation does not necessarily mean opposition between individuals.

Previous studies examined the effect of an argumentation-based professional development programme on teachers' argumentation skills. For example, Xie & Mui SO (2012) examined the effect of an argumentation-based programme on PTs' ability to construct everyday arguments and scientific arguments at individual level (intra-argument). Similarly, Scholtz, Braund, Hodges, Koopman, and Lubben (2008) examined the effect of an argumentation-based programme on teachers' ability to participate in argumentation in small groups (inter-argument). This study, however, examined the effect of argumentation-based professional development programme on PTs' ability to construct every day, socio-scientific and scientific arguments at individual level (intra-argument), group level (inter-argument) and whole class level (trans-argument). The findings reveal that compared to individual's arguments the collective arguments of the groups comprise of several claims and counter-claims supported by data and warrant. Moreover, evidences were more logical, stronger and almost all of the evidences were linked with the claims made. In addition, some PTs who were unable to construct arguments with rebuttals at individual level were able to generate arguments with rebuttals during small and whole class discussion. In a nutshell, the findings seem to suggest that the collective arguments of the groups reflect a more convincing reasoned argument than the individual arguments.

4.4 Ability to use the Argumentation-Based Instructional Model (ABIM)

This section examines and discusses the extent of PTs' ability to use argumentation-based instructional model (ABIM) to implement a Learner-centred curriculum (LCC) by focusing on two aspects of teaching: (a) the organization of argument-based tasks within a lesson structure and (b) the oral contributions used by PTs to facilitate the discussion and argumentation process. Data for analysis was drawn from video and audiotaped transcripts and classroom observation checklists of three argumentation lessons with topics,, "Phase of the moon" (first lesson observed), "Mercury" (second lesson observed) and "heat transfer" (third lesson observed). PTs' interview and reflective responses were again, analysed to supplement the data drawn from lesson transcripts and classroom observation checklists. The findings are presented in two sub-sections.

The first sub-section looks at PTs' ability to structure argument-based tasks such that they can implement LCC in science classroom. The second sub-section examines PTs' classroom talk or oral contributions that show an orientation or ability to the facilitation the argumentation process in their class. A summary of PT's self-reflection and peers' reflection of the video-taped micro-teaching and actual teaching lessons is presented in this section. The objective is to highlight the effect of reflection in improving PTs' pedagogical skills to teach science as an argument to implement LCC.

4.4.1 PTs' ability to organize argument-based tasks within a lesson to implement LCC in science classroom

To determine how the pre-service teachers structured argument-based tasks the researcher scrutinized classroom observation checklist and viewed the video material for each of the three lessons for all the 25 PTs and noted the main phases of the lessons. Data drawn from classroom observation checklist and video materials were examined in terms of five domains and 10 performance standards indicated in Table 4.12. These domains and performance standards were found to be well linked with the stages of dialogical argumentation instruction suggested by Langenhoven & Ogunniyi (2009) and Simon et al. (2003) and with the major lesson phases of learner-centred instruction.

Individual PT's performances with reference to the examined domains and performance standards of argument-based lessons structure in three selected lessons are displayed in 10 separate tables (Tables M1-M10) in Appendix M. A summary of these tables that illustrates the total performance of all the 25 participating PTs with reference to the examined domains and performance standards of argument-based lessons structure (see Table 4.12). Analysis of the structure of the three argument-based tasks enabled the researcher to make comparison among PTs and across the lessons of how argumentation lessons were organized.

Table 4.12: PTs' performance with reference to the examined domains and performance standards of argument-based task structure in three selected lessons.

	Domains and performance standards	**Lesson one**			**Lesson two**			**Lesson Three**		
		P	I	E	P	I	E	P	I	E
		f(%)	f(%)	f(%)	f(%)	f(%)	f(%)	f(%)	f(%)	f(%)
1	**Introduction**									
	Learning goals	13 (52)	8 (32)	4 (16)	7 (28)	3 (12)	15 (60)	3 (12)	2 (8)	20 (80)
	Aim of the task	13 (52)	8 (32)	4 (16)	7 (28)	3 (12)	15 (60)	3 (12)	2 (8)	20 (80)
	Outlined/explained the task	7 (28)	5 (20)	13 (52)	5 (20)	3 (12)	17 (68)	0 (0)	3 (12)	22 (88)
2	**Lesson delivery**									
	Individuals task	0 (0)	10 (40)	15 (60)	0 (0)	7 (28)	18 (72)	0 (0)	4 (16)	21 (84)
	Small group task	9 (36)	0 (0)	16 (64)	5 (20)	2 (8)	18 (72)	0 (0)	5 (20)	20 (80)
	Group presentation and Mediation of whole class intervention/discussion	9 (36)	7 (28)	9 (36)	0 (0)	8 (32)	17 (68)	0 (0)	6 (24)	19 (76)

3	**Assessment**									
	Ascertain students' understanding of science concepts	5 (20)	10 (40)	10 (40)	3 (12)	6 (24)	16 (64)	0 (0)	4 (16)	21 (84)
	Quality of students' argument	14 (56)	4 (16)	7 (28)	8 (32)	5 (20)	12 (48)	5 (20)	4 (16)	16 (64)
4	**Provided feedback**	17 (68)	3 (12)	5 (20)	15 (60)	2 (08)	8 (32)	5 (20)	2 (8)	18 (72)
5	**Rounded off the argument-based lesson**	12 (48)	4 (16)	9 (36)	6 (24)	6 (24)	13 (52)	4 (16)	5 (20)	16 (64)
	Total	99	55	96	56	45	149	20	37	193
	Average rounded: **Total/10**	**10**	**5**	**10**	**5**	**5**	**15**	**2**	**4**	**19**

Key: P= Poor I= Intermediate E= Excellent (for details see the rubric in Appendix K)

i) Stating learning goals and aim of the task

A perusal of Table 4.12 shows that almost half (12) of the participating PTs stated the learning goals and the aims of the task in the first lesson. Of these, four PTs stated the learning goals and aims of the lesson in the light of constructivist perspective and the rest eight PTs state the learning goals and aims of the lesson in the lenses of behaviourist/positivists. The following excerpts taken from video lesson transcripts of the first lesson observed of some PTs are representatives.

> *The learning goal of today's lesson is to judge or evaluate explanations or arguments and provide justifications for what you believe in (PT13).*
>
> *The specific aim of today's task* is to *choose the best explanation from a list of statements that explain why the moon has different phases and support it with evidence. The task is also aimed at promoting student-teacher and student-student dialogue, discussion, and debate on the specified topic (PT13).*
>
> *By the end of the lesson the students will be able to describe the three phases of the moon (PT23)*

> *The aim of this task is to answer the questions indicated in the worksheet correctly after reading information on phases of the moon from science textbook (PT23).*

A close examination of the above excerpts reveals that PT23's learning goals and aims encourage memorization or rote learning and seem to corroborate with positivists view of science learning. To positivist science is perceived as a school subject in which there are clear right answers and data lead to uncontroversial to agreed conclusions (Driver et al., 2000, p. 288). On the other hand, PT13's learning goals and aims initiate construction of knowledge claim through discussion and argument and seem to reflect the view of social constructivist. These theorists believe that scientific knowledge is socially constructed through discursive practices and arguments. Looking at PT13's learning goals and aims of the task one could argue that PT13 was guided by social constructivist theory which would possibly assist him to implement LCC better than PT23.

When asked why his learning goals and aims did not encouraged discussion and learning with understanding, PT23 replied "*well I have adapted the format for writing learning goals and aims recommended in the General Method of Teaching (GMT) courses offered in my former ATTI and here in the College of Education at EIT*". His response seems to reinforce the general assertion that shows that teachers teach the way they have been taught (Warnich & Meyer, 2013; Vavrus, Jones & Carter, 2007).

In addition, the data set displayed in Appendix M discloses that all the eight PTs who had teaching experience prior to their enrolment in the department of science education had stated the learning goals and aims of the lesson, although four of them were unable to state them in the lenses of constructivist perspective. This implies that PTs' prior pedagogical knowledge and teaching experience have helped them to realize the prominence of communicating the learning goals and aims to students. This finding is consistent with the view of Jackson (2014) and Weimer (2002) who argue that experienced teachers spend more time unpacking standards and objectives than they do planning learning activities because they understand that clear learning goals will drive everything else they do. On the other hand, data displayed in Table 4.12 revealed that initially slightly more than half (13) of the PTs outlined the argument-based task without informing the learning goals and the specific aims of the task.

During informal interviews and feedback discussion sessions, majority of the 13 PTs noted that they did not value the importance of indicating the learning goals and the aim of the day's task in each of their lesson. To give an example, PT6 stated:

The learning goal and the aim of the task are included in my lesson plan. However, I did not see the importance of stating the learning goal and the aim of the task to the students in my actual class. In the successive lessons I promise to state them in the introduction part of the lesson because students have to know what is expected from them right from the beginning of the lesson [after first classroom observation].

However, the data set also shows that the PTs' ability to state or communicate the goals and aims of the lesson improved overtime. 18 and 22 of the 25 PTs were able to indicate the learning goals and the aim of the task in the second and third lessons respectively. Of these, 15 and 20 PTs were able to clearly state the learning goals and aims in the light of social constructivist perspective in the second and third lessons respectively.

ii) Outlining and explaining the task

The data set drawn from the three observed argumentation lessons displayed in Table 4.12 shows that almost two-third of the PTs (18) outlined and explained the task to the students from the outset. Of these, while 13PTs were able to outline the task and explain it well to the students, five PTs outlined the task and attempted to explain it to a certain extent. Also, Table 12 revealed that the number of PTs who outlined the task and explained it well increased from 13 in lesson one to 17 in lesson two and 22 in lesson three. In contrast, the number of PTs who outlined the task but did not attempt to explain it to their students dropped from seven in lesson one to five in lesson two and zero in lesson three. The findings seem to show that as the study progresses almost all the participating PTs were able to outline and explain the task well to the students.

iii) Ability to provide and facilitate individual tasks, small group tasks, group presentations and whole class discussions

All the 25 participating PTs provided individual task to their students in all the three lessons observed. Of these, 16 PTs provided and facilitated small group tasks followed by group presentation from the outset. These PTs posed argument prompt question to encourage their students to generate reasoned arguments individually and then compare and discuss their arguments in small groups. The 16 PTs also attempted to develop the spirit of collaboration among the students and encouraged the groups to present the substance of their argument to the whole class. Of the 16 PTs, nine of them mediated whole class intervention by encouraging students to throw arguments and counter-arguments to each other's argument. The rest seven PT did not scaffold discussion during whole class intervention; rather they attempted to provide corrections to some of the questions presented in the argumentation activity worksheet.

In contrast, one-third of the PTs (9) who provided and facilitated individual task failed to: provide small group task, encourage students to present their work to the whole class and mediate the whole class intervention. These PTs organized the argument-based task using traditional teacher-centred mode of teaching. They did not display any evidence at all of being able to help students to compare, contrast and distinguish different lines of reasoning in small and whole class interactions in the first lesson. Rather they spent most of the instructional time presenting scientific concepts, clarifying terminologies and writing notes on the board with little emphasis on the development of argumentation skills and the cultivating of inquiring attitudes (Baxter, Bass, & Glaser, 2000; Maree & Fraser, 2004; Erduran, 2006) Surprisingly, out of these nine PTs three of them had nine to twelve years teaching experience before they joined the College of Education.

According to the nine PTs interviewed, the main reasons for not adapting lesson structure that facilitates classroom interaction and generation of arguments in the first lesson observed were: time constraints, large class size, lack of classroom management skills, new approach of teaching to teachers and students. Four of the nine PTs added that they lacked confidence and were not even sure whether they are able to employ this approach in an actual classroom. The following excerpts are representatives:

> *PT15: I fully understand that small group and whole class discussion has a potential to promote students' conceptual understanding of scientific concepts. However, as a novice teacher I was not confident enough to implement individual, small group and whole class interaction and encourage students to construct arguments. Also, I felt that I don't have adequate pedagogical skills to promote students ability to generate argument as argumentation instruction was new approach to me and to my students…..Well, I will try it out in the next lesson.*

> *PT5: To be frank I thought that it is going to be difficult for me to manage small group and whole class interaction with such a large class size. I was also of the view that I may not cover the lessons stipulated in the annual plan on time if I employ student-student interaction and teacher-student interaction. On top of that, I felt that I have to master the basic pedagogical skills such as classroom management techniques before facilitating individual task (intra-locutory arguments), small group task (inter-argument) and whole-class discussion (trans- arguments).*

Three of the PTs (PT9, PT23, and PT25) who had teaching experience before declared the importance of intra- argument, dialogical-argument and trans- argument in science teaching. Yet, they replied that it was not easy for them to change their style from teacher-centred to learner-centred approach. Their view accords with the findings of a similar study (Qhobela, 2010). The author indicated that the major challenge to introduction of argumentation in Lesotho's science classrooms was related to changing the teaching practices that science teachers have adopted.

From the forgoing, it is evident that these nine PTs lacked the required pedagogical knowledge and skills that will enable them to scaffold discussion and argumentation with confidence using small group and whole class discussion. It seems that these PTs were not aware of the fact that the communication pattern in a learner-centred science classroom should be multi-way and the sources of information should include the teacher, an individual student, a group of students and the whole class (Suter & Busienei, 2013). A finding that reinforces the idea that teachers' basic capacity for change may be dependent on their existing knowledge and thinking. The findings also revealed that the three PTs who had teaching experiences seem to struggle with their new role of facilitators of learning and tend to stick with the traditional transmission model of teaching. As argued by Erduran (2006) one of the possible major reasons could be the initial training of science teachers does not conventionally place an explicit emphasis on how teachers can be supported in teaching new aspect of the curriculum. Teachers produced from such training programmes will then be rigid in their teaching style and stick closely to their prepared notes or textbook with minimal teacher-student interactions (Stoll,1994).

In the subsequent two lessons, however, 17 and 19 PTs respectively have managed to facilitate individual task, small group task, group presentation and mediated whole class discussion. In both the lessons there is sufficient evidence that showed that these PTs valued the role of small group discussion and whole class discussion. More specifically, they put efforts to encourage their students to: (a) externalize their idea or argument, (b) justify their knowledge claims using evidence, and (c) develop the spirit of collaboration and cooperative learning. The data seem to suggest that as the study progresses the PTs improved their practices of organizing argument-based tasks. Such practices in turn helped them to establish learning environment that encourages active learning and learning with understand, which are central features of LCC (Alsardary & Blumberg, 2009).

During interviews and feedback sessions, the PTs credited their progress, in utilising lesson structure that encourages discussions, small group interactions and whole class discussions, to the reflection workshop sessions and feedback discussion sessions. They said that they had opportunities during the reflection workshop sessions to improve their skills on how to structure argument-based lessons and to learn how argumentation-based instructional model can be used as a tool to implement LCC. This is succinctly articulated by PT4,

> *My engagement in the reflective workshop sessions was a golden opportunity to share my classroom experience with my peers. The best classroom practices presented during the reflective workshop sessions helped me to rethink on how to structure my lessons in order to promote classroom discourse in small and whole class discussions.*

iv.) Ascertaining students' understandings of scientific concepts

In the first lesson, 10 out of 25 PTs attempted to ascertain students' understandings of scientific concepts by posing several open-ended questions (argument promote questions) such as 'how do you know'?, 'what is your evidence?' and 'why?' during the small group and whole class discussion. The 10 PTs also used such questions to help their students justify their arguments using multiple evidences. The conversation below, taken from the introductory part of PT12's first lesson observed, is an excellent example:

PT12: *Is moon luminous or non-luminous body? Justify your claim with evidence or reason.*

Student: *The moon is a non-luminous body*

PT12: *What is your evidence?*

Student: We *have learnt it in the previous class and it is also indicated in our textbook*' (Almaz).

PT12: *I know we have learnt it in our previous class but what I want is for you to find out why"*

PT12 *:* *Who can help Almaz? Yohannes can you tell us why the moon is a non-luminous body?*

It seems that these PTs attempted to promote students' understanding of scientific concepts through argumentation. In agreement with the findings of Venville and Dawson (2010) and Zohar and Nemet (2002); Shemwell and Furtak (2010) and Von Aufschnaiter et al. (2008), these PTs became knowledgably about the role of argumentation in promoting students' understanding of scientific concepts as a result of their involvement in the argumentation-based intervention programme.

In contrast, five PTs did not check at all students' understanding of the science concepts taught in the first lesson observed. The remaining 10 PTs used close-ended questions with one specific correct answer in an attempt to check students' understanding of scientific concepts. Below are examples of close-ended questions posed by four PTs in an attempt to assess students' conceptual understanding in the first lesson observed.

PT2: How many phases does a moon have?
PT5: Is the moon luminous or non-luminous body?
PT23: From the three figures illustrated on the board which one represents half-moon?
PT25: Define luminous body

It seems clear that the PTs did not place emphasis on asking thought provoking questions, rather they focused on examination oriented questions. The possible reason could be that, (a) the nature of the Eritrean science curriculum, which is examination oriented and (b) pressure from school directors and department heads to emphasize on examination related questions. These issues are further discussed in detail (see section 4.5.2). The learning environment in such situation could not be described as inquisitive, participatory or focused on understanding of scientific concepts. This finding seems to corroborate with the findings from previous studies that showed that conceptual understanding and practical applications of science to real life are all seen as missing from Eritrean teachers' pedagogical strategies, rendering teaching and learning mainly theoretical (Department of General Education, 2010). Osborne (2010) and Erduran, Ardac, & Yakmaci-Guzel (2006) argue that in classrooms of such kind, students consider science as absolute characterized by right and wrong answer with the origin of scientific ideas and any element of uncertainty simply excised.

Moreover, a critical analysis of PT2, PT5, PT23 and PT25s' pre-post LCAI questionnaire responses provides further insights into why these PTs emphasis on transmitting factual concepts of science and did not show interest to promote students' understanding of scientific concepts through argumentation. In their responses these PTs indicated that argumentation does not have any role in science teaching. Their lack of content pedagogical knowledge of argumentation could be possible explanations for their use of close-ended questions to assess students' conceptual understanding of science. This finding reinforces Zohar's (2008) view that to implement argumentation in science classrooms, science teachers need to experience a fundamental shift in their pedagogical understanding and practice.

On the other hand, majority of the PTs were observed to progress from not being able to generate open-ended questions that assess students' understanding of science concepts presented in the first lesson observed, to 16 and 21 PTs being able to use argument-prompt questions and different assessment techniques to ensure that the students have clear understanding of the lessons being taught during the second and third lessons respectively. Some PTs even lead their students to assess each other's' understanding through peer review. An example of such questions generated by the students through the guidance of (PT16) was

"What is your evidence that the moon has different phases?"
"How do you know that the moon does not give out light?" "Do you have evidence?"
"How do you know that the light that comes from the moon is reflected from the sun?"
Such questions not only helped the students to promote their understanding of scientific concepts, but also enabled them to develop scientific knowledge by constructing arguments and counter-arguments. These findings seem to be consistent with the results of previous studies that show the potential of argumentation in knowledge building and in enhancing students' and teachers' conceptual understanding of scientific concepts (e.g., Leitao, 2000; Venville & Dawson, 2010; Zohar & Nemet, 2002). The major observation that could be made from the above discussion is that as the study progressed these PTs improved their pedagogical ability to assess students' understanding of scientific concepts.

v) Evaluating the quality of students' argument

Slightly less than one-third of the PTs (7) evaluated the quality of argumentation generated during small group and whole class discussion of the first lesson observed using analytical tool modified after Erduran, Simon and Osborne (2004). Few of these PTs have also clearly stated the quality of arguments constructed in the small groups and/or whole class discussion in the evaluation part of their lesson plans. For example, in his lesson plan, PT10 indicated how he assessed the quality of argument constructed by group one during 'the phases of the moon' lesson. The excerpt below taken from PT10's lesson plan is an excellent example.

> ***Group One's argument**: We believe the appropriate argument is card 'A': "The moon spins around so that the half of the moon that gives out light is not always facing us". We believe this is an appropriate argument because the moon does not give out light.*
>
> ***PT10's assessment**: Group one had claimed that card A is the best explanation for why the moon has different phases. The members of the group have also managed to*

provide evidence to support their claim, but they did not provide counter-argument to weaken anticipated oppositions from their opponents. In terms of the simplified version of TAP, this group was now operating at level 2 where an arguer supply evidence to support his/her knowledge claims.

The above excerpt reveals that PT10 seems to utilize the levels of argumentation (modified after Erduran et al., 2004) that are used to evaluate the quality of arguments from the outset, which is an indication that he has a good understanding of these analytical tools.

On the other hand, the data set revealed that while four PTs were able to assess the quality of students' arguments with some difficulty, the rest 14PTs did not display any evidence at all of being able to evaluate the quality of students' arguments in the first lesson observed . During informal interview and feedback discussion, most of the PTs expressed that they have limited understanding of the analytical tools that are required to assess the quality of written and spoken argumentations. For instance PT22 suggested *"these analytical tools to be elaborated further and practiced in the reflective workshop sessions"*. Few PTs commented that "*it was difficult for them to evaluate the quality of students' arguments in such a large class size"*. The data seems to suggest that lack of PTs' pedagogical knowledge and skills of argumentation theory and large class size were the main problems for not evaluating students' arguments constructed in the first lesson observed.

However, as depicted in the table there was quantifiable improvement overtime in terms of PT's ability to evaluate the quality of arguments. For example, in the final lesson observed (lesson three) more than half of the participating PTs (16) successfully assessed the quality of students' written and spoken arguments.

During interviews, the majority of the PTs attributed their progress in utilising analytical tools to evaluate students' arguments to the reflective workshop sessions. Some of them credited to the feedback discussion sessions and to their personal teaching practices. The following excerpts, derived from the interview responses and discussions during feedback sessions of some of the PTs are representative:

PT22: In the first lesson, I was not able to evaluate the quality of students' argument because I had limited understanding of the theoretical background of the analytical frameworks that are required to analyse the quality of arguments. I also had difficulty on how to evaluate the quality of students' arguments using the modified form of TAP. In the reflection workshop sessions the researcher elaborated the components of TAP and the levels of argumentation using examples and some of my classmates also shared their experiences on how they evaluated the quality of students' arguments.

Thus, my participation in the reflective workshop sessions helped me to define the quality of arguments in terms of the levels of argumentation and enabled me to realize what makes one argument better than the other.

*PT6: My involvement in the reflection workshop sessions helped me to gain experiences on how to evaluate the quality of arguments. The individual feedback discussion session held after classroom observation further assisted me to distinguish data from warrant and warrant from rebuttal. Now **I am confident** to evaluate the quality of students' argument using the analytical tools.*

What seems to come out clearly from the above excerpt is that these PTs now seemed to have developed pedagogical knowledge and skills that are required to evaluate the quality of arguments as the study progresses. This development is extremely significant for this study that seeks professional development of PTs overtime. In terms of CAT, a more cohesive understanding of the analytical tools that are used to evaluate the quality of arguments was gradually assimilated and new skills emerged as there was little prior knowledge and skills of these analytical tools.

It is important to note that very few PTs (5) were not able to evaluate the quality of students' arguments even in the last (third) lesson observed. Perusal of LCAI questionnaire responses of these PTs on this item (see section 4.2.2) corroborates the above finding. In their post-test response these PTs explicitly indicated that they would evaluate the quality of arguments by focusing on the final answer. The implication is that PTs' pedagogical knowledge and understanding, in this case, on how to evaluate the quality of arguments influenced their classroom practices, reinforces the view of Simon et al. (2006), Erduran et al. (2004) and Osborne et al. (2004). In terms of CAT, it seems that their prior knowledge and perceptions on assessment and evaluation suppressed the new knowledge and skills they have gained during the intervention programme.

The foregoing analysis shows that, of these five PTs, three had teaching experience. Interview responses of these PTs show that they still did not value the importance of evaluating the quality of students' arguments in the teaching and learning process of science. This finding was informed by the wider literature on teacher beliefs and their resistant to change (e.g., Jones & Carter, 2007; McNeill and Knight, 2011; Sampson, 2009).

vii) Providing feedback

The number of PTs (5) who provided feedback frequently to their students was initially very low. On the other hand, the majority of PTs (17) were unable to provide quality feedback to students in the first lesson observed. Very few (3) PTs provided feedback some of the time. During the second lesson observed, my expectation was to see improvements. Nonetheless, this group of PTs displayed minimal to no change in their ability to provide feedback to their students. Yet it is important to note that some of these PTs have successfully adapted most of the strategies that are required to support and facilitate argumentation in argument-based lesson (see Appendix M). For instance, a 22 year old female pre-service teacher (PT12) was able to demonstrate advanced skills such as posing argument prompt, playing devils advocacy and modelling argument to promote and scaffold argumentation in her second lesson observed "Is mercury a metal or non-metal". Nonetheless, she was not able to provide quality feedback to here students in two instances. For example:

When a participant said, 'mercury is a metalloid' [claim] 'because it possesses the property of metals and non-metals' she did not use the opportunity to provide feedback in order to correct the common misconception held by the students. In another instance, while PT12 was concluding the day's lesson a student asked a clarification question: "Teacher, is being a liquid the property of a non-metal?" She directed his question to the class which is a good strategy. One of the students attended to her request and responded that 'Yes, being a liquid is one of the general properties of metals'. I expected her to correct the misconception by responding 'No, most non-metals are gases, some are solids, and Bromine is the only liquid non-metal. Surprisingly she continued highlighting the gist of the day's lesson without attending to the student's response.

This is the second time she missed the opportunity to provide a feedback in order to correct the students' misconception. Similarly, numerous missed opportunities for giving feedback to students were observed in the lessons of other pre-service teachers. This finding seems to be consistent with the results of previous studies that examined the ability of pre-service teachers to teach argumentation elsewhere (Erduran, et al., 2006). The authors suggested that formative feedback in argumentation might be challenging to beginning pre-service teachers although other advanced skills such as modelling and questioning did not seem to present as much difficulty.

It was only in the second reflective workshop session that the PTs appear to understand the importance of providing feedback to students' response. During this session the PTs were guided by the researcher to observe video recorded lessons of their fellow PTs who successfully provided feedback to students' responses. Such best practices followed by a discussion enabled the PTs to realize that providing feedback could improve students' ability to argue. The outcome of the reflective workshop session was reflected in the third lesson observed where almost three fourth of the PTs (18) managed to provide feedback to students' responses.

viii) Rounding off argument-based lesson

Crucial to the effective use of argumentation activities is the way in which they are finished (Osborne et al., 2004, p. 3.19). In line with this, this study examined the ability of PTs to round off argument-based activities. The findings as disclosed in Table 4.12 revealed that initially about half of the PTs (13) were able to round off the lesson. Of these, nine PTs rounded off argument-based task by asking students to reflect on the process of argumentation and to indicate if there is a mind change or review of views they had experienced as the result of the discussions. The data seem to show that the approaches of these PTs were more aligned towards learner-centred as they were observed encouraging their students to develop high cognitive thinking skills through the process of reflection. Simon et al. (2004) classified 'reflecting on argument processes as higher-order talk. Similarly, Bloom and his team (Bloom, Engelhart, Furst, Hill, & Krathwohl, 1956) have also categorized 'reflection' as the highest cognitive level of thinking. On the other hand, the four PTs attempted to round off the lesson by just reviewing the main points of the day's lesson and were not observed to employ any of the specific strategies that are required to round off argument-based lesson to which they have been exposed in the intervention programme.

The remaining 12 PT were observed to progress from not being able to round off the argument-based activity during the first lesson observed, to majority being able to round off the activity in the successive two lessons using different strategies. For instance, PT21 who was unable to round off the argument-based activity in the first lesson observed demonstrated excellent practices while rounding off the second argument lesson observed on 'Mercury' using students' responses, as shown in the excerpt below:

> *PT21: Ok students two groups have reported back their constructed arguments for the mercury activity to the whole class. Both the groups provided evidences to justify whether mercury is a metal or non-metal. Group one argued that 'Mercury is a metal' and provided evidences 'because it is a good conductor of heat and electricity and has a d orbital' to justify their claim. The group continued, arguing that "Mercury is not a non-metal because most non-metals are gases, some are solids, and Bromine is the only liquid non-metal'. On the other hand, Group two argued that 'mercury is a*

non-metal' and supplied evidences to support their claim: because it is a liquid at room temperature'.

PT21: is there any difference in these groups presentation? What actually did group one or group two included within their argument? Express your reflection
Haile (student): I think group one have included why mercury is not a non-metal

PT21: Why do you think is important to explain why mercury is not a non-metal
Aster (student): to make the argument persuasive.

Then PT21 showed them a thermometer and drew their attention to the liquid part of the thermometer indicating that it is mercury. He then took a class vote (26 metals, 10 non-metals and eight metalloids) and finally told the class that Mercury is a metal. He further substantiated his claim by indicating that "the only property that suggests mercury is not a metal is its liquid state. PT21 encouraged students to accept and correct their misconceptions in their arguments and asked them about mind change or review of views as the result of the discussion.

A 23 year old male pre-service teacher, PT16 have also rounded off the third lesson observed about the snowmen activity as described below:

PT16's students read out the arguments that they constructed in their respective groups for the snow man activity, which was written on a chart to present to the whole class. The chart provided a visual display of the arguments for all to see, and enable PT16 to compare the quality of different arguments generated from the groups. He encouraged and made time for the students to talk about how they evaluated their arguments and finally to reflect on the process of arguments.

From the forgoing discussion, it is evident that the findings of this study are consistent with what was reported in earlier studies (e.g. Erduran, et al, 2004; Ogunniyi, 2004, 2007a & b; Ogunniyi, & Hewson, 2008; Ogunniyi & Ogawa, 2008; Osborne, 2010; Simon et al (2003). These earlier studies showed that argumentation-based professional development programmes do enhance teachers' and pre-service teachers' ability to implement classroom discourses, create the necessary conducive environment for learning as well as facilitated conceptual change and belief revision. More specifically, these earlier studies have shown the effect of argumentation instruction on teachers' and pre-service teachers' ability to state the learning goals, organize small group discussions, encourage classroom interactions and decision making.

In addition to the above issues the study has examined the effect of argumentation instruction on the PTs' ability to: (a) assess students' understanding of science concepts, (b) evaluate the quality of students' arguments, (c) provide feedback to students' response and (d) rounded off the argument-based lesson. These issues reflect the essential components of an argumentation-based classroom. Findings from this study have also shown that the argumentation-based intervention training programme has to a reasonable degree been effective in enhancing the PTs' ability to:

- Provide feedback frequently to students' responses.
- Use argument-prompt questions and different assessment techniques to ensure that the students have clear conceptual understanding of science.
- Successfully assess the quality of students' written and spoken arguments using analytical tools modified after Erduran et al. (2004).
- Rounded off argument-based task by asking students to reflect on the process of argumentation and to indicate if there is a mind change or review of views they had experienced as the result of the discussions.

Of great importance, the findings of this study seem to have revealed how the PTs' pedagogical content knowledge has had a positive effect on their ability to promote students' understanding of scientific concepts through argumentation. The findings further showed that PTs' pedagogical knowledge and understanding of argumentation seem to have an effect on their ability to evaluate the quality of arguments in their classroom practices.

Overall performance of pre-service teachers on how they organized the argument-based tasks to implement LCC

The data with regard to PTs' ability to structure argument-based task to implement LCC generated through classroom observations and lesson transcripts in selected Eritrean middle schools revealed an overall increase in aggregate scores for almost all the 25 participating PTs overtime (see Table 4.12 and Figure 4.1). The aggregate scores shows that the number of PTs who were able to employ majority of the domains and performance standards that are required to structure the argument-based activities increased from 10 (40%) in the first lesson to 15 (60%) in the second lesson and further increased to 19 (76%) in the third lesson. This general pattern of increasing scores in most individual PT's case was reflected from the first lesson observation to the second and the final (third) lesson (see Appendix M). On the other hand, the number of PTs who were unable to employ majority of the domains and performance standards that are required to structure the argument-based activities dropped from 10 (40%) in the first lesson to five (20%) in the second lesson and further dropped drastically to two (8%) in the third lesson(see Appendix M).

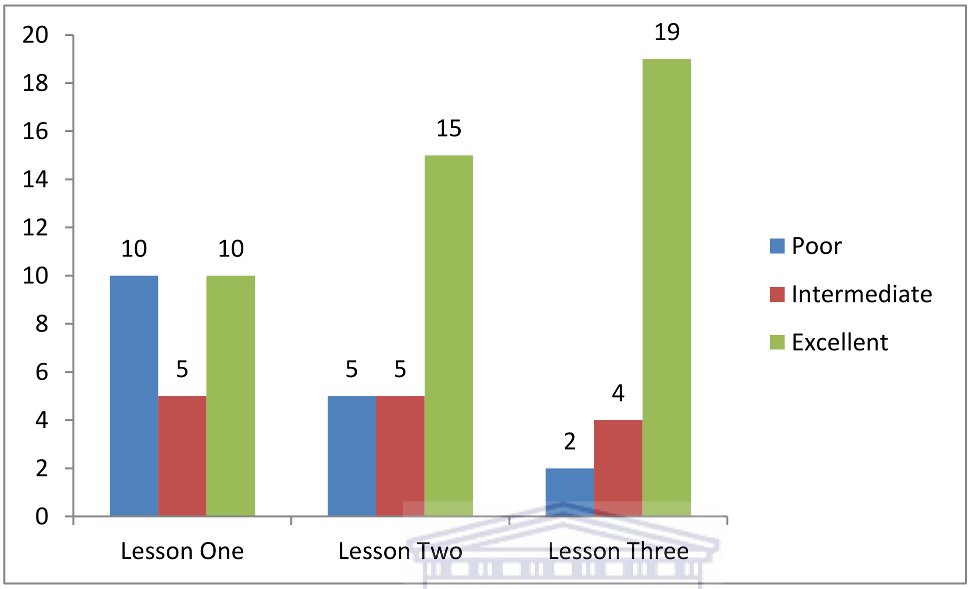

Figure 4.1: Aggregate argumentation-based task organization scores overtime for all the 25 pre-service teachers

The improved performance noted in Table 4.12 were, however, not equally evident across all 10 performance standards in terms of magnitude. A close perusal of the data displayed in Table 4.12 discloses that the highest change in the performance of PTs across the three lessons was their ability to: “state learning goals and the aim of the task” followed by “providing feedback to the students’ responses” and ‘ascertaining the students’ understanding of science concepts’. More specifically, the ability of PTs to: “state learning goals and aim of the task”, “providing feedback to students’ responses” and ‘ascertaining students’ understanding of science concepts’ increased from four (16%) , five (20%), and 10 (40%) in the first lesson to 15 (60%) and eight (32%) and 16 (64%) in the second lesson and further to 20(80%), 18 (72%) and 21(84%) in the third (final lesson) respectively. In contrast, little changes were noticed in the PTs’ ability to provide “individual task” and “small group task” as a good number of PTs have already performed these actions from the outset (the first lesson observed).

On the other hand, the improved performance noticed in Figure 4.1 were similar in terms of a trend toward improvement overtime in almost all PTs, as is shown in Table 12 using PTs' average scores on a three level rating scale (for details see the performance rubrics in Appendix K).

Overall, the data set presents the picture that progress was made through practice by most of the participating PTs while engaging in the ABIM to implement LCC. During interview and feedback discussion sessions the PTs credited their progress in using ABIM to implement LCC to the reflective workshop sessions and discussions during the feedback sessions held after each observation. The PTs said that they had the opportunity during the reflective workshop sessions to improve their pedagogical skills that are required to support and facilitate argumentation in their respective science classrooms and learn how argumentation-based instructional model can be used as a teaching strategy to effectively implement LCC.

Section Summary

This part of the study was set out to examine the PTs' ability to organize argument-based tasks to implement LCC in science classrooms after they have been exposed to argumentation-based intervention programme. The findings seem to show that an argumentation-based intervention programme had an effect on PTs' ability to structure argument-based task to implement LCC to a certain extent. In terms of the aggregated scores of the domains and performance standards examined (Table 4.12), 10 and five PTs respectively were able to structure argument-based tasks very well (excellent level) and to a certain extent (intermediate level) in the first lesson observed (The phase of the moon). On the other hand, the aggregated score of the domains and performance standards examined for the rest 10 PTs' in the first lesson observed seem to be unsatisfactory (poor). In the second lesson (Mercury) and third (final) lesson observed (heat transfer) while 15 PTs and 19 PTs respectively structured argument-based lesson very well (excellent level), four and five PTs respectively structure argument-based lesson to a certain extent (intermediate level). In contrast, the data displayed in Table 4.12 showed that two PTs poorly structured the tasks even in the third (final) argument-based lesson observed. It is important to note that although the aggregated scores of these two PTs showed that there was no change in the overall practices in terms of organizing the argument-based tasks overtime, it does not mean that they did show improvement in all the performance standards examined in this study.

Taken as a whole, the data set suggests that, as the study progressed a good number of the PTs were able to successfully deploy dialogical argumentation as a framework to:

- Scaffold discussions during small group and whole class intervention.
- Encourage active students' participation in classroom discourse.
- Promote students' understanding of scientific concepts.
- Encourage their students to construct their own scientific knowledge through social interaction.
- Help their students to clear their doubts through reflection.
- Enhance their students' ability to develop high-cognitive thinking skills.
- Create cooperative, collaborative, and supportive learning environment.

This finding is consistent with the findings of other similar studies (e.g., Ebenezer, 1996; Erduran, 2006; Ogunniyi, 2004, 2007a; Osborne, et al., 2004a). These earlier studies also indicate that the interactive classroom arguments and dialogues do help leaners and teachers to clear their doubts, acquire new attitudes and reasoning skills, gain new insights, make informed decisions and change their perceptions.

Another observation made from the above findings is that the various outcomes are interconnected with the salient features of LCC. A plethora of studies in the area of learner-centred curriculum (e.g., Blumberg, 2004, 2008; Lambert & McCombs, 2000; Weimer, 2002) has indicated that LCC encourages active student engagement in the teaching-learning process, fosters learning with understanding, facilitates critical thinking and problem solving skills and tends to encourage a cooperative learning environment just to mention a few. At this stage the tentative conclusion that could be made is that as the study progressed a reasonable number of the PTs seemed to have adopted ABIM to implement a LCC in their science classrooms.

From the forgoing, it is safe to state that considerable progress was made through practice by most of the PTs while organizing the task within the argumentation lesson structure through ABIM to implement LCC. Such advancement or progress seems to link well with the emergent category of CAT (Ogunniyi, 2004, 2007a, 2008b), where new pedagogical skills that are pertinent to organize argument-based tasks in a learner-centred science classrooms were added to the old ones. The improved performance portrayed by Table 4.12 scores were, however, not equally apparent across all 10 performance standards in terms of magnitude (for details see Appendix M). During interview and feedback discussions, the PTs credited their progress in structuring argument-based tasks to the reflective workshop sessions held after each classroom visit round. They said that they had opportunity during these sessions, to share their practice with their peers and accordingly improve their pedagogical skills to structure argument-based tasks to implement LCC in science classrooms. PTs have also credited their progress to the feedback discussion sessions held after each classroom observation. Despite the fact that the majority of them have shown progress over time, very few PTs showed little or no improvements in most of the domains and standard performances examined in all of the three lessons observed.

Hitherto, the PTs' ability to organize argument-based tasks using ABIM to implement LCC was presented and discussed. The sub-section that follows presents findings about the nature of the PTs' classroom talk oriented to the facilitation of argumentation process.

4.4.2 PTs' classroom talk that are oriented to the facilitation of argumentation process

The section aims at determining how pre-service teachers' classroom talk or oral contributions reflect their epistemic goals during argument-based lessons. It also aims at examining the effect or otherwise of PTs' argumentation skills on their ability to use ABIM to promote and sustain argumentation in a learner-centred science classroom. To illustrate this analysis in detail it requires a deeper qualitative analysis of the lesson transcripts, hence the focus of the analysis has been on a small number of contrasting cases. Thus, it was decided to report only on two groups consisting of three PTs each.

PT12, PT13 and PT16 (Group A) were selected because they not only constructed high level arguments (arguments with rebuttals), but also had participated actively in argumentation discourse, generated rebuttals to a certain extent to weaken opponent's arguments during small group and whole classroom discussion and had reasonably good understanding of scientific argumentation at the post-test. In contrast, PT2, PT5 and PT23 (Group B) were selected because they not only constructed low level arguments (arguments with no rebuttals), but also had demonstrated little to no engagement in argumentation discourse during small group and whole classroom discussion and had limited understanding of scientific argumentation at the post-test, (see Tables 4.4 to 4.9 and Appendix J, episodes 1-9).

Below the profile (vignette) of the six selected cases is presented.

PT12 was a 22 year old, female pre-service science teacher. She joined the Department of Science Education at the College of Education immediately after post-high school and had no teaching experience before. PT12 was observed to express her view freely to the small group and whole class discussion. She often attempted to convince the group by using persuasive language and by providing plausible examples. Apart from that she was observed to be confident and proficient in English language. Because of her calibre she was nominated by her group to present the group's discussion although she was not a group leader. PT12 was devoted to perform all the tasks targeted for the training programme with great interest.

PT13 was a 38 year old, male pre-service science teacher enrolled in the teaching practice course in the Department of Science Education, College of Education. Before joining the College of education he had received a teaching certificate from ATTI and had 11 years teaching experience at elementary school. PT13 had leadership ability and participated actively in all tasks and activities targeted for the intervention programme. During small and whole class discussions PT13 attempted to generate arguments and counter arguments/rebuttals. In general, PT13 was an outstanding group leader and was observed to be an outgoing participant who was happy to participate in small group classroom discourses and in whole-class discussions, although he made no attempt to dominate the discussion.

PT16 was a 23 year old, male pre-service science teacher. He joined the Department of Science Education at the College of Education straight from high school and had no teaching experience before. Although he was in his young age PT16 had shown matured personality throughout the study. He fully participated in all tasks and activities targeted for the intervention programme diligently. He was also observed to use specified scientific and persuasive language in many of his oral contributions to class discussion. Throughout the study he was keen enough to learn new things and to share his personal experiences with the group. He also tended to empower the members of the group to express their personal views. Generally, PT16 was observed as a confident participant, although he made no attempt to dominate both group and whole class discussions.

PT2 was a 20 year old, male pre-service science teacher. He joined the department of Science Education at the College of Education straight from high school and had no teaching experience before. PT2 maintained high attendance rate during the intervention training programme and in the teaching practices period. However, his involvement during group and whole class discussion was minimal.

PT23 was a 34 year old, male pre-service science teacher registered in the teaching practice course in the Department of Science Education at the College of Education. He was a former graduate of ATTI and had been working as a teacher for 11 years in elementary schools before joining the college of education. PT23 maintained high attendance rate during the intervention training programme as well as in the actual teaching practices session. Despite all his commitments and enthusiasm he was not observed of being able to participate actively in both small and whole class discussion.

PT5 was a 21 year old, female pre-service science teacher. She joined the department of Science Education at the College of Education immediately after she completed secondary school education and had no teaching experience before. Like PT23, PT5 was a quiet participant and was observed to seldom express her view within the group and during whole class discussion.

As stated earlier, the PTs' oral contributions were determined by conducting classroom observation and by viewing video materials for each of the three argument-based lessons focusing on how each of the six selected PTs facilitated the process of argumentation. Data obtained from observation check list and from the lesson transcripts of each of the three lessons taught by each of the six selected pre-service teachers were analysed using a coding scheme and categories of argument processes developed by Simon and his team (Simon, et al., 2006). The codes were further grouped into eight categories of argument processes. These are: talking and listening, defining and modelling good argument, positioning, justifying with evidence, constructing arguments, evaluating arguments, counter-arguing and reflecting on argument process (see Appendix L). The presence or absence of each of these eight categories of argument processes reflected by each of the six selected pre-service teachers during each of the three argumentation lessons is illustrated in Appendix N. Below the pre-service teachers' classroom talk/oral contributions teachers' reflected in each of the eight categories of argumentation will further be qualitatively analysed and discussed. This will be supplemented by the data drawn from pre-service teachers' interviews and reflective responses and from individual feedback discussions held after each classroom observation.

Talking and listening

The act of talking and listening is crucial in the process of argumentation. Within this premise, teachers have to encourage their students to share their views (talking) and listening to other's views during small group and whole classroom discussion. A perusal of the table in

Appendix N showing the occurrences of categories and codes of argument processes utilized in the PTs utterances reveals that two out of the six PTs reflected the goal of ‘students listening’ from the onset. For example, in his first lesson PT13, a pre-service teacher who had 11 years teaching experience said,

> *Your attention please, I want you to understand that your emphasis should not be to win the argument; rather you need to share and discusses your ideas within your groups to reach a consensus. To do so, I encourage you to listen attentively to what the other members of your group are saying. I want you to know that the extent of your engagement in argumentation process within your group and in whole class discussion depends on how seriously you listen to the other’s argument.*

In his second and third lesson PT13 did not give much emphasis to this category as he did in his first lesson. Instead he reminded them: *students don’t forget to listen to other’s ideas or comments.*

During follow up interview, when asked why he did not emphasis**e** on reflecting the goal of student, listening, PT13 said:

> *I believe encouraging students to listen to each other’s arguments is vital in argumentation process. However, I felt that I have already grounded that skill in the first three weeks’ duration of the teaching practice period. Also, I felt that if I keep on repeating the same things time and again the students might be fatigued.*

PT12, a 22 year female pre-service teacher also demonstrated the goal of students listening in her first lesson (phase of the moon) but she did not give much attention as she did in her second lesson. She just informed them: *Ok students don’t hesitate to air out your idea but you also need to listen to your peer’s idea.* She then proceeded to another talk. As displayed in the table in Appendix N her improvement from the first lesson to the second subsequent lesson is not apparent, as it illustrates she had demonstrated such goal from the outset. However, she foregrounded this goal strongly in her second lesson**.** PT12 encouraged purposeful listening by asking students what other students have said. Below is a snapshot of the conversation between PT12 and five of her students.

PT12: *Alright, who can tell me how Petros defend his claim “ Mercury is a metal”*

Solomon (S1): *Yes teacher, he said mercury is a metal because it is a good conductor of electricity.*

PT12: *Did Petros offer one evidence for arguing that Mercury is a metal or did he give more than one? Who can tell me, Rachel can you try?*

Rachel (S2): *Yes teacher, Petros provided one evidence.*

Dawit (S3): No, no…Petros provided two evidences.

PT12: Can you tell me the second evidence?

Dawit (S3): Yes, it has a d- orbital

PT12: Did any one generate a rebuttal to weaken Petros's argument?

Solmon (S1): Yes, Alamz did

PT12: Nahom give me one thing that Almaz said to counter-argue Petros' argument

PT12's practice of encouraging students to listen to each other's argument extends the discussion beyond the common pattern where the teacher listens to one response, assess it, and proceeds to another question (see Lemke, 1990) that dominated much discourse in a science lesson. While asking students to articulate Petros's evidences and rebuttal, PT12 was encouraging purposeful listening, an action which many students did not practice during the discussion or dialogue. This approach was not common in other PTs' instructional practices.

When asked how PT12 changed her practice of encouraging students to listen she gave credit to her own professional development. She indicated further that implementing an argumentation-based instructional model increased her consciousness about what she was saying, what she was trying to achieve in her teaching and what was happening in the classroom. She further noted that:

> *I observed many students talking to each other but not been engaged in a meaningful dialogue and not being aligned to the task given then I decided that I have to use another strategy in the successive argumentation lessons to bring them to the track.*

From the foregoing, it is evident that both PT13 and PT12 attempted to reflect the goal of student listening in their classes. Yet, PT12 demonstrated more advanced approach in her second lesson than was the case in her first lesson. Her attempt to try a new approach is probably an indication of teacher change (Loucks-Horsely, Hewson, Love, & Stiles, 1998). PT2, a 21 year male pre-service teacher is one of the PTs who were not able to reflect the goal of students listening in their first lesson (see the table in Appendix N). When asked why he did not attempt to encourage his students to listen to each other's idea during argumentation he noted that:

> *I remember during the intervention programme we have discussed about listening and its role in facilitating argumentation process. However, I did not value its importance… I also felt that I don't have enough skills to apply it in my class.*

This seems to show that PT2 had limited pedagogical knowledge and skills that could enable him to demonstrate the goal of listening to develop the associated process in his students' arguments. It is worthy of note that similar problems were also observed in the lessons of other pre-service teachers. However, there is sufficient evidence that shows that after their involvement in the reflection sessions they seemed to have been empowered to engage their students in purposeful listening. For example, PT2 attempted to encourage his students to listen to other's ideas or views by explaining the value of purposeful listening in facilitating the process of argumentation. The following excerpt is taken from his third lesson on "Heat transfer".

> *Can anyone tell me the importance of listening? Semira can you try? Em…I have no idea. Who can help her? ….Let me tell you then. Attention please…This is very important. If you want to engage in meaningful argumentation you need to listen to each other's ideas or arguments…. You can only attend your opponent's argument if you begin to listen to what the opponents are saying. Therefore, I encourage you to listen to the claim articulated by others and suggest evidences and argue for or against the claim made.*

It follows that after participation in the reflection session PT2 seemed to have developed a new pedagogical skill in terms of understanding and insights about the role that purposeful listening could play in implementing meaningful argumentation in small or whole class discussion. It is safe to suggest his involvement in the study has eventually resulted in a progressive perceptual shift concerning the value of purposeful listening in facilitating an argumentation lesson. According to the CAT, he has developed an emergent view having been exposed and having developed new understandings on a topic/concept of which he had little to no prior experience.

2. Knowing the meaning of argument

As displayed in Appendix N, the majority of the participating PTs attempted to address the goal of knowing the meaning of argument in their second and/or third lesson by defining the meaning of argumentation and associating it with the argument-based task outlined for the day's lesson. For example, PT5, a 21 year female PT did this in the introductory part of her second lesson on "Is Mercury a metal or non-metal?"

> *PT5: attention please! Today's task is to argue for or against the claim "Mercury is a metal" and justify it by providing reasons/evidence. Before that I want you to know that an argument is more than striving to get the right answer to the question given.*

An argument is an instance of reasoning that attempts to justify a conclusion by supporting it with reasons or defending it from objections.

Other PTs attempted to define scientific argumentation in their first lesson observed. For instance, PT16 demonstrated this goal when he outlined the argument-based task on phases of the moon in an attempt to link the task with the work of scientists:

PT16: Scientists investigated the universe in all sorts of ways. Some depend on experiments, others on observational studies. Still others cast doubt on an established theory. But despite all that diversity, the aim of science remains unchanged — to build more accurate and powerful natural explanations of how the universe works — and that requires testing ideas with evidence to build scientific arguments. In line to this, we are going to work on a set of argument-based activities in this semester to generate scientific arguments. (First lesson observed)

In his second and third lessons, PT16 addressed this goal by *exemplifying* argument. The following excerpt is taken from his third lesson:

Today we are going to work on the snowmen activity. Let me give you an example on how you are going to articulate your thoughts…… Some of you may support the idea 'Fred will melt first' [claim] because he is not wearing any coat [evidence]. He will get direct heat energy from the sun [warrant]. Others may argue against Fred's idea.

PT16's development overtime is not apparent as he addressed this goal right from outset (see the table in Appendix N). However, a close analysis of his oral contribution reveals that PT16 attempted to change his strategy from defining an argument to exemplifying/ modelling an argument. PT13's approach was rather different. He tried to address this goal beyond defining argument and attempted to inform his students about the centrality of argumentation in science learning and in constructing scientific knowledge claim. PT13 did this towards the end of his third lesson. Below is a snapshot of the conversation between PT13 and his students.

PT13: So far we have done several argument-based tasks. Can any of you tell me the importance of argumentation in learning science.

Sara(S1): To support or oppose someone's claim.

PT13: Any other reason why we need to use argumentation in science classrooms? Letet (S2) can you tell me why we are using argumentation in our lessons?

Letet (S2): To articulate our opinion and if possible to change the mind of the opponents using persuasive language.

PT13: Wow!! You said persuasive language…Very good. The main reason why we are incorporating argumentation in our lesson is to help you move from memorizing scientific concepts to building your own idea through purposive critics and dialogue. This in turn will help you to promote your understanding of scientific concepts.

The above conversation shows that PT13 encouraged his students to develop an understanding of a strong argument in an extra ordinary way. None of the participating PTs had demonstrated the goal of knowing the meaning of argument in such a way. Additionally, it seems that PT13: (a) had well informed understanding of the importance of scientific argumentation in science teaching and (b) is aware that argumentation provides a platform for students to construct their own knowledge through discussion, a view foregrounded by the constructivist theory of learning (e.g., Driver, et al., 2000; Grace, 2005; Jimenez-Aleixandre, 2008; Kolsto, 2006; Mercer, 2000).

Positioning

Appendix N discloses that all the six PTs used positioning as a strategy to facilitate argumentation, which is an indication that they had assimilated this goal in their teaching practice. PT12 informed her students to take position during the individual task and small group task in her first argumentation lesson on phases of the moon, as shown in the excerpt below:

You are given five alternative ideas that explain why the moon has different phases. Read each of them carefully and decide individually which of the explanations is the best and then share your position within your small groups. You need to provide evidence to support your position

Some PTs encouraged their students to take position during small group discussion, but placed little to no emphasis on this goal during the individual tasks. For example, PT23, a 34 year PTs with 11 years teaching experience manifested this goal after the small groups did preliminary thoughts in the second argumentation lesson observed.

PT23: Ok students you have done initial brainstorm exercise in your groups. Now you need to decide and take position to say yes mercury is a metal or no, mercury is not a metal. In any case don't forget to back up your position with evidence(s).

When asked why he did not encourage the students to take a position at the individual level PT23 indicated that he was not aware that argument could take place at the individual level i.e. what Ogunniyi (2007a) calls self-conversation or intra-argumentation. I was surprised by his responses as we had done a serious of argument-based tasks at individual level, small group level and whole class level of interactions during the intervention training. At this stage his view seems to be in sharp contrast with the view of many science educators (e.g., Billig, 1987, Driver et al., 2000; Ogunniyi**,** 2007a) who have asserted that argumentation could take place as an individual activity, through thinking and writing, or as a social activity taking place with a group- a negotiated social act within a specific community.

After a while, PT23 was observed to progress from not being able to encourage his students to take a position on a subject matter during individual task in the first lesson (see Appendix N) to being able to address this goal frequently in the second and third lessons at the individual task level as well as at the small group-task level. When asked why PT23 attempted to demonstrate the goal of positioning during individual task and small group tasks in the third (final) lesson observed, he stated that it was only after the reflection workshop sessions that he was aware that argumentation could take place at the individual level, in small groups and across the groups.

Pedagogical strategies, such as debating, inevitably involve positioning. During a debate, students take position and argue for it and counter-argue to weaken their opponent's idea. PT13 grounded the goal of positioning more explicitly in the debating session of his third argumentation lesson on the two snowmen activity, for example, when some of the small groups encountered difficulties in deciding what their position was:

> *PT13*: *I can see that your discussions are grounded on the basis of your scientific knowledge and personal knowledge. In your discussions you have mentioned three points: (a) heat transfers from hot to cold body (a) woollen coats are insulators or poor conductors of heat and (c) a peace of ice covered with a plastic or any other staff will take some time to melt than a piece of ice which is not covered. With this understanding you need to decide to argue in favour of Fred's argument or Birt's argument. I feel that you cannot believe that the snowman who is wearing a coat will melt first.*

Justifying with evidence

The PTs used different ways to encourage students to justify their claim or argument with evidence. They attempted several ways to encourage their students to justify their claims with evidence. Some of them modelled the goal of justifying with evidence by *providing evidence in response to students' ideas or views*. The excerpt below taken from the lesson of PT5 (first lesson observed) on phases of the moon typifies this goal:

PT5: Now I want to remind you that the moon is a non-luminous body. Isn't it? Yes, it is (student response). Non-luminous bodies do not produce their own light. Do you agree with me? Yes, I agree. They get light from luminous bodies (student response). The moon does not give out light. Does it? It doesn't (student response). Actually the light that comes from the moon is the light that is reflected from the sun.

Some of the PTs attempted to address this goal by making their students aware that they could use different sources to back their claims. For example, PT13 spent the first part of his lesson on phases of the moon by guiding her students *to know* if they had adduced evidence to support their claims:

Last week I told you to refer books from the library on phases of the moon. I am expecting that you have consulted some science books and you may have acquired some knowledge about the three phases of the moon. You may have also asked your parents or elders in your community about why the moon has different phases and had an insight on how elders interpret natural phenomena in relation to their culture or traditions.

All the six PTs used *argument-prompt* questions to help students to justify their claim. PT23 used this strategy in all the three lesson observed. For example in the second lesson observed he posed the following argument prompts: *how do you know that mercury is a metal? What is your evidence? Can you suggest alternative explanations for your claim?*

Two of the six PTs were observed to *play the devil's advocate,* a technique that encourages students to extend their justification for their claims or arguments. PT13 demonstrated this strategy during whole class intervention in the third lesson observed by suggesting contrary views: *Birt will melt first because he is wearing a coat. It is the same of a human wearing a coat to stop heat escape from their bodies (third lesson- heat transfer: task on the two snowmen).*

Constructing arguments

Appendix N illustrates that all the six PTs manifested the goal of constructing arguments to engage students in the associated process, showing that they had clearly integrated this goal within their practice. Data displayed in the table in Appendix N showed that most of the PTs reflected the goal of constructing arguments in their second and third lessons by either asking students to construct their arguments on paper using writing frame or asking them to prepare presentations of arguments. For example, in her second lesson observed, PT5 guided her students to construct arguments using a writing frame.

Today we are going to argue for or against the claim "Mercury is a metal". I am going to give you a worksheet and you are going to fill it in as you discuss this issue within your groups. In the worksheet you are provided with another example of a writing frame that will help you to construct your arguments.

PT5 did also encourage her students to present group's discussion points to the whole class (see Table 4.12).

In contrast, PT2 reflected the goal of constructing arguments using writing frames in the first lesson observed. However, he did not encourage students to present group's discussion points to the whole class. When asked why he did reflect this goal, he responded that:

Well in my lesson plan I have indicated that some of the groups will report back to the whole class. Nonetheless, I couldn't make it in the actual classroom because I spent quite a lot of time with individual groups to help them articulate their arguments in a more structured way and fill it in the worksheet provided. Hence, I could not get time to ask the groups to present their argument.

Some of the PTs used both writing frame and presentations to engage students in the construction of arguments from the outset, which PT16 did it in the first two lessons observed. In his third lesson observed, however, he attempted to use extended writing frame to help students construct better and more convincing argument, as indicated in the excerpt below:

PT16: let me introduce the task of formulating a better, more convincing argument using an example of the two snowmen activity worksheet. I am going to provide you with pieces of evidence in order to help you think and discuss about how to be persuasive. The main objective is to enhance your skills of argumentation through construction of written argument. Let me read the stem or initial prompts on the worksheet relevant to the snowmen argument.

PT16 made use of presentations by using envoys across groups and allowed some groups to report back to the whole class to extend their ability to construct arguments. PT16's development overtime is not apparent in the table in Appendix N, as it shows he had addressed this goal from the outset, but he made this goal more explicit by providing initial prompts that encouraged students to construct extended arguments during 'pair task' and 'pair to four task' in the third lesson.

Evaluating argument

Three out of the six PTs demonstrated the goal of evaluating argument in all the three lessons, showing that these PTs had clearly assimilated this goal within their practice. This implies that the three PTs seem to recognize the importance of evaluating arguments and thus attempted to develop the associated processes in their students' argumentation.

While PT13 focused on the importance of evidence, PT12 emphasized on the nature of evidence. PT16 did both of these things. For example, the following excerpt taken from PT13's second lesson observed illustrates how he demonstrated this goal:

> *So far we had done many argument-based tasks. Today I am expecting each one of you to construct a good argument in favour or against the claim: 'Mercury is a metal?'. As a reminder I want to highlight that a good argument involves multiple evidences.*

As indicated above, PT16 exhibited the goal of evaluating arguments focusing on the importance of evidence and on the nature of the evidence. For instance, during the individual and small group task of the first lesson observed, PT16 gave emphasis on the importance of evidence as the following excerpt typifies.

> ***PT16***: *I want each one of you to select the best statement which explains why the moon has different phases from the five alternative statements provided and support your choice with evidence. Then share your argument with your respective groups and try to evaluate the arguments constructed by each member. As a point of reference you need to consider that a good argument consists of at least one evidence.*

In his second and third lesson, PT16 did both, that is, he evaluated argument process using evidence and evaluated the content of the argument using the nature of evidence. In his third lesson, while interacting with the small groups, PT16 focused on evaluating the process of argument. His talk demonstrates this process:

> *One major characteristics of a good argument is the presence of evidence(s). With this understanding, whose argument do you think is a good argument Fred's or Birt's? Give your reasons as evidence(s) and provide justification to link your claim with evidence.*

PT16 exhibited the goal of evaluating the content of argument more explicitly towards the end of the third lesson observed. In organizing the whole class intervention, his talk modelled the process of producing a strong argument.

> *PT16: Students pay attention please. This is the time to report back. Four groups, two in favour of Fred's argument and two in favour of Birt's argument will be presenting to the whole class. You need to listen carefully in order to either argue for or against the arguments articulated by the groups. Before starting the whole class intervention let us spend some time discussing on what makes a strong argument.*

PT16: From your point of view what makes an argument a good argument?

S1: The presence of evidence

PT16: Yes, we need to include evidence

PT16: Why do we need to include evidence, Eden?

S2: To back up or support our idea

PT16: What else do you think you need to include in a good argument? Awet can you try

S3: Emm……….(noded his head)

PT16: Any other one who can try?

S4: You need to include facts

PT16: Very good Jemila. You need to include facts to support your claim

PT16: What else do you need to include?

S5: You need to use persuasive language

S6: You need to be persuasive. You need to try and make people agree with what you are saying.

PT16: Alright, what makes an argument weak or what makes an argument not a good one?

S7: Emm… I think if it does not include evidence.

Although the focus of the above discourse is on evaluating argument, there is an indication which shows that PT16 have also extended the notion of the meaning of argumentation beyond defining and exemplifying it. Such practice was not common in lessons of other PTs. For instance, three out of six PTs (PT2, PT5 and PT23) did not display any evidence at all of being able to help their students evaluate their own arguments and the argument of their peers in all the three lessons observed.

Counter-arguing/debating

One of the skills of arguing is being able to argue against somebody else's idea. An examination of Appendix N reveals that PT2, PT5 and PT23 did not exhibit the goal of counter-argument in all the three lessons observed. Rather they placed more emphasis on encouraging students to engage in constructing counterclaims or oppositional claims, which are considered as the simplest kind of arguments against other's arguments. On the other hand, the data illustrates that while PT13 and PT16 reflected the goal of counter-argument in all the three lessons, PT12 demonstrated this goal in her third lesson only by asking students to think of an argument that could possibly weaken the opponent's argument. The excerpt below illustrates how PT16 demonstrated this process in the first lesson observed:

PT16: Although it is important to support your idea with evidence you need also to anticipate oppositions or alternative ideas from your opponents. For example, if your group suggested that statement A is the best statement that explains why the moon has different phases and the other groups suggest statement B as the best explanation you need to generate arguments that weaken the other group's argument or demonstrate how the other groups' idea, warrant and backing are false. Such kind of argument is called counter arguments.

PT16 also exhibited this advanced goal later during whole class intervention. He encouraged two groups to report back to the whole class and the rest to construct arguments for or against the two groups' arguments. The following oppositional episode with rebuttals taken from PT16's first lesson is indicated below:

Group 2: Card 'A' is the best explanation because we know that the moon rotates around its own axis. Therefore, the part of the moon that gives out light is not always facing us.

Group 3: Card 'D' is the best explanation because we cannot always see all the part of the moon which is reflected by the sun. This natural phenomenon happens due to the motion of the moon around the earth.

PT16: Ok you have heard group 2's and group 3's arguments. Now it is the time to argue for or against these arguments.

Group 1: The moon does not give out light (rebuttal to argument from group2).

Group 5: In reality the light that comes from the moon is the light that is reflected from the sun (rebuttal to argument from group2).

Group 6: The moon is a non-luminous body. It does not produce its own light (rebuttal to argument from group 2).

Group 4: The moon moves in and out of the earth's shadow. That is why we cannot see always all the part of the moon which is lit up by the sun" (rebuttal to argument from group 3).

When asked why he demonstrated the goal of counter argument from the outset, he replied that:

I value the importance of encouraging counter-argument as it has the potential to undermine the force of the supporting argument. Unlike counter-claim which simply provide an oppositional claim, counter-argument demonstrates how the other person's data, warrant and backing are false. Such approaches will help students to develop higher-order cognitive thinking skills such as critical thinking and problem solving.

From the above excerpt, two important points can be deduced. It seems that PT16: had sufficient pedagogical skills to: (a) motivate counter-arguments in facilitating argumentation, (b) demonstrate the goal of counter-arguments and thereby, develop critical thinking skills of students. His view is well documented in the extant literature (e.g. Driver et al., 2000; Erduran et al., 2004; Osborne et al., 2004; Osborne, 2010; Simon et al., 2003, 2006).

As indicated above, PT12 did not exhibit the goal of encouraging counter-argument in the first and second lessons observed. In the third lesson observed, however, she attempted to demonstrate this goal more explicitly during the whole class intervention.

> *PT12: If someone else has different idea from your point of view you need to think about his/her argument and try to give reasons why he/she is not right. We call this counterargument. Today we are going to practice this process of argument in the whole class intervention. …… Alright from their arguments you have realized that groups 1 and 3 are in favour of Fred's argument. They attempted to justify that Fred will melt first. Ok. Groups 2, 4 and 5 it is your turn now. What would you say to make their argument weak or a bit faulty (Lesson three observed).*

Her development overtime is apparent in the data displayed in the table in Appendix N, as it shows that she had such goal only in the third lesson. When asked how she changed her practice overtime she gave credit to the feedback discussion and to the reflective workshop sessions. She said that:

> *In the first place I did not value the importance of encouraging students to counter-argue. The feedback discussion and reflective workshop session one helped me to realize the importance of this goal but I could not demonstrate it in the second lesson as I did not have enough skill to do so. Later the best practices presented in the second reflective session and the models/examples provided by the researcher helped me to gain confidence and enabled me to apply it in my third lesson.*

From the above data it is evident that PT12 had shifted her perception about the importance of counter arguments in the light of the new knowledge acquired in reflective session one and during feedback discussion. In addition, she had improved her pedagogical skills on how to demonstrate this goal overtime. The shift of perception and the new pedagogical skills for PT12 can be placed under the emergent category of CAT. The emergent category refers to a situation where a new knowledge claim emerges as the individual is exposed to more compelling or convincing information. This pre-service teacher was exposed to best practices that incorporated pedagogical knowledge and strategies which are likely to have influenced her change of perception and practice.

The interview response data reveals that some participating PTs seem not to recognize the importance of counterargument in facilitating higher level argumentation discourses in science classrooms. A typical example of this type of response was that of PT2 who asserted that:

> *Teaching students to generate counter-arguments requires a lot of time. What I mean is, if much of the instructional time is spent in teaching students to construct counter-arguments, students will not be able to grasp the important concepts of science which they are supposed to.*

It seems that PT2 did not understand the positive impact of argumentation on students' conceptual understanding of scientific concepts (e.g., Cross, Taasoobshirazi, Hendricks, & Hickey, 2008; Venville & Dawson, 2010; Zohar & Nemet, 2002).

Other PTs are of the opinion that it is too early to expect students to generate counterarguments as they don't have even the basic skills of constructing arguments. The PTs seem to believe that generating counter argument requires advanced skills and such advanced skills can only be acquired through prolonged practice. For instance, PT5 said:

> *In general, argumentation instruction is a new practice for me and for my students. On top of that constructing counter-argument that successfully weaken the force of other's argument is a challenging task and time consuming. Therefore, I decided to focus on encouraging students to construct argument.*

Still a few PTs seem to discourage their students from disagreeing or generating counter-argument. For example, in the second lesson observed, PT23 did this. He invited the students to argue for or against the claim 'Mercury is a metal" in their respective groups. Majority of the students were in favour of the claim and provided evidences such as: mercury is a good conductor of electricity, It has shiny appearance, has a d-orbital. On the other hand, few students were not in favour of the claim 'mercury is not a metal'. For example, a student said that I want to disagree with the groups who argue that Mercury is a metal. PT23 responded that:

PT23: No, you can't they have supported their claim with appropriate scientific evidences

S: Please,… teacher give me chance. I will also support my argument with evidence

PT23: No, no (shouted) don't waste our time, you have to accept what the majority have agreed.

Although the student intended to open a room for discussion PT23 seems to discourage him to rebut the claims or to produce further evidence in the face of opposition. One would expect more rebuttals in discourse were there are episodes of oppositions and counter-arguments, as disagreement can be established through rebuttal of an opponent's idea. Furthermore, opposition generates the need to define a claim, forcing opponents either to use evidence or, more of it or to elaborate their backing and warrants. Thus, no wonder the argumentation in PT23's classroom was likely to include few rebuttals and backing. His prior teaching experience, which is highly teacher-centred, could probably have influenced his practices.

Reflecting on argument process

The PTs' attempt to enhance the process of reflecting on argumentation process was not common, as the majority of the participating PTs did not assimilate this goal within their practices. Nonetheless, there is sufficient evidence that shows that few PTs exhibited this goal successfully. Some of them demonstrated the goal of reflection by asking their students to evaluate the process of argument and others asked their students to indicate if they have changed their position or mind as the result of the discussion. In the first lesson observed, PT12 asked her students to reflect on the process of argumentation that took place during the lesson as the excerpt below exemplifies:

> *PT12: In the introductory part of the lesson I stated the learning goals of the lesson. Do you remember? I said 'the major goal is to help you develop the skills of argumentation that will enable you to construct better argument and challenge other's argument'. Do you think that we have achieved the intended learning goals? What is your reflection on the general process of argumentation that took place in this lesson? Was it simple or challenging experience for you? Did you realize what I was doing? I continually questioned you what you were saying by posing questions such as (what is your evidence? How do you know? Why?) to help you construct better argument. Did you notice that I repeatedly asked you to supply evidences or reasons to back up your arguments?*

In the second and third lessons observed, PT12 emphasises more on encouraging her students to reflect by asking them about mind change they had experienced as the result of the small and whole class discussions. During the small group discussion she did this in a structured way:

> *PT12: I encourage each one of you to share your view within your groups and evaluate each other's view. If you came up with different views, then each one of you should use strong arguments and persuasive language to change each other's mind/view within your group.*

While conducting whole class intervention, PT12 asked the students: how many of you have changed your mind or your position? Why did you change? Whose ideas influenced you more?

Teachers would at some point encourage students to change their mind or position themselves either individually or as a group, for example, as PT16 did it in pair, pair to four and whole class intervention in the third lesson observed:

PT16: did any one of you change his/her position as the result of the discussion within your respective groups? Did any one of you manage to change the prior position of someone?

S1: Yes I managed to change the position of Michel during pair discussion

PT16: Can you explain how you persuaded him? Or convinced him to change his position?

S1: To be frank it was not so easy to convince him because he strongly argued that 'Birt will melt first because he is wearing a coat and hat and this will make him to worm and melt first'. My position was the opposite. I argued that Fred will melt first because he is getting direct heat energy from the sun through convection and radiation. This will make him melt faster. Michael continued to argue that No, Birt will melt first, it is the same like wearing a jacket will make us worm. My counter-argument was 'I don't agree, It is the reverse of human wearing a coat to stop heat escape from their bodies'. Towards the end Michael changed his position and pointed out that I think you are right because if we cover a cube of ice with a piece of cloth it needs some time to melt than uncovered cube of ice.

During whole class discussion PT16 stated that:

> *PT16: Students pay attention please. I want to inform you that it is appropriate to change your mind or position when you are confronted with compelling argument or when you find someone else's argument is more logical and reasonable than your own.*

This finding is resonant with the general assertion which shows that when people are confronted with new evidence they could choose to reject or accept the evidence based on the strength of the advanced evidence. They could also choose to conciliate or compromise their original idea (Leitio, 2000).

In contrast, some PTs were observed to discourage students from reflecting on the process of argumentation, as PT23 did in his second lesson.

S1: teachers I want to inform you that the chair person dominated the discussion in our small group discussion. Even if we support our arguments with evidence he did not consider it. I can say that what was presented to the whole class on behalf of our group is rather his own ideas. Would you please advise him not to do so in the next task?

PT23: If your opinion does not have any contribution towards answering the question, what do you expect him to do.

S1: Teacher you can ask other members of the group if you don't trust me

PT23: please don't raise none sense questions Ok.

Interpretive summary of PTs' classroom talk oriented towards the facilitation of an argumentation process

Appendix N shows categories and codes of argument processes demonstrated in the utterance of each of the six selected PTs across the three lessons observed. It also indicates the categories and codes of argument processes that were not reflected by some PTs. If PTs exhibited these codes, it is an indication that they attempted to develop the associated processes in their students' argumentation. For example, if a pre-service teacher demonstrated the goals of encouraging 'counter-argument' in his/her teaching, it is an indication that he/she believes that this code is an important process, reinforces the findings of (Aguirre & Speer, 2000; Emest, 1989; Standen, 2002; Thompson, 1992) who examined the relationship between teacher beliefs and teacher practice in science and mathematics education. These authors reported a high degree of agreement between teacher beliefs and the practice of teaching and further asserted that teachers' practice is greatly influenced by their belief about the goals of teaching and learning science.

Appendix N reveals that all the six selected PTs attempted different mechanisms or categories of argumentation to develop the associated processes in their students' argumentation. A close examination of the lessons of the six selected PTs discloses that three of the six selected PTs (PT12, PT13 and PT16) have demonstrated all the eight categories of argumentation process outlined by Simon and et al. (2006) to develop the associated processes in their students' argumentation. This implies that these three PTs attempted to use full range of categories of argumentation to facilitate argumentation process in their respective classes. On the other hand, the rest three PTs (PT2, PT5 and PT23) did not exhibit all eight categories of argument processes examined for the purpose of this study.

It seems that the three PTs above have shown only a limited appreciation of the full range of goals identified in PT12, PT13 and PT16's lessons. This is supported by the fact that PT2, PT5 and PT23 exhibited only four out of the eight categories of argument processes to scaffold and keep argumentation going. The result further discloses that these three PTs show a narrower range of higher order talk as they did not show any evidence of being able to demonstrate the goals of encouraging students to construct counter-arguments to evaluate and reflect on the process of argumentation. From the forgoing it seems evident that while some of the PTs appreciated and exhibited full range of categories others did not show evidence of being able to demonstrate full range of goals identified in the other PTs.

In the analysis of the six PTs' use of oral contributions that facilitated argumentation, two important points relating to the use of ABIM in implementing LCC surfaced. On one hand, there is sufficient evidence that show that all the six selected PTs attempted different mechanisms or categories of argumentation to implement LCC in science classrooms. On the other, the three PTs (PT12, PT13 and PT16) who demonstrated all the eight categories of argumentation process to scaffold and sustain argumentation employed more elements of LCC that are associated within the categories and therefore, were observed to implement LCC very well when compared with the other three PTs (PT2, PT5 and PT23) who exhibited only four categories of argument processes. PT2, PT5 and PT23 not only implemented narrow range of categories of argument processes but were also unable to encourage their students to develop high-order thinking skills such as evaluation, reflection, which are highly recommended in learner-centred pedagogy.

Contrasting all the six selected PTs' lessons, it became evident that there were differences in emphasis that were reflected in the PTs' classroom talk in the lessons observed. A critical difference between (PT12, PT13 and PT16) and (PT2, PT5 and PT23), among others, was in their emphasis on counter-argument. PT13 and PT16 introduced counter-argument in small group and/or whole class discussions from the onset, whereas PT12 manifested this goal only in the third lesson observed. Thus, it is evident that while PT12's development from lessons one and two to lesson three was apparent, PT13 and PT16 development from lesson one to lesson two and then to lesson three was not apparent because they exhibited the goal of counter-argument from the outset (see Appendix N). Yet they placed more emphasis on this process in the whole classroom discussion in the successive two lessons. In addition, PT12, PT13 and PT16 encouraged their students to throw arguments and counterarguments at each other during the open whole group discussions. These PTs were able to mediate whole class intervention following group presentation (see Table 4.12).

PT2, PT5 and PT23 however, did not encourage the goal of constructing counter-arguments or generating rebuttals to weaken the opponents' view or arguments in all the three lessons. PT23 even discouraged his students to disagree with some groups who presented their argument to the whole class in his second lesson. These three PTs rather focused entirely on encouraging students to justify their knowledge claim using evidence and warrant to produce a wide range of arguments. The absence of counter argument from PT2, PT5 and PT23's classroom talk could therefore, be the possible explanation for not mediating whole class discussion in their teaching (see table 4.12), which is an essential phase of an argumentation-based lesson.

Analysis of PT2, PT5 and PT23's interview responses provides further insights for why they did not reflect the goal of counter-argument across the three lessons. These PTs responded that they did not value the importance of counter-argument in generating strong argument. They were of the view that it is rather important to devote much of the instructional time to encourage students to offer evidence that substantiate their knowledge claim than to encourage students to construct counter-arguments which is quite beyond their capacity. From their responses it seems evident that their practices were influenced by their belief. This findings reinforces the results of earlier studies (Aguirre & Speer, 2000; Ernest, 1989; Standen, 2002; Thompson, 1992) that have shown the relationship between teacher beliefs and teacher practice.

Another critical difference between (PT12, PT13 and PT16) and (PT2, PT5 and PT23) was in their emphasis on reflecting the process of argument. PT12, PT13 and PT16 encouraged students to reflect on the process of argumentation employed in the day's lesson from the onset. They also initiated students' reflection ability by asking about change of position or change of view they had experienced as the result of the discussion that took place in the small group and whole class intervention. These PTs seem to be aware that reflection is an essential element and an integral part of learning (Kolb, 1984; Schon, 1983) and is the key to learning from experience (Schon, 1983; Johns 2000; Baumgartner, 2001). PT2, PT5 and PT23, however, entirely omitted the goal of reflecting the process of argument from their teaching in all three lessons.

The absence of the goal of reflecting the process of argument from the PTs' utterances suggests a possible explanation for the difference between the mechanism which PT2, PT5 and PT23 employed to round off the argument lesson from that of PT12, PT13 and PT16's strategies. PT2, PT5 and PT23's emphasis in revising factual scientific concepts to round off argument-based lesson indicated in Table 4.12, seem to show that they were unable to encourage their students to reflect on any change of position or change of view demonstrated among students. Put in other words, the absence of the goal of reflecting on argumentation process from their teaching in all the three classes seem to influence the way they round off the argument lesson.

In addition, in contrasting the lessons of all the six selected PTs, it became evident that there were differences in utterance occurred not only between the PTs but also from one lesson to another lesson. For instance, although PT12, PT13 and PT16 attempted to use full range of categories of argumentation in almost all their lessons it is evident that they have changed their emphasis on higher order talk in the successive two lessons. This was supported by the fact that in their second and third lesson, these three PTs reflected their well-developed epistemic goals by emphasising on evaluating arguments, constructing counter-argument and reflecting the process of argumentation which are considered to be of higher order processes of argumentation according to Simon and her team (Simon et al., 2006). In contrast, the change in PTs' classroom talk was not apparent across the lessons of PT2, PT5 and PT23. In all the three lessons observed they emphasised on the four lower order categories of argumentation to facilitate argumentation.

Importantly, the findings revealed that the three selected PTs (PT12, PT13 and PT16) who were able to construct high level arguments with rebuttals at individual level (see Tables 4.4-4.9) and during small group and whole classroom discussions (see episodes 1-9 in Appendix J) exhibited full range of categories of argument process (eight categories) to facilitate argumentation discourse in science classrooms (see the table in Appendix N and sub-section 4.4.2). In contrast, the other three selected PTs (PT2, PT5 and PT23) who constructed low level arguments with no rebuttals at individual level (see Tables 4.4-4.9) and demonstrated little to no engagement in argumentation discourse during small group and whole classroom discussion (see episodes 1-9 in Appendix J) exhibited limited range (four out of eight) of categories of argument process (see the table in Appendix N and sub-section 4.4.2). These three PTs (PT2, PT5 and PT23) show a narrower range of higher order talk and did not demonstrate the goals of encouraging students to evaluate arguments, construct counter-argument and reflect the process of argumentation.

An analysis of the post-LCAI questionnaire responses of PT2, PT5 and PT23 has also shown that these PTs had a naïve understanding of scientific argumentation and its role in science teaching. Although these findings require further exploration, the PTs' understanding of argumentation and their ability to construct quality arguments seem to have an effect on their ability to use higher order talk (oral contributions) that is oriented to the facilitation of argumentation discourse in science classrooms; a significant finding for this research question and for this study. That is probably why Zohar (2008) argues that to successfully implement argumentation in science classrooms, science teachers need to experience a fundamental shift in their pedagogical understanding and practice.

In summary, the findings of this study seem to corroborate what earlier studies have reported about the positive value of argumentation instruction on students' conceptual development, belief revision and ability to support their claims with valid evidence (Erduran, 2006; Erduran, Osborne, & Simon, 2004; Erduran, Ardac, & Yakmaci-Guzel, 2006; Hall & Sampson, 2009; Simon, Erduran, & Osborne, 2006; Simon & Johnson, 2008; Skoumios & Hatzinikita, 2009). For instance, the findings of this study have been found to be consistent with what was reported in the studies of McNeill and Knight (2011, 2013). In addition, the study has been found to be effective in enhancing the PTs' ability to support and sustain argumentation in structured classroom discourses.

Others findings on argumentation instruction which have emerged from this study but which have probably not been reported that much in earlier studies include the fact that argumentation instruction does:

- Motivate PTs' (perhaps teachers') and learners living in a traditional society such as Eritrea to be favourably disposed to participating in an argumentation-driven lesson.
- Enhance PTs' ability to want to implement a learner-centred curriculum and instruction in their classrooms contrary to what is currently the case in most Eritrean schools.
- Facilitate PTs' and students' perceptual shifts and consequently belief revision in favour of classroom discourses.
- Increase the PTs' awareness about the value argumentation instruction and how it can enrich their instructional practice.
- Enhance the PTs' pedagogical content knowledge of argumentation.

4.4.3 Pre-service teacher's self-reflection and peer reflection of the micro-teaching lesson and actual classroom lessons

This section presents a brief summary of the PTs reflections of their own and their peers' video teaching lessons captured during micro-teaching lessons and during actual teaching practice period. The PT's reflective essays of their own video-taped lessons and the group's reflective analysis of their peers' sample video-taped lessons are presented in section 3.8.2 and 3.9.

PT's self- reflection and peer reflection of micro-teaching lessons

As indicated in chapter three, PTs were instructed to examine their own video teaching lessons captured during the micro-teaching sessions and write a reflective essay that includes at least 3 strengths and 3 specific skills they would like to improve in their future teaching. The table below illustrates major areas of strengths and areas that require improvement as presented in the reflective essay of the majority of the PTs.

Table 4.13: PT's self-reflection of micro-teaching lesson

Strengths	**Specific skills PT's would like to improve in their future teaching**
Introduced the lesson by reviewing previous topic	State the learning goals and aims of the task
Presented the lesson using appropriate teaching aid and examples	Mange the instruction time properly
Posed argument promote questions to help students supply evidence to their claim	Monitor students' work
Related the lesson with the day-to-day life	Consider prior knowledge of students
Jot down key points on the board	Conclude the lesson
	Check students' understanding

A perusal of Table 4.13 reveals that majority of the PTs attempted to evaluate their success and suggested areas that requires further attention in the light of the general performance standards required to deliver a good lecture or a good presentation. These PTs gave little to no emphasis on the specific skills and techniques required to facilitate argumentation. However, few PTs attempted to evaluate their success and areas they would like to improve in the future teaching in accordance to the skills and strategies targeted in the argumentation-based intervention programme. The following excerpts taken from individual PT's portfolio are representatives.

> *...I believe that I was able to explain the tasks to my peers clearly. I also tried to model argument and facilitated group discussion in the limited time I had.....In the future I am going to structure the task more carefully, encourage students (my fellow*

> *PTs) to share their ideas with their peers and use specific strategies to round off the task (PT16).*

> *In my view I tried my level best to provide individual and group task, ask my peers to take position and defend it using evidence…in the successive lessons I will state the learning goals and aims of the task, outline the task clearly and evaluate the quality of arguments constructed during individual and group task (PT8).*

The PTs were also asked to evaluate their peers lessons delivered during micro-teaching sessions. While majority of PTs emphasize on the points sketched in the table above (Table 4.13), some PTs tried to critically analyse the lessons in accordance with the pedagogical strategies targeted by the intervention programme. For example, PT22 evaluated the micro-lesson presented by PT5 on homogeneous and heterogeneous mixtures as described below.

> *Although PT5 presented a task that encourages discussion she did not: provide clear explanation on how to engage in the task, question for evidence and justification, provide opportunity to students to express their view.*

A critical glance of PT22's analysis seems to reveal that PT22 had reasonably good pedagogical knowledge about argumentation and the strategies required to facilitate it. Similarly, other 6PTs have provided constructive feedback.

Although space limitation would not allow me to present a detailed analysis, the result of this study seems to show that micro-teaching does provide a viable platform for self-reflection and professional growth (Amobi, 2005). This instructional approach did help the PTs to be aware of their own teaching style and reconceptualise on how to improve it (I'Anson, Rodrigues, & Wilson, 2003). The exercise was also found to be an effective tool for the PT to learn from others in the group and develop their skills in providing constructive feedback to classmates. It further helped them be reflective in their learning to teach argumentation and accordingly develop a better lesson plan that will enable them to effectively use ABIM in their successive lessons.

PT's self- reflection and peer reflection of actual teaching lessons

i) PT's self- reflection of actual teaching lessons

The PTs evaluated their own and their peers video teaching lessons focusing on specific pedagogical strategies required to facilitate ABIM in science classroom. They wrote a reflective essay of the micro-teaching exercise viewed. At this stage most of the PTs provided better reflection of their own lessons than was the case in the micro-teaching. A snapshot of PT12's self-reflection of the second lesson observed (Is Mercury a metal?) indicated below is an excellent example.

> *Some of the events which I considered them valuable in promoting argumentation in my lesson were: when one of the group asked for further clarification on how they are going to write their arguments, I spent some time to assist them on how to use the writing frames to write structured arguments. I also asked argument promote question to group 3 as I realize that they were straggling to justify their position for "Mercury is a non-metal". I also tried to evaluate the quality of students' arguments constructed during small group and whole class discussion. Areas of teaching that needs improvement are: manage the instructional time using well-designed lesson plan, encouraging students to ask questions and to ask students for mind change, give their reflection.*

Yet, some of the PTs' self-reflection was not satisfactory. The following excerpt taken from PT23's reflective essay is representative.

> *I was able to finish the intended lesson on the specific time, I also allowed the groups to present the discussion points to the whole class, I concluded the lesson by asking questions to students…I managed the time and discipline of the students successfully. In the next lesson I will ask questions at intervals to assess students' progress. I will also give reading assignment to students.*

ii) Peer reflection of actual teaching lessons

As indicated in chapter three, three reflective workshop sessions were organized to help PTs learn from their peers' classroom practices and, thereby, improve their experiences to use ABIM to implement LCC. The reflective sessions provided a platform for PTs to examine and reflect on their own and their peers' classroom practices in light of the pedagogical knowledge and skills of argumentation instruction to which they have been exposed in the intervention training programme.

The PTs were guided to analyse the video lessons in their respective group using guided points indicated in sub-section 3.8.3. The video lessons analysed included samples of best and unsatisfactory classroom practices to help PTs identify the strength and the limitation of each of the video lessons viewed. For the reason mentioned above a detailed analysis and discussion of these video lessons will not be provided. Rather a snapshot of group's reflection on two video lessons viewed: PT12's lesson considered best practice and PT23's lesson considered unsatisfactory will be presented. The snapshot of group's reflection will also help the reader to see how effective these two PTs assess their own lessons.

PT12's video lesson peer-reflection:

> *Our group evaluated this lesson as one of the best lessons viewed and we believe that we will learn a lot from it. Our reflection is: PT12 introduced the idea of argument to students very well. She gave them an example on how they are going to argue for or against the claim" Mercury is a metal". She managed individual, small group and whole class discussion very well. PT12 posed several argument prompt question to promote justification. To help students articulate their thoughts more carefully, PT12 encouraged her students to construct written arguments using writing frame. She also utilized analytical tools to evaluate the quality of arguments constructed by the students and rounded off the lesson successfully. Above all she was very confident throughout the lesson. Despite her ability to employ many pedagogical skills that facilitate argumentation she did not encourage counter-argument. Moreover, she was not able to provide feedback to students' responses. These practices would certainly develop students' misconception of scientific concepts and need to be improved in future teaching.*

PT23's video lesson peer-reflection:

> *Our group reviewed video teaching lesson of PT23 and identified many events that need to be improved. Among others, although PT23 placed more emphasis on his interaction with students' in small groups he was deliberately looking for precisely correct answer from the students. Such practice will not encourage students to promote their understanding of scientific concepts and to develop high cognitive thinking skills. In many instances he did not attend to students' difficulties rather he was running to complete the task on time. He did not encourage the goals of counter-argument. At certain instance he even discourages students to oppose opponents' views. PT23 tried to rounded off the lesson using close-ended question and failed to encourage student to reflect. Overall, PT's lesson is more aligned to teacher-centred approach. Yet, he performed well in some aspects. For example, he stated the learning goal, outlined the task, encourages the groups to present their arguments to the whole class and assists the students to use writing frames to construct written arguments.*

The two excerpts above indicate that the group were able to critically analyse their peer's classroom practices and provided constructive feedback. The data also showed that compared to self-reflection group's peer reflection identified several satisfactory and unsatisfactory classroom events.

In summary, the PT's self and peer reflective analysis of classroom events indicated above seems to exemplify what actually transpired during the reflective workshop sessions by allowing one to learn the extent the PTs have learned from their own and their peers' reflection. Of great importance has been the fact that the organization of the reflective workshops proved to be a valuable experience for the professional development of the PTs. It not only reinforced their work but also facilitated their overall instructional practice (Simon et al., 2003, 2006; Simon & Maloney, 2006, Ogunniyi, 2004, 2007a; Ogunniyi, 2011; Ogunniyi & Hewson, 2008). The PTs' responses to the interview and reflective response questionnaire also substantiate this finding. As indicated before, during interview and feedback discussion sessions the PTs credited their progress in employing argumentation-based instructional model to the reflective workshop sessions held after each round visit of classroom observation.

The above section was an analysis of the PTs' ability to use ABIM to implement LCC in science classrooms. The next section focuses on the major factors that promoted or hindered the PTs from using ABIM to implement LCC in their respective classroom to the extent that one would have liked to see.

4.5. Factors that promotes or hinders the use of an argumentation-based instructional model in science classrooms?

This section provides a narrative of the 25 pre-service teachers constructed from interviews and reflective response questionnaire on the factors that promoted or hindered them from using the ABIM in their science classrooms. The section also presents the analyses and discusses video transcripts of the lessons observed and field notes taken during the classroom observation sessions to supplement the above data. The discussion proceeds in two sub-sections. The first sub-section will look at the factors that promote pre-service teachers to use ABIM to implement LCC curriculum in their science classrooms. The effect of the intervention training programme in preparing PTs to use argumentation instruction in implementing a LCC in science classrooms will also be discussed in this sub-section. The second sub-section will focuses on the major problems the pre-service teachers had experienced in implementing ABIM.

4.5.1 Factors that enhanced the pre-service teachers' ability to use argumentation-based instructional model in their science classrooms

In this section, a broad summary of the results of the major factors that enhanced the PTs' ability to use ABIM in their classrooms are provided and discussed. The data set for analysis was primarily drawn from PTs' reflective responses and was supplemented by PTs' interview responses, video transcripts of the lessons and field notes. The data were then analysed qualitatively using open-coding and the generation of categories using the constant comparative method (Strauss & Corbin, 1990). The analysis of participating PTs' responses depicted in Table 4.14 below identified five factors that promoted them to use argumentation-based instructional model in their classroom. Similar factors are then grouped and ranked in descending order of occurrence.

Table 4.14: PTs' perceptions about the factors that enhanced their ability to use ABIM in their science classrooms.

Factors	No. of references	%
The argumentation-based intervention training programme equipped me to use argumentation instruction in my class	19	32
Reflective sessions and feedback discussion sessions were vital in my professional development to employ argumentation instruction in my class	14	24
The exemplary teaching learning material guided me on how to use argumentation instruction in science classroom	11	19
Students enjoyed argumentation instruction and I was also excited to adapt this new approach of teaching	8	14
Students had prior experiences to discuss in small groups and to present the discussion points to the whole class	7	12
Total	**59**	**100**

Ranked and coded in descending order (N=25)

Of the 59 responses illustrated in Table 4.14, nineteen (32%) responses showed that the argumentation-based intervention training programme have equipped them with the necessary pedagogical knowledge and skills that will enable them to use argumentation instruction in their respective science class. 14 (24%) of the responses showed that the reflective sessions and feedback discussions administered during the teaching practice period were of great help for their professional development in using argumentation as a teaching strategy in their classroom. 11 (19%) of the responses showed that the exemplary teaching learning material which was developed for the purpose of this study guided the PTs on how to employ argumentation instruction in their classroom. Eight (14%) of the responses showed that students' readiness and enthusiasm to engage in argumentation promote PTs to use argumentation instruction in science classroom. The remaining seven (12%) of the responses showed that the prior experiences of students to work in small groups and to present their work to the whole class promote PTs to organize the argument-based tasks within the lesson.

From the forgoing, the effect of the argumentation-based intervention training programme seems to be the major factor that promotes PTs to use argumentation instruction in teaching science in their respective classrooms. This finding corroborates with the findings of earlier studies that determine the effect or otherwise of argumentation-based intervention programme in preparing teachers to use argumentation instruction in teaching science (see e.g., Erduran, Arda**c,** & Yakmaci-Guzel, 2006; Hewson & Ogunniyi, 2008; Kuhn, 2010; Ogunniyi, 2005, 2006, 2007a & b; Ogunniyi & Hewson, 2010; Osborne, Erduran, & Simon, 2004a; Simon et al., 2006). Findings from these studies showed that there was development in teachers' use of argumentation as the result of their exposure to the intervention training program.

PTs were further probed to reflect on the major aspects and activities of the intervention programme that influenced them to use ABIM to implement a LCC in science classrooms. The result is summarised as reflected in Table 4.15.

Table 4.15: A classification table of aspects and activities that were most influential in enabling the participating PTs to navigate frame and make sense of implementing a LCC using ABIM

No.	Coded categories of influence	No. of references	Context and pertinent observations
1	Active participation and interaction within participating PTs	17 (20)	The role of interactive participation and sharing of ideas and experiences with peers.
2	The content of the intervention training programme/lectures	15(17)	Lectures, where participating PTs were introduced to argumentation, ABIM and strategies for implementing LCC using AIM
3	The nature of the argument-based tasks	12(14)	The argument-based tasks provided a platform for engagement and a nodal point from which scientific and socio-scientific discourse emerged
4	Reference to effects of argumentation instruction	11(13)	Examining strategies for promoting and sustaining argumentation. Argumentation instruction as a teaching strategy for implementing LCC
5	Reference to Reflective workshop sessions and feedback discussions	10(12)	Reflective workshop sessions, where PTs' conception of argumentation and classroom experiences relating to teaching science as an argument were shared, had a positive effect. Feedback discussions guided the PTs on how to improve certain pedagogical skills in their future teaching.
6	Video clips of ordinary teachers dealing with how to structure and approach the teaching of argument in science	8(9)	From the video show, PTs identified the practices that could be adapt in their respective classrooms
7	Practical classroom experiences	7(8)	practical classroom experiences of PTs had positive effect to use argumentation instruction to implement

			LCC in science classrooms
8	Reference to Micro-teaching	6(7)	PTs evaluated their own lessons and the lessons taught by their peers and provided constructive feedback in accordance to the pedagogical strategies targeted in the training programme.
	Total number of response references	**86(100)**	

Ranked and coded in descending order. (N=25); Figures in parenthesis are percentages

From the results depicted in Table 4.15, it is evident that the participating PTs' collaborative and interactive classroom arguments and dialogues helped them to share their ideas and gained insights on how to implement LCC using ABIM. The following excerpt was derived from the reflective diaries of PT8 is representative:

> *PT8: At the beginning of the intervention I did not appreciate the inclusion of argumentation instruction in science teaching. At that early stage I was not able to see the importance of argumentation in the field of science. 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.*

This finding resonates with the general assertion that shows that interactive classroom arguments and dialogues can help leaners and teachers to clear their doubts acquire new attitude and reasoning skills, gain new insights, make informed decisions and change their perceptions (Ebenezer, 1996; Erduran, 2006; Ogunniyi, 2007a).

Another salient finding from this study is that the intensive lecture series provided during the intervention programme introduced PTs to the idea of argument and prepared them on how to use ABIM to implement LCC. This is succinctly articulated by PT24:

> *PT24: After attending the lecture sessions and having gone through a series of argument-based tasks, I came to understand the conception of argumentation and argumentation instruction as a viable instructional tool to implement learner-centred curriculum. Without these activities it would have been impossible to understand the theoretical base of argumentation frameworks and how to use them in science teaching to help students construct argument.*

The findings of this study, in agreement with the previous studies (Borko, 2004; Sherin, 2000, 2004) revealed that video clips of ordinary UK teachers and participating PTs dealing with how to structure and approach the teaching of argument in science had positive effect in changing PTs' classroom practice. These studies noted the importance of observing video recordings of classroom discussions in improving teachers' classroom practice (Sherin, 2000, 2004) and in supporting teacher change (Borko, 2004).

Ogunniyi (2005, 2006) also asserted that the most effective way to get teachers to be involved in the implementation of the new curriculum, in this case learner-centred curriculum is to engage them in a long-term intensive dialogues, argumentation, and explicitly reflective instructional approaches. This requires the development of activities or tasks that provides small groups of participants (students and/or PTs) with an opportunity to evaluate alternative perspectives and the acceptability, relevance, and sufficiency of the reasons used to support these different perspectives (Osborne, Erduran, & Simon, 2004). It is for the same reason that this study developed and administered argument-based tasks during the intervention programme. These tasks were considered by 12 PTs responses as influential activities that prepared them to implement LCC using ABIM. In agreement with (Hall & Sampson, 2009, p.16) these PTs attested that such tasks provided a platform to discuss and critique the reasons offered in the support or refute of an idea or view.

Responses by 11 PTs indicate that they regarded dialogical argumentation as an effective strategy for implementing LCC in science classrooms. Qhobela's study (2010) came up with a similar conclusion. The author proven that argumentation instruction is a viable teaching strategy to introduce learner-centred approach in science classrooms. Indicating the effectiveness of dialogical argumentation, the PTs noted that this approach of teaching can be used to teach any science concepts at any grade level. The sentiment was pertinently expressed by PT3:

> *PT3: I have come to the conclusion that the use of dialogical argumentation is a very effective method for teaching any science concept at any grade level, especially for teaching science in relation with students' traditional or indigenous knowledge.*

PT3's view accords with the view of Hall and Sampson (2009) who contended that argumentation works with diverse scientific concepts and age groups. They further explicated that with modifications, it can fit any science classroom. PT3's view also accords with the view of Dziva, Mpofu and Kusure (2011) who asserted that if a learner centred approach is to be taken seriously it should include students' traditional cultural knowledge which they bring into the science classes.

An important finding in this study, and in agreement with previous findings (e.g., Simon & Maloney, 2006; Simon et al., 2003, Villanueva & Webb, 2008), revealed that reflective workshop sessions and feedback discussions provided a platform for PTs to share their classroom practices, review the video recordings of their own teaching and that of other PTs and engage in questioning and discussing the details of each other's lesson and learn from each other's experiences. For the same reason Simon et al. (2003) recommended that in a professional development programmes teachers need to have opportunity for interacting with others to challenge and stimulate their own thinking and discuss and share strategies for teaching argumentation lessons. The following excerpt derived from the reflective diaries of PT12 is representative:

> *PT6: The best classroom practices presented by our peers during the reflective workshop sessions increased my awareness on how best to apply the strategies we have learned in the intervention programme in my actual classrooms. Among other, after attending the reflective sessions I have learned on how to successful introduce a writing frame to the students. Now I am able to guide my students to construct spoken and written arguments… Reflective workshop sessions and feedback discussion have also helped me to realize the importance of encouraging students to construct counter-argument.*

The finding also revealed that from the list of aspects and activities of the intervention programme that enabled the participating PTs to make sense of implementing a LCC using ABIM, micro teaching (7%) was considered the least influential. In contrast, extant literature in the area of teaching practice indicated that micro-teaching is one of the most powerful techniques for improving teaching and provides a basis for self-reflection and professional growth (Amobi, 2005; I'Anson, Rodrigues, & Wilson, 2003). Although this result was surprising and disappointing, few PTs noted the importance of micro-teaching. This was concisely articulate by PT9:

> *PT9: the micro-teaching session provided me a forum to try out new teaching strategies and share feedback with peers in a constructive manner.*

A PT who had 10 years teaching experience (PT10) indicated that the micro-teaching sessions helped him to realize the difficulty teachers encountered to transform curriculum reform initiatives into practice. He recommended that teacher need continuous mentoring, monitoring and evaluation followed by constructive feedback. His recommendation accords with the view of Joyce and Showers (1988) who recommended the need of coaching and mentoring of teachers for their professional growth.

In addition to the factors mentioned above, analysis of video transcripts of the lessons and field notes revealed other factors that promoted PTs to use argumentation instruction in their classrooms. These are:

(a) All PTs had sound knowledge of the subject matter. They displayed an evidence of being able to clearly explain the science topics using multiple examples to help their students understand the scientific concepts. Some of them even attempted to link the science knowledge with the daily life of students. PTs' mastery of the knowledge base of the subject seems to be one of the factors that promote them to use argumentation instruction in their classroom. This corroborates with earlier study that examined teachers' perceptions on the factors that promote or hindered argumentation in science classrooms (Siseho, Daniel, & Ogunniyi, 2013). The authors found that a sound content knowledge of the topic greatly influence the success of the implementation of argumentation in the science class. It seems that teachers' content knowledge is very crucial for promoting PTs to use argumentation instruction in their classrooms. This corroborates the views of many science educators (e.g., Von Aufschnaiter, et al., 2008; Osborne et al., 2004; Sandoval & Millwood, 2005). In the same vein, Supovitz and Turner (2000) added that a teacher with a sound content knowledge of the subject could be creative enough to design argumentation activities that would promote argumentation in the science classroom. Osborne et al. (2004) further explicated that PTs' mastery of science content knowledge is also essential in structuring argument-based tasks that necessarily include multiple competing theories from which students need to choose, based on evidences that support theory one, theory two, both or neither of the theories.

(b) In the second and third lessons observed most PTs were observed to progress from not being able to pose open-ended questions to promoting dialogue among the students through argument prompts, such as, 'is there an argument against the claim?' 'any different idea?' 'what more scientific argumentation do you need?' and 'what other questions do you need for further investigation?'. Some students were also transformed from asking close-ended questions to open-ended questions and from responding to teachers question to posing questions that challenge the arguments of their classmates and their teachers. This data suggested that progress was made though practice by both the PTs and their students while engaging in argumentation discourse. This data also seems to suggest that these PTs were able use appropriate questions such as argument prompt to promote argumentation (Simon et al., 2003) and help their students to engage in higher-order reasoning associated with scientific argumentation (Bulgren & Ellid, 2012). Of great importance, it seems that these PTs were able to move from a teacher-centred approach to a more learner-centred approach through shifting their questioning patterns, which reinforces the findings of Martin and Hand (2009).

Hitherto, the factors that promoted effective implementation of argumentation instruction in Eritrean classrooms were discussed. The sub-section that follows presents and discusses the major barriers to implementation of argumentation instruction in learner-centred science classroom.

4.5.2 Factors that hindered pre-service teachers from using argumentation-based instructional model to implement LCC in their science classrooms.

The analysis of participating PTs' responses to reflective response questionnaire and semi-structured interview portrayed in Table 4.16 below identified several factors that hindered PTs from using ABIM to implement LCC in their classroom. Similar factors are then clustered resulting in four groups: student factor, teacher factor, curriculum factor and stakeholders-related factor.

Table 4.16: Factors that hindered implementation of ABIM process

Factors	**No. of references (%)**
Student factor	
Unfamiliarity with the learning dynamics of argumentation instruction	19
Difficulty to provide appropriate scientific evidence and reasoning to justify their explanation, difficulty to understand and distinguish the components of TAP.	17
lack of adequate knowledge and understanding of the subject matter	10
Lack of students' adequate prior knowledge about the topic	8
Not matured enough to engage in argumentation	6
Sub-total	**60(44%)**
Pre-service teacher factor	
Lack of adequate knowledge and practical use of argumentation framework (the TAP)	14
Lack of PTs' pedagogical knowledge and skills that are required to support and sustain argumentation in science classroom	11
Lack of managing small and whole class discussions effectively	10
Lack of confidence	10
Sub-total	**45 (32%)**
Curriculum factor	
Nature of the curriculum: exam-oriented curriculum	11
Nature of the learning material do not encourage students to engage in argumentation process	9
Sub-total	**19 (14%)**
Lack of support from stakeholders	

Pressure to complete the syllabus	7
Pressure to emphasis on content matter and questions related to national exam	7
Sub-total	**14 (10%)**
Total	**138 (100%)**

Ranked and coded in descending order

Analysis of the data displayed in Table 4.16 reveals that PTs experienced several challenges when implementing argumentation instruction in their classroom. Of the 138 responses illustrated in Table 4.16, 60 (44%) of the responses showed that student-factor is the most determinate factor that hindered PTs from using argumentation in their classrooms. 45 (32%) of the responses showed that teacher-factor is also another factor that hindered PTs from using argumentation instruction to implement LCC. Few of the responses (19) and (14) respectively have showed that the nature of the curriculum and lack of stakeholders support moderately hindered PTs from using argumentation instruction to implement LCC.

Student-related factor

As illustrated in Table 4.16 PTs indicated four student-related factors that impede them from using argumentation instruction in their classrooms. One of the critical factors as considered by PTs was that students were not familiar with the learning dynamics of argumentation instruction as: (a) this approach was not introduced in Eritrean education system and (b) students had little exposure to teaching strategies that are associated with student-centred approach. This finding corroborates with the recent study that determined the obstacles in the implementation of the argumentation based science inquiry approach in Turkey science classrooms. Results from this study revealed that Turkish students and teachers were not familiar with argumentation based inquiry approach aligned with student-centred approaches because of the tendency toward traditional teacher-centred science learning environment (Yesildag-Hasancebi & Kingir, 2012). Extant literature in the area of argumentation indicated that lack of exposure to arguments, explicit instruction and practice in the skills of argumentation was found to be one of the major barriers for developing young people's skills of argumentation (Larson, Annebritt, & Kurby, 2009; Osborne, Erduran, & Simon, 2004; Takao & Kelly, 2003). That is why Mason (1994) argues that argumentation should be appropriated by students and explicitly taught through suitable instruction, task structured and modelling.

The PTs perceived that although their students were happy and eager to engage in argumentation they encountered problems in using appropriate scientific evidence and reasoning to justify their explanation. This finding resonate with the general assertion that shows that generating sufficient explanation based on evidence and appropriate reasoning is an integral, but extremely difficult component of the process of scientific inquiry and argumentation (Duschl & Osborne, 2002). It seems that students did not have informed views about the nature of scientific argumentation and also lack the skills required to construct valid scientific arguments. The implication is that students need a great deal of support and guidance when engaging in scientific argumentation. The findings seem to be consistent with the view of Simon et al. (2003) who argue that for students to engage in scientific debate and make informed decisions, students need to develop an understanding of the nature of scientific argumentation and the ability to understand and practice valid ways of arguing in a scientific context. Additionally, Table 4.16 highlights that students experienced difficulty to understand the components of TAP and straggled to distinguish 'data' from 'warrant' and 'baking' from 'rebuttal'. With this understanding, Some PTs noted that applying the complex components of TAP in science classroom without simplifying them was one of the critical factors that hindered students' understanding of argumentation.

Descriptive data analysis revealed that PTs perceived that lack of adequate knowledge and understanding of the subject matter was also an obstacle for the PTs to implement argumentation instruction. This finding seems to be consistent with the results of previous studies that show that a person's degree of understanding about a topic may influence the quality and complexity of the arguments they construct (Venville & Dawson, 2010). Sadler and Zeidler (2005b) hold a similar view and assert that students' content knowledge could influence the quality of their argumentation. Results from this study indicate that students with more advanced genetics understanding were more likely to incorporate content knowledge in their reasoning than students with naive understandings of genetics. Sadler's (2004) study confirms the above findings. The result of his finding revels that increased knowledge may lead to a quantitative increase in the number of justifications students make in an argument.

Lack of students' adequate prior knowledge about the topic was also another aspect mentioned by most PTs as a factor that imped them from using argumentation instruction. These PTs commented that prior knowledge on a topic was a prerequisite for students to engage in argumentation. Their view reinforces the work of previous studies concerned on examining the effect of prior knowledge in promoting students' argumentation skills (Von Aufschnaiter et al., 2008; Lewis & Leach, 2006). Results from these studies found out that students display better argumentation skills if they have some prior knowledge. However, some of the participating PTs commented otherwise and claim that students' could generate new knowledge through argumentation. In their seminal article "Argumentation-teaching as a method to introduce indigenous knowledge into science classrooms: Opportunities and challenges", Ogunniyi and Hewson (2010) reported similar findings.

The findings attested that PTs' prior belief about the age level at which students can engage in higher-order cognitive thinking associated with argumentation was different. Some PTs commented that implementation of argumentation instruction in classrooms was not possible because the middle school students are not matured enough to engage in argumentation. However, some other PTs' thought the age level does not have an effect in the implementation process of argumentation instruction. The latter finding accords with the view of Hall and Sampson (2009, p. 21) who argue that argumentation instruction work with a variety of scientific concepts and age groups.

An analysis of video recording and field notes reveals additional student-related factors that hindered PTs from using argumentation. Among others, the finding shows that the middle school students had difficulty to generate reliable explanations that are consistent with the types of explanations proven to be appropriate or logical in science, a finding that reinforced the work of (Carey, Evans, Honda, Jay & Unger, 1989; Lawson 2004; Ohlsson 1992 & Sandoval 2003). The finding also showed that most of the students failed to evaluate the validity or acceptability of an explanation for a given phenomenon in an appropriate manner. In order to produce citizens that can process and evaluate science information, students must understand how evidence is used in coordination with theory, how to assess the validity and reliability of both data and arguments, and how to engage in the praxis of constructing arguments (Osborne, et al., 2004; Osborne, 2010; Sampson & Clark, 2008; Venville & Dawson, 2010). It was of great importance to observe, that most students were not able to differentiate evidence from explanation.

Duschl (2008) further argues that the epistemic components of argumentation, while fundamental, cannot be transmitted to students simply and directly. In the same vein, Duschl (2008) and Sandoval (2005) have noted the difficulty of advancing students' typically naive understanding of the epistemological foundation of science. Hence, it is not surprising to see Eritrean students straggling to engage in scientific argumentation and PTs in turn experiencing difficulty to use argumentation instruction in their classrooms.

2. Pre-service teacher-related factor

Effective implementation of argumentation instruction required mastery of teacher's pedagogical practices such as outlining argument-based tasks, promoting argument prompts, modelling argument, providing feedback (Osborne et al., 2004). Mastery of PTs' pedagogical practices would further result in improvement of students' argumentation skills and conceptual understanding (e.g., Omar, Gunnel, & Hand, 2004; Martin & Hand, 2009; Yoon, Bennett, Mendez, & Hand, 2010). However, analysis of the data displayed in Table 4.16 reveals that lack of PTs' adequate practical use of the argumentation framework (the TAP) and lack of PTs' pedagogical knowledge and skills required to support and sustain argumentation were considered by PTs as *critical teacher-related factors that impeded PTs from using argumentation instruction effectively.* PTs' limited pedagogical knowledge and skills about argumentation could possibly be one of the reasons for the difficulties the students' encountered to generate scientific arguments. Driver et al's (2000) study supports this finding. In their study they found that teachers' limited pedagogical repertoire to adapt argument-lesson and facilitate argumentation is a barrier to developing students' skills of argumentation.

Another teacher-related factor that might have deterred the PTs from using argumentation instruction in their classrooms was their inability to manage small and whole class discussions effectively and their lack of confidence to implement ABIM. This finding corroborates earlier studies that examined the quality of teachers' classroom practice (Driver et al., 2000). Results from this study affirm that most science teachers do not have the necessary skills to effectively organize group and class discussions and, hence, they lack confidence in their ability to successfully manage sessions devoted to argumentation and discussion in the classroom. The fact that some PTs expressed that they still had problems to practice argumentation instruction substantiate Fullan's and Martin & Hand's arguments that educational change is complex and takes time (Fullan, 2001) and the shift in pedagogical practices is not easy, requires trial and error and takes a long time (e.g., Martin & Hand, 2009).

From the descriptive analysis of the video recordings and field notes, there is sufficient evidence to show that some of the participating PTs who had teaching experience were resistant to change from the traditional teacher-centred expository teaching approach to an argumentation-based approach. This is one of the determinant factors that impeded the PTs from using argumentation instruction to implement LCC in their classrooms. This finding is consistent with the results of many other studies of this kind. For instance, in their study, Mdolo and Doidge (2010) indicated that one of the factors that hindered Malawian teachers to implement LCC was that they struggled with their new role as facilitators of learning and tend to stick with the traditional transmission mode of teaching. Similarly, Yesildag-Hasancebi and Kingir (2012) found that the problems encountered in argumentation-based inquiry classes mainly originated from the tendency of traditional teaching methods and perception toward learning and teaching. The findings seem to substantiate the view of (Osborne, et al., 2004) who argue that the two factors that can impede argumentation instruction in science classroom is the need for overwhelming majority of science teachers to change their instructional practices in order to allow their students to effectively learn these skills, and, if students are to practice these skills in the classroom a teacher may have to give up some of the authority in the classroom.

In responses to these difficulties, several science educators (e.g., Erduran, Ardac, & Yakmaci-Guzel, 2006; Osborne, Erduran, Simon, 2004) organized school-based intervention programmes on learning to teach argumentation (for details see section 2.3.4 of this thesis). Additional work may also be needed to better align science teachers' epistemological commitments so that they are more congruent with those of science (Sandoval & Resier, 2004).

Professional development studies have shown that teachers who participated in longer term professional development tend to change one or more aspects of their teaching practice (Boyle, Lamprianou, & Boyle, 2005) because teacher change requires time and energy (Zhang et al., 2003). Further, Ogunniyi (2005, 2006) explicated that the most effective way to get teachers to be involved in the implementation of a new curriculum is to engage them in a long-term mentoring process in the form of dialogue, argumentation and explicitly reflective instructional approaches. In view of warnings pointed in earlier studies in the area I did not anticipate that fundamental and substantial changes could be achieved within one semester. Nevertheless, the flash of positive findings in this study seem promising enough for me to consider a long-term study in the area not simply to fulfil the requirements of a doctoral study with limited resources and time at my disposal but as a matter worthy of further scholarly pursuit .

Stakeholders-related factor

Interview responses of the PTs showed that some of them perceived that the lack of support from the stakeholders was also a barrier in using argumentation instruction to implement LCC in their classrooms. These PTs stated that they did not get support from the stakeholders (school principals, department heads and teachers) to introduce argumentation instruction in their classrooms. Rather they were pressurized by the school principals and department heads to focus on the content of science which appears frequently in the national examination as their intention was to maintain the good rapport of the school. PTs expressed that it was difficult for them to introduce argumentation instruction in such learning environment [Comments from PTs assigned in School B].

From the PTs' responses one can deduce that classrooms in School B are highly teacher dominated. The learning environment does not seem to encourage students to reason, argue and think critically through the process of argumentation. Moreover, it is very unlikely for teachers to adopt teaching strategies that are aligned with learner-centred approach under these circumstances.

On the other hand, most of the PTs stated that the school principals were cooperative and made necessary arrangement whenever the need arises to help us effectively implement argumentation instruction. The PTs further commented that the school principals had positive attitude towards the new approach of teaching and were eager to know about argumentation and how to introduce it as a teaching strategy in their school. [Comments from PTs assigned in School A, C, D]. The following excerpts derived from the reflective diaries and interview responses of some of the PTs represent the different views of PTs:

> *PT15: Although I was very much enthusiastic to implement argumentation instruction in my class, I was not able to use it in all of my lessons because I was instructed and pressurized by the school principal and department head to go in conformity with the timeline stipulated in the unit and annual plan of the permanent science teachers. I was also instructed to emphasis on the content aspect of the topic. Yet, I tried my level best to use argumentation instruction in some of my lessons [PT assigned in School B].*

PT12: the school principals and the department heads were cooperative and supportive in many aspects such as, in arranging timetable, providing teaching aids. In fact, some of them were interested in observing our lessons and get a sense of argumentation instruction [PT assigned in School C].

The data seems to suggest that the school directors and department heads implement the directives of the MOE differently. While three school directors seem to be in favour of moving from teacher-centred to learner-centred approach, one school director seems to be resistant to accommodate change in terms of instructional practices that are required to implement LCC. It can be assumed that the prevalence of rigid administration, planning and management by the school directors i.e. school principals are likely to force the teachers to rush their work and to rely mainly on the lecture method without having sufficient time to learn any new teaching method that might take more time than they could afford. The introduction of a new teaching approach such as argumentation instruction into school B proved to be challenging for the PTs. It cannot be overemphasized therefore that effective introduction of a learner-centred curriculum in science classrooms in Eritrea requires directors to change their attitude about the goals of teaching and learning science.

In addition to the four major factors illustrated in Table 4.16, analysis of video records and field notes revealed that the nature of the learning environment and the nature of the teacher education programmes were also barriers in using argumentation instruction to implement LCC in science classroom.

Learning environment

An analysis of the video recordings and field notes also show that some of the participating PTs were not able to create a learning environment that fosters argumentation. More specifically, the PTs were not able to create a responsive environment where each student felt free to express his or her opinion without being intimidated. Rather, the learning environment was highly dominated by the PTs. It seems that these PTs did not consider the dynamics of teacher-student and student-student interactions in facilitating learning. Maskiewicz and Winters (2012) and Acat, Anilan, and Anagun (2010) provide empirical evidence to show how a focus on the teacher can easily overlook the complex dynamics of the classroom. Within this perspective, the authors suggest that the learning environment of the science classroom should be shaped by the teacher and the learners together (Maskiewicz & Winters, 2012). However, as argued by (Empson & Jacobs, 2008; Hammer, 1997) listening and attending to each and every student's request, can be challenging even for experienced teachers. Large class size, fixed or non-flexible seating arrangement of science classroom were also identified as factors that hindered PTs from using argumentation instruction in learner-centred science classrooms.

Nature of teacher education programmes

Several teacher-related factors that impede implementation of argumentation instruction discussed above notably shows that the main cause of these problems might not be unrelated to the nature of the current teacher education programmes in Eritrea. Simon and Maloney (2006) stated that many teacher training programmes are so focused on the delivery of a content-laden curriculum that they ignore the actual cognitive needs of the learners in terms of acquiring ownership of what they are learning. Consequently, trainees have little opportunity to broaden their instructional approach to teach science as an inquiry rife with conjectures and refutations rather than a completive product-orientated enterprise. Erduran (2006) adds that the initial training of science teachers does not conventionally place an explicit emphasis on how teachers can be supported in teaching new aspects of the curriculum. Teachers produced from such training programmes will then be rigid in their teaching style and stick closely to their prepared notes or textbook with minimal teacher-student interactions (Stoll, 1994). That is why Czerniak and Lumpe (1996) have suggested that pre-service science teachers need to be given opportunities to see inquiry-based interventions modelled and then practice and see the effectiveness of those methods on students' learning.

Summary of the findings

An analysis of the context of argumentation in this study identified possible effects of argumentation-based intervention training programme on a group of participating Eritrean PTs' understanding of argumentation, ability to construct scientific arguments, ability to use argumentation-based instructional model to implement a learner-centred curriculum (LCC) in science classrooms. It also highlighted their ability to examine and reflect on their classroom practices. The section further sheds light on some of the difficulties that the PTs encountered in their attempt to use an argumentation-based instructional model to enact LCC in the classroom context.

The PTs' pre-and post-questionnaire responses showed that the argumentation-based intervention training programme was valuable in enhancing their understanding of LCC and argumentation. In particular, they exhibited a reasonably good understanding of scientific argumentation, the role of argumentation in science education and the skills and techniques required to promote and sustain argumentation in science classrooms. It seems that the argumentation-based intervention training programme facilitated the PTs' pedagogical content knowledge of argumentation and LCC. Additionally, the participating PTs' comments in the interview and reflective diary suggest that the intervention programme (including the reflective workshop sessions and feedback discussions), as in earlier studies, enhanced their understanding of LCC and argumentation considerably.

The argument-based intervention training programme in vogue seemed to be effective in equipping the PTs with necessary argumentation skills that should enable them to take part in a meaningful discourse. The findings have shown that the majority of the participating PTs have the basic skills of constructing arguments in every day, socio-scientific and scientific contexts of argumentation. In the three tasks, they were able to: (1) provide evidence (data) to support their claims; (2) connect the data with the claim (warrant). Some of the PTs were able to use rebuttals to a certain extent to nullify certain claims i.e. level 3 and 4 of argumentation. In agreement with the previous studies (Durant et al, 1989; Xie & and Mui SO, 2012) the finding shows that some PTs demonstrated lower level of argumentation in scientific scenarios compared with their daily and socio-scientific argumentation. Taken as a whole, the result obtained from the series of argument-based tasks administered during the intervention programme confirmed that PTs' ability to argue improved as they went through many discursive activities.

In line with the objective of the study it is safe to conclude that the argument-based intervention training programme has, to a reasonable degree, been effective in enhancing the PTs' ability to use an argumentation-based instructional model to implement learner-centred curriculum in their classrooms. The majority, that is, 22 out of 25 PTs were able to structure argument-based tasks in their classrooms. Also, most of them progressively improved their ability to structure argument-based tasks. While an analysis of classroom talk oriented to the facilitation of argumentation showed very minimal improvement it changed considerably as the study progressed. In other words, some the PTs began to emphasize more on higher-order talk that encouraged their students to construct counter-arguments, evaluate arguments and reflect on the process of argumentation. Despite the generally noticeable progress made however, the PTs differed in their ability to use the new instructional approach i.e. some made considerable progress while others did not make much progress. As stated before, changing teachers' or PTs' beliefs and practices does not come that readily. It requires a long-term mentoring process (e.g. Erduran et al., 2004; Ogunniyi, 2007a & b; Simon, et al., 2006).

Although the above findings require further exploration it is worth noting that the argumentation-based instruction used in the study does have potential to bring about considerable changes among the PTs and possibly practising teachers in using the approach to enact the new learner-centred curriculum in Eritrean science classrooms. A critical analysis of the results discussed in subsections 4.4.1 and 4.4.2 provide further explanation as well as highlight the points listed below. Three PTs namely, PT12, PT13 and PT23 who had reasonably good skills of argumentation were able to:

- Organize the argument-based tasks efficaciously to a large degree (see Appendix M and sub-section 4.4.1) to implement LCC in science classrooms.
- Demonstrate a full range of categories of argumentation to facilitate argumentation process and therefore to implement more features of LCC in science classroom.
- Exhibit higher-order talks such as counter-argument, reflection and evaluation, which are highly recommended in a learner-centred pedagogy.

In contrast, PT2, PT5 and PT23 demonstrated relatively lower-level argumentation skills in that they were only able to:

- Organize the argument-based tasks less efficaciously than their counterparts above (see Appendix M and sub-section 4.4.1) to implement LCC in science classrooms
- Demonstrate a narrow range of categories of argumentation that could facilitate argumentation process and concomitantly were less able to implement lesser features of LCC in the science classroom context.
- Exhibit limited instances of higher-order talks. Some of them even discouraged such talk.

In the light of the forgoing, it seems obvious that the PTs who have reasonably good skills of argumentation were able to use ABIM very well to implement LCC in science classrooms than those who lacked such skills. The data seem to suggest that the PTs' argumentation skills had an effect on their ability to use ABIM to implement LCC in science.

In addition, this study explored the effect of a series of reflective workshop sessions on the PTs' professional development. The findings indicate the reflective workshop sessions carried out during the course of this study led to an initial change in pre-service teachers' classroom practice for about three quarters of the group. In other words, PTs seemed to change from a teacher-centred classroom to a learner-centred classroom as a result of their involvement in the reflective workshop sessions. The message here is that it is possible for pre-service teachers to adapt and advance their classroom practice in order to bring desirable change in the nature of classroom discourse if given the necessary training and support.

The study has also identified certain factors that promoted or hindered the PTs from using an argumentation-based instructional model to implement ABIM in science the classroom. The findings suggest that the effect of the argumentation-based intervention training programme was the major factor that enhanced the PTs to use ABIM in teaching science in their respective classrooms. The data further suggests that the major factors that hindered the PTs from using ABIM in their classrooms include among others: student-related, teacher-related, curriculum–related, stakeholders-related factors as well as the learning environment and the nature of the teacher education programmes. However, a detailed account of these factors would warrant a new in-depth study.

Reflection of the methodological issues

This sub-section attempts to shed light on the appropriateness of the research method adopted in this study. It also analyses and discuses some of the most important methodological issues related to 'the need for exploring PTs' understanding and ability of LCC and argumentation' and 'the causal interpretation of the data'.

Appropriateness of the research method

The adoption of a predominantly qualitative research approach for this study was a suitable approach to address the complexity and fluidity of the issues raised in the study. This approach allowed the researcher to access rich, in depth information of a qualitative nature without requiring large sample (Lincoln & Guba, 1985; Sinkovics, Penz, & Ghauri, 2008; Sykes, 1990) and offers a clear and holistic view of the classroom context (Denzin & Lincoln, 1994; Ghauri & Grønhaug, 2005; Sinkovics, Penz, & Ghauri, 2008). The case study method was considered useful for this study as it enabled the researcher to consider a particular case and study it narrowly (Babbie & Mouton, 2001) in order to know it well (Stake, 1995). In agreement with the view of Cohen, Manion, and Morrison (2001, p. 181), this methodological approach enabled the researcher to penetrate deep into situations in ways that are not always susceptible to numerical analysis. The use of in-depth instrumental case studies was also appropriate for this study. Instrumental case study approach helped to investigate particular cases and provided information that helped to answer the research questions. The sample was carefully constructed and provided relevant data from a wide range of PTs.

The mixed method approach to data collection and analysis and the multiple data sources provided the needed credibility to the research methodology and made it to answer the research questions in extensive way. In addition, the diverse data sources used in this study provided adequate triangulation and helped to frame and strengthen the conclusion and recommendations. Yet, it is worthy of note to indicate that although the adopted methodology was sound it does not imply that it had no limitation. The limitation of the study is presented in sub-section 1.12 and will not be repeated here.

The need for exploring PTs' understanding and ability of LCC and argumentation'

The study explored PTs' understanding of LCC and argumentation (sub-research question 1) and PTs ability to construct arguments (sub-research question 2) as a change of PT's understanding and skills is a prerequisite for PT classroom implementation of ABIM in a learner-centred science classrooms. Within this perspective, Lawson (2002, p.237) argues that "Effective teaching requires prior understanding". Zohar (2008) extended this view and contends that to implement argumentation in science classrooms, science teachers need to experience a fundamental shift in their pedagogical understanding and practice. In a more broader perspective, Shulman argued that, when teachers know their subject content knowledge very well, they could apply the necessary pedagogical content knowledge (PCK) to promote learners‘ understanding. The current study provides additional evidence that shows the impact of professional development programmes on argumentation in enhancing prospective teachers' ability to implement ABIM in learner-centred science classrooms.

Evidence for the causal interpretation of the data

The validity and diversity of the data collection methods and the nature of the data justify a causal interpretation of the data. The following excerpts taken from reflective responses of some PTs indicate some of the evidences for causal relationships in this study.

> *Initially, I was aware that a learner-centred curriculum and instruction intends to attend to individual student's needs and aspires to develop student's problem solving and critical thinking skills. The intervention opened my eyes to realize that successful implementation of the learning goals of learner-centred curriculum requires the use of different repertoires of teaching strategies. The intervention programme also*

> *helped me to select appropriate instructional approaches to implement learner-centred curriculum in science classrooms. In my teaching practice period I was able to use argumentation as a teaching strategy to promote students' higher-level cognitive thinking skills (PT18).*

Form the excerpt above it is evident that the intervention programme and the reflective sessions were instrumental in broadening PT18's understanding of LCCI. More specifically, PT18 indicated that the intervention helped her to increase her awareness *of the methods of instruction* that are useful to implement a learner-centred curriculum.

> *Initially, I was aware that the two forms of argumentation are not the same. Yet, I had vague conceptions 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 inquires arguers to generate adequate explanations and validate them using appropriate evidence and reasoning. As the study progresses I was able to master the unique forms of scientific argumentation and practiced it with my students in my class (PT16).*

A critical glance of the excerpt above revealed that the intervention programme helped PT16 to realize the difference between the two forms of argumentation and to describe scientific argumentation more clearly than was the case before.

The excerpts above are a few of the excerpts presented in the theses and serve as evidences for causal relationships of this study.

CHAPTER FIVE

CONCLUSION, IMPLICATIONS AND RECOMMENDATIONS

5.1 Introduction

This chapter focuses on the major findings presented in chapter four and their implications for policy, curriculum development and instructional practices. It then makes some recommendations before drawing the final conclusion as well as highlighting possible directions for future studies.

5.2 Summary of major findings

A plethora of studies has examined the effect of explicit argumentation instruction on teachers' and learners' understanding of scientific conceptions. This study examined the effect of an argumentation-based intervention training programme on pre-service teachers' (PTs') ability to implement a learner-centred curriculum in selected Eritrean middle schools. More specifically, this study set out to investigate the effect of the intervention programme on the PTs': (a) understanding of LCC and argumentation; (b) ability to construct arguments; and (c) ability to implement LCC using ABIM. In chapter four, the factors that facilitated and/or hindered the implementation of ABIM in science classrooms were highlighted. The major findings of this study with respect to the four research questions that the study set out to address are presented in the section that follows.

5.2.1 Conception of a Learner-Centred Curriculum/instruction and argumentation

The argumentation-based intervention training programme was valuable in enhancing the PTs' understanding of LCC and argumentation. After the intervention, majority of the PTs seemed to:

- Possess a more comprehensive understanding of a learner-centred curriculum and instruction than was the case before the intervention.
- Shift from seeing argumentation as a dialogue or debate among people who are in a quarrel rather than as a process where people debate and negotiate to reach a mutually acceptable conclusion.
- Realize the difference between every day argumentation and scientific argumentation.
- Accept the central role of argumentation in science education and science learning.
- Acquire the necessary skills and strategies on how to support and sustain argumentation in science classrooms

- Possess a reasonably good understanding of the analytical tools that are used to assess the quality of argumentative discourses

5.2.2 Pre-service teachers' construction of an argument

The argumentation-based instructional model was found to be effective to a certain extent in equipping the PTs with the necessary argumentation skills that could enable them to take part in a meaningful discourse. The majority of the participating PTs seemed to have the basic skills of constructing every day, socio-scientific and scientific argumentation. In the three tasks, they were able to: (1) provide evidence (data) to support their claims; (2) connect the evidence with the claim (warrant). The findings also showed that some of the PTs constructed lower level arguments when engaged in argumentation on scientific scenarios, unlike when they engaged with day-to-day issues or socio-scientific argumentation. This finding is consistent with earlier studies in the area (e.g., Durant, Evans & Thomas, 1989; Xie & Mui SO, 2012). The latter studies indicated that pre-service science teachers demonstrated low level of argumentation in scientific scenarios compared with their daily argumentation.

The findings further showed that the PTs' ability to argue improved considerably as they went through many discursive activities, as indicated below.

- Some PTs who did not offer evidence for their claims at the initial stage of the study were able to do so as the study progressed. However, only a few PTs constructed arguments with rebuttals.

- Initially, both in the small groups and the whole class discussion, the participants tended to focus entirely on their own arguments and failed to attend critically to their opponents' arguments. Later on, most of the PTs were able to listen to each other's argument and to respond directly to each other's arguments so as to weaken their opponents' arguments. In other words, they demonstrated a greater skill in generating rebuttal.

- It was also observed that the group members who hold oppositional views made no attempt to dominate the discussion; rather, they provided appropriate evidence to justify their claims and attempted to use persuasive language to convince the group members who initially argued against the claim. As a result, some of the group members who initially argued against a particular claim were able to change their mind. The implication is that overtime the PTs began to understand that opposition between the views of arguers during argumentation does not necessarily mean opposition between individuals.

- Compared to individual's arguments the collective arguments of the groups comprise of several claims and counter-claims supported by data and warrant. It is worth noting that some of the PTs who were unable to construct arguments with rebuttals at individual level were able to generate arguments with rebuttals during the small and whole class discussion.

5.2.3 Ability to use the Argumentation Based Instructional Model (ABIM)

This study can safely conclude that the argument-based intervention training programme has enabled the PTs to use argumentation-based instructional model to implement LCC in the science classroom as well as experienced some success in doing so. The majority of the PTs were able to structure argument-based tasks reasonably. As the study progressed most of the PTs improved their ability to structure argument-based tasks. However, in terms of classroom talk oriented towards the facilitation of argumentation, it is safe to state that their initial approach was not that noticeable. However, with more exposure to the training, some of them began to emphasise more on higher-order talks that encouraged students to construct counter-arguments, evaluate arguments and reflect on the process of argumentation than was the case initially. The findings further showed that the growth in PTs' use of argumentation instruction varies from one pre-service teacher to another. The message here is that PTs implement new ideas differently and so there are no homogenous outcomes.

The study has also shown that the PTs' argumentation skills had an effect on their ability to use ABIM to implement LCC in science. More specifically, the study has proven that those PTs who had reasonably good skills of argumentation were able to:

- Organize the argument-based tasks very well to implement LCC in science classrooms.
- Demonstrate a full range of categories of argumentation to facilitate argumentation process and therefore implemented more features of LCC in science classrooms.
- Exhibit higher-order talks such as counter-argument, reflection and evaluation, which are highly recommended in learner-centred pedagogy.

In contrast, PTs who demonstrated relatively lower-level argumentation skills:

- Organized their argument-based tasks to implement LCC in science classrooms to a lesser extent.

- Demonstrated only a narrow range of categories of argumentation to facilitate argumentation process and therefore implement less features of LCC in science classrooms.
- Did not exhibit higher-order talks; some even discouraged such talks in their classrooms.

5.2.4 Factors that promoted or hindered the use of an argumentation-based instructional model in science classrooms?

The study also identified factors that promoted and hindered the PTs from using argumentation-based instructional model to implement ABIM in science classroom. It was found that the effect of the argumentation-based intervention training programme and reflective workshop sessions were the major factors that promoted PTs to use ABIM to implement LCC in the science classroom. The major factors that hindered PTs from using ABIM in science classroom are: student-related, teacher-related, curriculum–related, stakeholders-related, learning environment and nature of the teacher education programmes.

The findings of this study have implications for policy, curriculum development and instructional practices.

5.3 Implications of major findings

The findings of this study have implications for policy, curriculum development and instructional practice which the MOE, curriculum designers, teacher educators and science teachers in Eritrea and perhaps other countries implementing learner-centred curricula using inquiry-based instruction could find informative and useful. More details about such implication are presented below.

Implications for policy, curriculum development and instruction

According to Vavrus, Thomas, & Bartlett (2011), "Throughout sub-Saharan Africa, there has been a gradual shift in policy, if not necessarily in practice, away from prevailing pedagogical traditions toward Learner-Centred Pedagogy (LCP) as a result of economic, educational and political factors" (p.33). A number of countries, including Eritrea have implemented curriculum reforms that incorporated some elements of LCP, such as students' experiences and active student involvement. However, the history of the implementation of the learner-centred curriculum in the classroom context in most counties usually resulted in stories of failures (Schweisfurth, 2011). For example, recently the Department of General Education (2010, p.18) reported that classrooms in Eritrea are still dominated by a teacher-centred approach despite the efforts made to implement a learner-centred curriculum into science classrooms. In a learner-centred approach, the primary role of the teacher is to engage students in inductive, hands-on activities, group work, and reflection to promote critical thinking, self-evaluation and the integration of knowledge across traditional subject areas (Lambert & McCombs, 2000). In contrast, in my supervision of pre-service teachers and in-service teachers during the teaching practice for a period of 10 years, I found that most Eritrean teachers have usually struggled with their new role as facilitators of learning. They tend to use the traditional outdated mode of teaching.

The above findings join a plethora of others (Altinyelken, 2010; Aksit, 2007; Nakabugo, Sieborger, 2001; SMICT Study, 2005) in confirming that the idea of a LCC has not taken root in Eritrean classrooms. One possible factor for such failure is that although policy reforms encourage the use of learner-centred pedagogy (LCP), the syllabi and the national examinations in Eritrea as in most African countries, continue to be based on behaviourist objectives that largely test students' ability to recall factual information. Another factor is that policymakers have taken the initiative in many countries to express the goals of reform using the language of LCP, but the actual learning objectives in many subjects stipulated in the syllabi do not align closely with this approach. In the case of Eritrea, while the broader curriculum goals lean more towards constructivism, the subject syllabus and teachers guide waves between behaviourism and constructivism, with a general tendency towards behaviourism. Such inconsistency could also impede teachers from using learner-centred approach in their classrooms. Therefore, policy reform across the education system needs to show explicitly how, specifically, LCP is infused in the curriculum and in the national examinations.

In addition, it is not enough to suggest in the revised curricula that teachers include group work and discussion into their lessons if, in the end, these techniques are still directed at recalling pre-defined content rather than inquiring more deeply into it. Curriculum documents need to provide assistance for teachers in terms of how to move from the positivist view of science, which emphasizes on factual recall of information to a more constructivist perspective which focuses on helping students to develop higher-order cognitive thinking skills through discussion and argumentation. Moreover, the activities included in the textbook are more of recall type questions that encourage students to get the right answer through rote memorization. Is there any hope for teachers to adopt teaching strategies that are aligned with learner-centred approach under these circumstances? This calls for curriculum developers and textbook designers to revise the nature of the textbooks in general and the activities in particular in order to facilitate meaningful discussions and debates among students. More importantly, the MOE should take a bold step to introduce argumentation in the national science curriculum of Eritrea, as this study and several other studies have shown the importance of introducing argumentation in science curriculum and science teaching (see Siegel, 1992; Duschl, 2008; Jimenez-Aleixandre & Erduran, 2008).

Furthermore, the importance of argumentation-based instructional model and its implications need to be spelt out in the national science curriculum as it has been identified as a viable teaching strategy with potential to stimulate learner participation and engagement in structured discussion in science classrooms (e.g., Berland & Reiser, 2009; Bricker & Bell, 2008; Driver et al., 2000; Duschl, 2007; Jimenez-Aleixandre & Erduran 2008; Ogunniyi, 2007a & b, 2008, 2011; Osborne, 2010). When learners engage in dialogical argumentation, the interaction between the personal and the social dimension promote reflexivity, appropriation and the development of knowledge, beliefs and values (Bricker & Bell, 2008; Ebenezer, 1996; Erduran, 2006; Ogunniyi, 2007a; Simon & Richardson, 2009). All these concepts are well aligned with the major tents of constructivism where the Eritrean new LCC is grounded.

The shift from a teacher-centred approach to a learner-centred approach could also be facilitated by aligning the examination system with the learning goals of LCP. However, the findings of this study have shown that examination-oriented curriculum was one of the factors that deter pre-service teachers from using argumentation-based instructional model to implement learner-centred curriculum. The effect of assessment and examinations on teaching methods and on what is taught has been well documented in the literature (Dello-Iacovo, 2009; Llewellyn & Rajesh, 2011; Simon et al., 2006) further explicate that a narrow examination-focused orientation in teaching makes teachers to rush without having time for any method that might take off more time, such as argumentation and discursive practices.

Therefore, as implementation of LCE is a prerequisite for the improvement of quality of education throughout the system, policy makers and curriculum designers of the MOE need to take initiatives to reconsider the nature of the education system in general and the nature of the school curriculum and the examination in particular. The turn toward LCP as an aspect of education policy has significant implications for pre-service and in-service teacher education institutions in Eritrea and elsewhere. In view of this, the following sub-section will shed light on the implications of the new learner-centred curriculum on teacher education institutions.

Implications for teacher education

Since the inception of the new learner-centred curriculum, the MOE in Eritrea has aspired towards the transformation of classroom interactions from a teacher-centred to a learner-centred method. The new curriculum emphasizes on the process skills of science such as, interpreting, analysing, evaluating and problem solving (MOE, 2005). Teachers have a key role to play in helping students to develop such skills that are necessary for the 21st century. Yet, most Eritrean science teachers are unaware of how to achieve this aim. The Department of General Education (2010) indicated that lack of the required knowledge and skills of science teachers to adapt the contemporary approach of teaching was found to be the bottleneck for the proper implementation of the new curriculum. It appears that policy has changed more than practice when it comes to teachers actually utilizing learner-centred pedagogy.

One potential factor that possibly contributed to the failure of teachers' adaptation of the new teaching practice could be the nature of the teacher-education programme. Improving the quality of instruction depends to a large extent on the pedagogical training and support provided to teachers before they begin their teaching careers and throughout the years they are in the classroom. However, as noted by Erduran (2006) the teacher education programmes in Eritrea emphasize more on delivery of a content-laden curriculum and provide little support to pre-service teachers on how to teach the new aspect of the curriculum. If pre-service teachers who graduate from teacher training colleges do not acquire sufficient and applicable pedagogical knowledge and skills about learner-centred approach and instructions, it would be a sheer dream to expect them to apply the approaches in their teaching. As noted by Stoll (1994) such pre-service teachers will rather be rigid in their teaching style and stick closely to their prepared notes or textbook with minimal teacher-student interactions. This implies that without high-quality initial training it is difficult for teachers to adapt and adopt learner-centred pedagogy.

The issue above calls for teacher education institutions in Eritrea and elsewhere to revise the curriculum and instruction of their programmes. Among others, LCP need to be fully integrated into teacher education curriculum and examination. In addition, it would be more appropriate to implement the reflective practitioner model in which teacher educators aim to create conditions for pre-service teachers to use active learning strategies and to think critically about the authoritative knowledge in their fields, inquire into and discuss various ways of teaching content for different contexts, and develop their own pedagogical style. Such model would assist pre-service teachers to fully understand LCP's underlying philosophy and its attendant methods. Extant literature in the area of LCP outlined several teaching strategies that are aligned with learner-centred approach. (e.g., Lambert & McCombs, 2000; Wright, 2006). Problem solving, discussion, field work and inquiry are viable teaching strategies just to mention but a few.

In addition to these strategies this study has shown that argumentation-based instructional model is a viable teaching strategy to implement learner-centred curriculum in science classrooms. The message here is, argumentation courses need to be integrated into science teacher education curriculum as well as in the entire teacher education programme. Furthermore, professional development workshops should be organized for Eritrean teacher educators to support them incorporate this important practice into their own classrooms. Benefiting from the findings of Zembal-Saul and her colleges (Zembal-Saul, Munford, Crawford, Friedrichsen, & Land, 2002) teacher educators should place more emphasis on argumentation in science methods classes through the use of video cases in order to encourage pre-service teachers to focus more on the purpose of learning science and the importance of classroom discourse in science teaching. Teacher educators are also advised to use varying strategies to demonstrate to pre-service teachers that supplying evidence to justify knowledge claim or to support explanations of phenomena can be achieved by all students. By doing so, pre-service teachers will have a deeper understanding of the role of argumentation and evidence in science classroom and on how to incorporate these important scientific practices into their own teaching (Zembal-Saul, 2005). In addition, teacher educators should put efforts to change pre-service teachers' belief system about argumentation teaching. As noted by Johnson (2009) teacher's beliefs about instructional strategies and their effectiveness impact teachers' willingness to use argumentation-based instruction in their classrooms.

Another potential factor that possibly contributed to the failure of teachers' adaptation of the new teaching practice is the attempt made by the MOE to implement learner-centred curriculum in Eritrean classrooms without equipping the teachers with adequate instructional skills required to introduce the new practice (MOE, 2005). Ogunniyi (2004) has argued that attempts to introduce new curriculum without helping teachers to translate theory into practice is a recipe for failure. As Fullan (2001) has noted, reforms can only succeed if implementers understand the concepts in the new practice. To ameliorate the above problems, among others, Continuing Professional Development (CPD) programs need to be organized for teachers to help them understand and implement changes in policy and curriculum. Teacher education institutions in collaboration with the MOE should take initiatives to run on-going school-based professional development programmes to upgrade teachers' pedagogical knowledge and skills that will enable them to employ learner-centred instructions such as argumentation instruction effectively. The most effective way to get teachers to be involved in the implementation of the new curriculum is to engage them in a long-term intensive dialogues, argumentation, and explicitly reflective instructional approaches (Ogunniyi, 2005, 2006).

In addition, professional development programmes should attend to the diverse behaviours and beliefs about teaching and learning of the participating teachers (Luft, 2001) as there is a strong connection between teachers' beliefs about teaching and learning and their actions (Tobin, Tippins, & Gallard, 1994). The message here is that stakeholders, that is, MOE and college of education need to provide opportunities for teachers to interact with others to challenge and stimulate their own thinking about the teaching and learning process and provide them with significant theoretical input. Furthermore, as Joyce and Showers (1988) noted, stakeholders need to continually coach and monitor teachers to help them reflect on the relationship between theory and practice and ensure that the new practice becomes a natural part of the teachers' repertoire of professional skills (Fullan & Miles, 1992). The sub-section that follows discusses the implications of the outcome of this study for science teachers.

Implementation for science teachers

A major goal of the current reform movement in science curriculum is for students to develop an understanding of the scientific view of the world and to be able to use scientific reasoning when a situation requires it (Sampson & Grooms, 2009, p. 66). However, as argued by Norris, Philips, and Osborne (2007) the achievement of this goal, seems to be hindered when science teachers require students to remember a great deal of scientific knowledge without expecting them to understand the empirical and theoretical grounding of that knowledge. Sampson and Grooms (2009, p. 66). For instance, the Department of General Education

(2010) attests that most Eritrean teachers' pedagogical strategies paid little or no attention to conceptual understanding and practical applications of science to real life, rendering teaching and learning mainly theoretical. My long work experience in classroom practices supports the above view. In my supervision of the performance of pre-service teachers and in-service teachers in the teaching practice sessions, I observed that discursive exploration of scientific ideas, their implications and their importance are absent even after the introduction of the learner-centred curriculum. If we expect students to attain this goal, scientific argumentation needs to play a more central role in the teaching and learning of science (NRC, 2000, p. 113) and the nature of the typical classroom activity and discourse patterns need to change (Hall & Sampson, 2009). Teachers are then required to do more than transmitting important concepts of science to students.

The new curriculum requires science teachers to use contemporary instructional approaches such as argumentation-based instructional model to promote and support students' engagement in scientific argumentation. In such instructional model teachers need to adopt more dialogic approaches (Alexander, 2005; Mortimer & Scott, 2003) that involve students in discussion and consider how they themselves interact with students to foster argumentation skills. They should play a crucial role in introducing arguments, managing small group discussions, sustaining and rounding off argument, modelling and evaluating arguments and making necessary interventions to ensure good quality arguments (Osborne, 2007; Osborne et al., 2004; Simon, et al., 2006). For the same reason, this study administered argumentation-based intervention training programme to pre-service teachers to help them incorporate argumentation, not as an add-on, but as an integral part of their classroom practices.

Science teachers are also required to develop argument-based tasks (Osborne, et al., 2004) that provide individual and groups of students with an opportunity to evaluate alternative views and the acceptability, relevance and sufficiency of the reasons used to support these different views. Supovitz and Turner (2000) contend that teachers with a sound content knowledge of science can design better argumentation activities that would promote argumentation in the science classroom than those teachers who had limited content knowledge. Therefore, teachers need the mastery of science content knowledge as it is very essential in structuring tasks for argumentation activities that necessarily include multiple competing theories or alternative theories from which learners need to choose based on supporting evidence (Osborne et al., 2004).

Several science educators (e.g., Duschl & Osborne, 2002; Khun, 2010) contend that although generating sufficient explanation based on evidence and appropriate reasoning is an integral part of argumentation, it is an extremely difficult component of the process of scientific inquiry and argumentation. The findings of this study corroborates with the above contention. The study revealed that promoting students engagement in constructing and validating scientific argumentation was one of the critical factors that hindered the participating pre-service teachers from using argumentation-based instructional model in Eritrean middle school science classrooms. That is why science educators argue that argumentation does not come naturally (e.g., Kuhn, 1993; Osborne et al., 2004) and therefore it needs to be explicitly taught through suitable instruction, task structuring and modelling Mason (1994). More importantly, teachers should often provide support and guidance to students during this process. Borrowing from the work of Kuhn (2010) the researcher suggests a piece of advice to teachers to primarily introduce the concept argumentation by providing a topic for discussion close to students' own experience to help them engage in everyday conversation. Once students are familiar with everyday argumentation it would be much easier for teachers to engage their students in socio-scientific and scientific scenarios.

Of great importance, teachers must experience argumentation not as a rote instructional approach to science teaching, but it should become a part of the way they think about and plan for science instruction. However, like any unfamiliar instructional strategy, the introduction of argumentation-instructional model in Eritrean science classroom will demand more than rhetoric. As alluded above, it will necessitate organising of long-term and supportive professional development programmes for science teachers aimed at training teachers to teach argumentation lessons in science classrooms. This precisely was what the argumentation-based intervention training programme administered in this study had attempted to do.

5.4 Recommendations

The conclusions made above provide insights for the following recommendations:

1. In many African countries including, Eritrea national education policy has changed more than practice when it comes to implementation of a learner-centred instruction in actual classroom setting. To make the implementation of the new learner-centred curriculum a

reality in Eritrean schools and elsewhere teacher education institutions should emphasize on equipping pre-service and in-service teachers with pedagogical knowledge and skills of inquiry-based pedagogies. Such pedagogical approaches will provide great opportunities to teachers to learn science in the light of social constructivism and transform these experiences in the science classroom. In such instructional approaches the teacher should act as facilitators who encourage learners to discover principles for themselves and to construct knowledge by working to solve realistic problems (Kim, 2005, p.8).

2. Pre-service curriculum and methods of instruction should be revised by: (a) integrating LCP into the curriculum across all courses and (b) restructuring the timetable to allow more structured opportunities for teaching practice using learner-centred approach of teaching such as argumentation-based instructional model**.**

3. LCP demands a different way of assessment where pre-service teachers should be able to demonstrate their ability to comprehend concepts and not only restate them, to apply theories to different settings, and to analyse novel problems critically by themselves and with others. Thus, in teacher education programmes, examinations and assessments should be aligned with learner-centred pedagogy so that the assessments are formative rather than only summative and they should include authentic learning tasks.

4. Professional development opportunities for science teacher educators should be provided through organising of professional development workshops that will enable them to: (a) appreciate the role of argumentation in science teaching and learning, and (b) design pedagogical strategies and resources for them to develop their practice in teaching science as an argument.

5. As alluded above, the result of this study suggests that it is possible to implement learner-centred curriculum in science classrooms using argumentation-based instructional model. In view of the promising findings of this study, the researcher recommended the inclusion of argumentation course in science teacher education programmes designed for the training of pre-service and in-service science teachers who are confronted with a new learner-centred curriculum.

6. This study, in agreement with previous studies (e.g., Erduran, 2006; Jimenez-Aleixandre & Erduran, 2008; Ogunniyi, 2004; Osborne, et al., 2004a.) confirms that argumentation-based instructional model has a potential to promote understanding of scientific concepts among learners with concrete logical reasoning and justified arguments. Although this finding is encouraging only very few pre-service teachers have been trained on how to use

argumentation-based instructional model in science classrooms. Therefore, to improve the practices of science teaching and learning at a national level, there is a need to train the wider group of school science teachers to teach science as an argument. This calls for the Eritrean science teacher education institutions and MOE to organize Continuing Professional Development (CPD) programmes for all science teachers on learning to teach argumentation. The institutions should further provide supportive materials and activities and set long-term follow-up strategies to monitor pre-service teachers' progress overtime. In this regard, Ogunniyi (2005, 2006) asserts that the most effective way to get teachers to be involved in the implementation of the new curriculum is to engage them in a long-term mentoring process in the form of dialogue, argumentation and explicitly reflective instructional approaches.

7. The findings of this study have indicated that even after a relatively short period of exposure to argumentation-based intervention training programme most pre-service teachers were able to participate in scientific and socio-scientific argumentation discourses and use argumentation-based instructional model to implement learner-centred curriculum in science classrooms. The underlying assumption that could be made from this finding is that introducing argumentation-based instructional model in all school subjects is likely to engage teachers and students in modes of thinking that characterize those of scientists. In the light of this assumption, this study recommends the introduction of argumentation instruction into the education system of Eritrea and other nations which are in the process of implementing learner-centred curriculum.

8. The limitations practised by some pre-service teachers in the process of implementation of argumentation instruction in science classrooms shows the importance of emphasising on epistemological goals in school-based professional development programme. Another limitation traced in this study is that some pre-service teachers did not value the role of argumentation in scaffolding discussion and in understanding the conceptual basis of the discussion points. Professional development programme should, therefore, train pre-service teachers about "alternative theories and evidences that support the theories as this help students to appreciate the justification for constructing scientific views as well as to understand why alternative views are not accepted" (Simon & Maloney, 2006, p.78).

9. The science teacher education programme need to take initiatives to undertake on-going school-based research on pre-service teachers' developmental stages on teaching science as

argument on the continuum from - their ability to engage in argumentation discourse as part of their science method course, to their initial practices for teaching science as argument during the teaching practice period, and finally their on-going development in the teaching practice and into their first years of teaching.

10. Teachers should create conducive learning environment that provides multiple opportunities for students to critique and refine their explanations through evidence-based argumentation.

11. "Critique is not a peripheral feature of science but rather it is core to its practice and without it the construction of realisable knowledge would be impossible" (Osborne, 2010, p. 465). Learning to critique and to weigh alternative evidences are invaluable skills that are applicable well beyond the science class. To develop such skills the teacher needs to help students to question assumptions and to think not just about finding a right answer, but about finding the best answer that relies on the best available evidence.

12. Science textbooks should incorporate activities that encourage discussion and argumentation on scientific and socio-scientific issues. Teachers guide should also guide teachers on how to:

- stimulate a learning environment which enable learners to actively participate in classroom discourse
- develop collaborative interaction within the small groups and across the groups
- enhance cognitive harmonization in science classes
- develop high level of argumentation skills
- use argumentation skills to promote students' conceptual understanding of science
- use students' prior knowledge to help them construct quality arguments.

5.5 Directions for further studies

Possible directions for future research that emerged out of this study are put forward. While this study seems to show the positive effect of argumentation-based intervention training programme on pre-service teachers' ability to implement learner-centred curriculum in science classrooms, continued empirical investigation with other cohort of pre-service teachers is a critical next step. It is anticipated that the next step will reveal areas of unexpected promise and difficulty. The encouraging outcomes of this study illustrates the need to further study the effect of argumentation-based instructional model in other school subjects as this area of research is relatively uncharted. As this study have not linked the effect of argumentation-based instructional model to students outcome, further studies are required to examine the effect of this model on Eritrean students': (a) conceptual understanding of science and (b) critical thinking and problem solving skills. The importance of dialogical argumentation in science teaching illustrates the need to further develop strategies for students who have low self-esteem and/or who encounter difficulties in socializing with their peers.

The results of this study seem to reveal that pre-service teachers' ability to employ argumentation-based instructional model in science classroom is influenced by their ability to construct quality arguments, a finding that can be unpacked further in future studies to examine how engagement in argumentation discourse can improve pre-service teachers' ability to teach argumentation lesson successfully. Studies that examine the correlation between teachers' understanding of argumentation and their ability to demonstrate complex arguments in their classroom are also recommended. Future studies directed toward the development of a learning progression for teaching science as argument which trace teachers' longitudinal development are also recommended. Little is known about this area of research in argumentation. Studies that examine the effect of the learning environment in the development of the social norms of scientific argumentation are also recommended.

There is a general consensus among educators that teachers largely teach the way they were taught. In agreement with this assertion, the findings of this study showed that some PTs who had teaching experience before were observed to use more of teacher-centred approach in their teaching even after their exposure to the intervention programme. We all know how difficult it is for teachers to change their practices especially if the change requires the acquisition of new skills. Therefore, more research is needed to define strategies that will reach teachers not using learner-centred approach and how factors such as previous teaching experience affect teachers' responses to professional development.

5.6 Conclusions

The argumentation-based intervention training programme has enabled the PTs to use argumentation-based instructional model to implement LCC in science classrooms and experienced some success in doing so. However, in a learning context where conceptual knowledge predominates, such as the case in Eritrean classrooms, emphasizing on alternative aims for science teaching would not be an easy task, thus requires a paradigm shift in the thinking and development of science curriculum and instruction. Moreover, the examination oriented school science curriculum and teacher education curriculum in Eritrean would often place additional burden on teachers and teacher educators. More importantly, without making fundamental change in the purpose and process of classroom assessment, it is unlikely that some of the encouraging findings obtained in this research might not be attained successfully.

It is noteworthy to indicate that this study trained very few pre-service teachers (25) on how to use argumentation-based instructional model in science classrooms. Therefore, to embed this new approach in the teaching of science as a normative practice in Eritrean classrooms and elsewhere, changes in pedagogy need to be adopted not just by individual pre-service science teachers in isolation but by whole science teachers working collaboratively (Simon, Richardson, Richardson, Christodolou, & Osborne, 2010). Hence, training science educators and the wider group of school science teachers in this area is warranted.

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Appendix A: Research corresponds

UNIVERSITY *of the* WESTERN CAPE

OFFICE OF THE DEAN
DEPARTMENT OF RESEARCH DEVELOPMENT

22 November 2012

To Whom It May Concern

I hereby certify that the Senate Research Committee of the University of the Western Cape has approved the methodology and ethics of the following research project by: Ms SB Berhe (Education)

Research Project:	The effect of an argumentation-based training programme on pre-service science teachers' ability to implement a learner-centred curriculum in selected Eritrean middle schools.
Registration no:	12/9/33

Any amendments, extension or other modifications to the protocol must be submitted to the Ethics Committee for approval.

The Committee must be informed of any serious adverse event and/or termination of the study.

Ms Patricia Josias
Research Ethics Committee Officer
University of the Western Cape

Private Bag X17, Bellville 7535, South Africa
T: +27 21 959 2988/2948 . F: +27 21 959 3170
E: pjosias@uwc.ac.za
www.uwc.ac.za

A place of quality,
a place to grow, from hope
to action through knowledge

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Private Bag X17, Belville, 7535
South Africa
Tel: +27 (0) 21 959 2040
Fax: +27 (0) 21 959 3943
Website: www.uwc.ac.za
Email: mogunniyi@uwc.ac.za

Date: 25 Jan, 2013

To: Tesfamichael Haile (PhD)
Academic Vice president, Eritrea Institute of Technology
Eritrea

Re: Permission to Conduct an Educational Pilot Study and Research Study

I am a lecture in the Department of Science Education, College of Education at the Eritrea Institute of Technology. Currently, I am studying at the University of Western Cape, South Africa for my doctoral degree. My research topic is: "The effect of an argumentation-based training programme on pre-service science teachers' ability to implement a learner-centred curriculum in selected Eritrean middle schools". I am planning to carry out a pilot study in the College of Education, Eritrea Institute of Technology for a couple of weeks (2-3). I intend to work with ten pre-service middle school science teachers from the College of Education.

The main study (to be conducted next month) will involve twenty pre-service middle school science teachers from the College of Education who are willing to take part in the research study. I am planning to conduct intervention training programme and collect data for my study in the College of Education at the Eritrea Institute of Technology from February 2013- up to June 2013. I will be using a video camera during the micro teaching as well as an audio-tape recorder for the interview sessions (if possible). The information gathered shall be used, solely for research purposes and the name of the pre-service science teaches shall not be disclosed to anyone.

The study attempts to examine the effect or otherwise of argumentation-based instructional approach on pre-service science teachers' ability to implement a learner-centred curriculum in selected Eritrean middle schools. However, the study does not endeavour to determine whether pre-service teachers are right or wrong in their teaching. It is therefore, anticipated that this study will expose relevant and necessary information that could be useful to both the Ministry of Education and College of Education. Also, it is hoped that it will contribute towards efforts directed at effecting change in science teaching, ameliorate the problems encountered in science classrooms and achieve the desired outcome.

RESPICE PROSPICE
UNIVERSITY of the
WESTERN CAPE

A place of quality, a place to grow, from hope to action through knowledge

At the end of my data analysis, I will give a summary report of my findings to the institute. For ethical consideration in data gathering, the stamp of the institute and signature will suffice for the purposes of proof of consultation and permission by concerned authority.

Could you kindly grant permission for conducting educational pilot study and research study in the college of Education under the jurisdiction of your institute?

With regards,

Senait Ghebru

College of Education

Eritrea Institute of technology

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STATE OF ERITREA
ERITREA INSTITUTE OF TECHNOLOGY
MAI NEFHI

Ref. No. AVP/4/ 04 /2013 Date: **15 Feb. 2013**

TO WHOM IT MAY CONCERN

Senait Ghebru is a lecturer in the Department of science Education, College of Education at the Eritrea Institute of technology (EIT). Currently she is studying at the University of Western Cape, South Africa for her doctoral degree. Her research topic is "The effect of an arguementation-based training program on pre-service science teachers' ability to implement a learner-centered curriculum in selected Eritrean Middle schools."

She is planning to carry out a study in the College of Education, EIT. Her study will involve school science teachers from the college and conduct intervention training program and collect data

The institute appreacites her plan and allows her to conduct educational pilot study and research study in the College of Education by using any convenient facilities such as a video camera, an audio-tape recorder for the interview sessions.

I thank you for your time and kind consideration.

Awet N'hafash
for 15/02/13
Tesfamichael Haile (Ph.D.)
A/President

ACADEMIC AFFAIRS
ERITREA INSTITUTE OF TECHNOLOGY

Address
ERITREA INSTITUTE OF TECHNOLOGY P.O.BOX 12676 TEL. 08371120

Appendix B - Learner-Centred Argumentation Instruction (LCAI) Questionnaire

The purpose of this questionnaire is to explore your views about the conceptions of learner-centred curriculum, learner-centred instruction and argumentation. The questionnaire consists of a demographic section, conceptions of learner-centred curriculum and instruction section as well as conceptions of argumentation section.

Please answer all items of this questionnaire. There are no right or wrong answers. It is neither a test nor an evaluation of you as a prospective science teacher. Feel free to express your view as honestly as possible. Your answers will be used for educational research purpose only. All your responses are confidential and will not be disclosed to anyone except as research information.

Section One: Personal data

Gender: Male ( ) Female ( ) Age: ………. Student ID: ……………………….

Years of teaching experience …………………….

Grade level assigned to teach: …………………………………

Home language: ……………………………………………………..

Other languages spoken: ……………………………………………

Religion: Christian ( ) Moslem ( ) Others: ……………..

Ethnic group you belong: ……………………………………………

Birth place: …………………………………………

Specify the place where you grew up: …………………………..

Section Two: Conceptions of learner-centred curriculum and instruction

1. What is your understanding of a learner-centred curriculum?

2. What is your understanding of a learner-centred instruction?

Section Three: Conceptions of Argumentation

3. Have you ever heard of argumentation before? Explain please.

4. What do you understand by the term "argumentation"?

5. Is there a difference between scientific argumentation and the informal argumentation people use in their daily lives?

6. What role if any, does scientific argumentation has in science education and in teaching science?

7. What skills and techniques do you think are required to support argumentation and keep argumentation going in a classroom setting?

8. If you are asked to assess the quality of arguments constructed by some of your classmates in a group discussion how would you evaluate it?

Appendix C: Selected Argument-based tasks

Task One: Everyday argumentation

Individual task (Activity 1a)

Name of pre-service teacher: ______________________ ID. No. : __________________

Argue for or against the claim" Punishment is an appropriate mechanism to control the discipline of students in a school setting". Organize your argument to support your position and write it in the space provided.

____
____
____

Group task

Group No. ______________________ ID. No(s) __________________

Follow the following steps

1. In your group, compare and discuss each other's reasoned argument.

2. Write down the most convincing reasoned argument in the space provided.

____
____
____
____

Task Two: Socio-scientific argumentation scenario

Individual task (Activity 1a)

Name of pre-service teacher: ______________________ ID. No. : __________________

Read the following peace of reading and answer the question that follows.

Should plastic bags be banned in our community?

Plastic shopping bags are usually distributed (for free in most cases) to customers by stores when purchasing goods. It is a popular method that is practiced in many countries for being a strong, cheap, and hygienic way of transporting items. Lightweight bags are commonly made from high-density polyethylene plastic. Problems associated with plastic bags include use of non-renewable resources (such as crude oil, gas and coal), disposal, and environmental impacts. Recent studies have also shown that the most evidence of plastic pollution consumption can be found in dead seabirds that have washed ashore containing bottle caps, cigarette lighters and coloured scraps that resemble baitfish. One animal dissected by Dutch researchers contained 1,603 pieces of plastic. More than a million seabirds, 100,000 marine mammals and countless fish die in North American waters by mistakenly eating plastic pollution. In India, an estimated number of 20 cows die per day as a result of ingesting plastic bags and having their digestive systems clogged by the bags. It is also very common across Africa including Eritrea to have sewers and drain systems clogged by bags which cause severe cases of malaria due to the increased population of mosquitoes that live on the flooded sewers.

To minimize the problems that are related with plastic bags, many countries, including Eritrea have banned taxed or restricted the use of plastic bags, just like the ones used at grocery stores, because they clog sewers and cause harm to wildlife. However, the American Plastics Council claims that it is not plastic that is causing the problem. They claim that plastics don't pollute, people do. (Source: Wikipedia, the free encyclopaedia, (2012, August 22). *Phase-out of lightweight plastic bags.* Retrieved from http://en.wikipedia.org/wiki/Phase-out_of_lightweight_plastic_bags)

Do you believe that plastics should be banned in your community? Please be sure to explain your position(s) clearly and tell **why** you believe the way you do. Consider the following argument prompts to help you construct strong arguments and counter arguments.

____
____
____

Argument prompts

- Why do you think that?
- What is your reason for that?
- Can you think of another argument against your view?
- How do you know?
- What is your evidence?
- Is there another argument for what you believe?

Group task

Group No. ______________________ **ID. No(s)** __________________

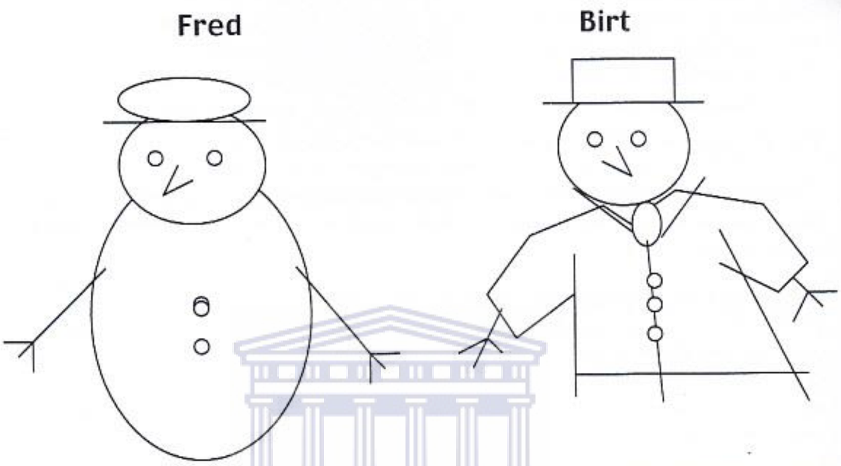
Follow the following steps

1. In your group, compare and discuss each other's reasoned argument.

2. Write down group's argument in the space provided.

Task Three: Scientific argumentation scenario-The Snowmen (Extracted from Osborne et al, 2004a)

The Melting Snowmen?



Fred: I think that I will melt first because the sun will hit me and the heat energy will change my snow into water

Birt: I think I will melt first because I will trap all the sun's energy inside my coat and this will cause my snow to melt into water

1. Which snowman do you think will melt first?
2. Why have you decided this?
3. Do you agree with the science behind Birt's argument?
4. Why?
5. Using the pieces of evidence given to you try to rewrite Fred's argument on the next diagram so that it is more convincing. (Be careful. Not all information is necessarily useful!)

Individual task

1) Read the statements constructed by Fred and Birt and decide which snowman (one wearing a coat and another not wearing a coat) will melt first

2) Why have you decided this?.

Pair task

a) Share your argument with the pre-service teacher next to you.

b) Write your reasons for why you believe in your argument in the writing frame displayed below.

Our Argument

Our group supports _______ argument. We believe this because: ______________________________ ______________________________ ______________________________ ______________________________ ______________________________ ______________________________

Pair to four

a) Share your argument with the pair next to you.

b) Use the evidence sheet to write an improved argument

Additional Evidence

- Woollen coats are insulators
- The sun's rays have both heat and light energy in them
- Heat energy needs to be stopped from escaping from the coat
- Heat energy from outside needs to be slowed from getting to the inside of the coat
- Heat is conducted by molecular vibrating and passing on the heat energy in the next molecule
- Water is a poor conductor of heat energy
- The snowman must reduce the amount of heat energy transferred to him from the sun if he isn't going to melt
- The snowman can reflect heat energy better if he is white and wearing coat

Appendix D: Argumentation lesson Observation Sheet/Instrument

Date: ________________________

School Name: ______________________ School Code: _____________

Pre-service teacher name: _________________

Pre-service teacher anonymous name: ________________

Gender: (Circle) Male or female

Age: ______________________

Grade level assigned to teach: ________________Number of learners: _________________

Duration: Start: ______________ End: ____________

Lesson Topic/subtopic: _________________

Consent by Pre-service science teacher

I consent to having my lesson observed today. The researcher explained the purpose and nature of the research and how data will be stored. Also, the researcher explained the extent to which confidentiality and anonymity will be protected, and assured me that my name shall not be disclosed to anyone. The researcher assured me that I have the right to decline or to withdraw at any time, without penalty if any of my rights is not respected. I fully understand that the information gathered shall be used, solely for research purposes. I understand that there are no implications for my studies and for the school where I am assigned to do my teaching practice.

Pre-service teacher's Signature: ____________________

Date: ____________________

Appendix I: Demography of PTs involved in this study

S. No.	Name	G	Age	Teaching Experience	Birth place	Place they grow up	Language and Ethic group	Religion
1.	PT1	M	20	No	Sudan	Sudan	Tigre	Muslim
2.*	PT2	M	20	No	Habero	Habero	Nara	Muslim
3	PT3	M	37	10	Shimbila	Sahel	Kunama	Muslim
4	PT4	F	21	No	Asmara	Asmara	Tigrigna	Christian
5.*	PT5	F	21	No	Adi-neamn	Asmara	Tigrigna	Christian
6	PT6	F	21	No	Asmara	Asmara	Tigrigna	Christian
7	PT7	M	20	No	Asseb	Massawa	Tigrigna	Christian
8	PT8	M	31	12	Asmara	Asmara	Tigrigna	Christian
9	PT9	M	35	11	Asmara	Asmara	Tigrigna	Christian
10	PT10	M	39	10	keren	keren	Blen	Christian
11.	PT11	F	22	No	Amader	Addis Abeba	Tigrigna	Christian
12.*	PT12	F	22	No	Addis Abeba	Asmara	Tigrigna	Christian
13*	PT13	M	38	11	Asmara	Asmara	Tigrigna	Christian
14	PT14	M	21	No	Asmara	Asmara	Tigrigna	Christian
15.	PT15	M	19	No	Asmara	Asmara	Tigrigna	Christian
16.*	PT16	M	23	No	Asmara	Asmara	Tigrigna	Christian
17	PT17	F	23	No	Sudan	Mendefera	Saho	Moslem
18	PT18	F	20	No	Massawa	Massawa	Afar	Moslem
19	PT19	F	19	No	Adi-Hdug	Adi-Qula	Tigrigna	Christian
20	PT20	F	21	No	Zagre	Asmara	Tigrigna	Christian
21	PT21	M	29	9	Asmara	Asmara	Tigrigna	Christian
22	PT22	M	24	No	Ethiopia	Daro Paulos	Tigrigna	Christian
23*	PT23	M	34	11	Adi-Teklay	Adi-Teklay	Tigrigna	Christian
24	PT24	F	22	No	Asmara	Asmara	Tigrigna	Christian
25	PT25	M	33	10	Qandeba	Qandeba	Tigrigna	Christian

* PTs selected for deeper qualitative analysis

Appendix E: Pre-service science teachers' interview schedule for argumentation lessons (Semi-structured questions)

Date: ______________________

School code: ____________________

School name:_________________________

Pre-service teacher name: ________________

Pre-service teacher anonymous name: _______________

Gender:

Age: ____________________

Grade level: ______________________ Number of learners: ________________

Duration: Start: _____________ End: ___________

Lesson Topic/subtopic: ________________

Introductory Comments

Thank you so much for allowing me to observe your lesson. I would like to follow up something with you. It is not possible to understand all that is going on in a lesson just from watching it. There are some aspects that I would like to talk to you about the overall teaching-learning process you are employing. I want to understand from you how and why you teach as you do. In this interview, we may not always understand each other well. If I ask anything that isn't clear or sounds strange, please tell me so that I can try to make it clearer. Finally, I kindly request you to allow me to audio record our conversation. This is to ensure that I cite you correctly.

1. Teachers use different strategies to get arguments started. Could you tell me what strategies you have used to start the process of argumentation?

2. In the lesson I observed students mainly worked on tasks/activities. What are the learning goals and aims of the tasks/activities? How did you outline and structure the task/activity?

3. I have observed in your class students ………….(presenting or not presenting) the discussion points of their respective groups to the whole class. Could you tell me how you facilitated group presentations and peer review? Why?

4. Do you think you have been evaluating the quality of argumentation constructed in the small group and whole class discussion? If so, could you tell me how you evaluate the levels of students' arguments?

5. I have noticed in your class that you have ………….(provided or not provided) feedback during group discussion and/or during whole class intervention. Could you explain why and how you have/have not provided feedback to students?

6. I have observed in your class …………(assessed or not assessed) students' understanding of scientific concepts. Could you explain why and how you have/have not assessed it?

7. Crucial to the effective use of argumentation activities is the way in which they are finished or rounded off. Do you think you have rounded off the argumentation lesson? If so, how and why did you rounded off the argumentation lesson? Elaborate it using example(s).

8. What skills and techniques did you employ to promote and sustain argumentation?

9. Do you think that you have modelled argument and counter argument in the lesson that I have observed? If so, how and why did you model argument?

10. I have observed students constructing written arguments in the writing frames. What strategies have you used to support students in developing this skill?

11. Do you think that you have encouraged your students to justify their claim using evidence. If so, could you tell me the strategies you have used to demonstrated this goal?

12. Do you think that you have encouraged the students to evaluate or make judgment about their own and their peers' arguments? If so, could you explain why and how you manifested this goal?

13. What are the factors that promoted you to use argumentation-based instructional model in science classroom?

14. What do you think are the most challenging factors that hindered you from using argumentation-based instructional approach to implementation a learner-centred curriculum in science classroom?

Further comments:

____

____

____

Appendix F: Reflective response questionnaire/Reflective interview

1. What narratives can you tell about your understanding of LCC and LCI before and after your involvement in the intervention programme and in the reflective sessions?

2. What narratives can you tell about your understanding of scientific argumentation and its role in science teaching/science education at the time you started participating in the intervention at the end of the intervention and after your involvement in the teaching practice session?

3. What narratives can you tell about your understanding of the skills and techniques required to support and sustain argumentation in science lessons at the time you started participating in the intervention at the end of the intervention and after your involvement in the teaching practice session?

4. How have the intervention training programme prepared you to use ABIM in implementing a LCC in science classrooms?

5. Which activities/aspect, during your involvement in the intervention programme were most influential, and enabled you to navigate, frame or make sense of introducing ABIM in science classrooms to implement a LCC?

6. What are the factors that promote or hinder you from using ABIM in your science classrooms during the teaching practice period?

Appendix G: Argumentation-based lessons carried out during the intervention programme

Task One: Everyday argumentation

Individual task (Activity 1a)

Name of pre-service teacher: ______________________ ID. No. : __________________

Argue for or against the claim" Punishment is an appropriate mechanism to control the discipline of students in a school setting". Organize your argument to support your position and write it in the space provided.

____
____
____

Group task

Group No. ______________________ ID. No(s) __________________

Follow the following steps

1. In your group, compare and discuss each other's reasoned argument.

2. Write down the most convincing reasoned argument in the space provided.

____
____
____
____

Task Two: Socio-scientific argumentation scenario

Individual task (Activity 1a)

Name of pre-service teacher: ______________________ ID. No. : __________________

Read the following peace of reading and answer the question that follows.

Should plastic bags be banned in our community?

Plastic shopping bags are usually distributed (for free in most cases) to customers by stores when purchasing goods. It is a popular method that is practiced in many countries for being a strong, cheap, and hygienic way of transporting items. Lightweight bags are commonly made from high-density polyethylene plastic. Problems associated with plastic bags include use of non-renewable resources (such as crude oil, gas and coal), disposal, and environmental impacts. Recent studies have also shown that the most evidence of plastic pollution consumption can be found in dead seabirds that have washed ashore containing bottle caps, cigarette lighters and coloured scraps that resemble baitfish. One animal dissected by Dutch researchers contained 1,603 pieces of plastic. More than a million seabirds, 100,000 marine mammals and countless fish die in North American waters by mistakenly eating plastic pollution. In India, an estimated number of 20 cows die per day as a result of ingesting plastic bags and having their digestive systems clogged by the bags. It is also very common across Africa including Eritrea to have sewers and drain systems clogged by bags which cause severe cases of malaria due to the increased population of mosquitoes that live on the flooded sewers.

To minimize the problems that are related with plastic bags, many countries, including Eritrea have banned taxed or restricted the use of plastic bags, just like the ones used at grocery stores, because they clog sewers and cause harm to wildlife. However, the American Plastics Council claims that it is not plastic that is causing the problem. They claim that plastics don't pollute, people do. (Source: Wikipedia, the free encyclopaedia, (2012, August 22). *Phase-out of lightweight plastic bags.* Retrieved from http://en.wikipedia.org/wiki/Phase-out_of_lightweight_plastic_bags)

Do you believe that plastics should be banned in your community? Please be sure to explain your position(s) clearly and tell **why** you believe the way you do. Consider the following argument prompts to help you construct strong arguments and counter arguments.

____
____
____

Argument prompts

- Why do you think that?
- What is your reason for that?
- Can you think of another argument against your view?
- How do you know?
- What is your evidence?
- Is there another argument for what you believe?

Group task

Group No. ______________________ ID. No(s) __________________

Follow the following steps

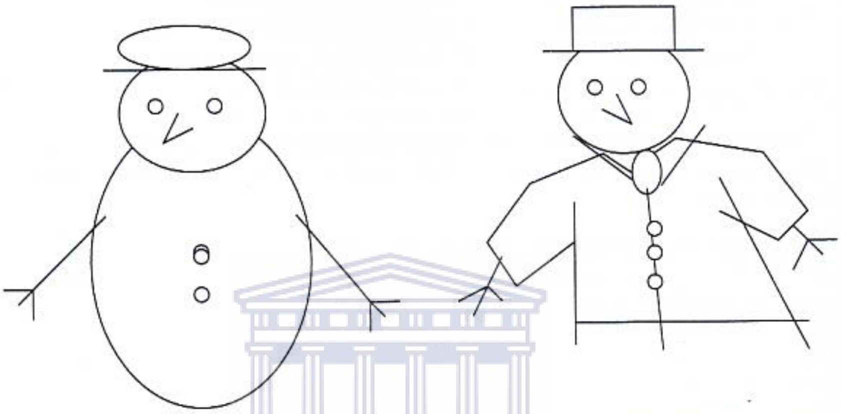
1. In your group, compare and discuss each other's reasoned argument.

2. Write down group's argument in the space provided.

Task Three: Scientific argumentation scenario-The Snowmen (Extracted from Osborne et al, 2004a)

The Melting Snowmen?

Fred | Birt



> I think that I will melt first because the sun will hit me and the heat energy will change my snow into water

> I think I will melt first because I will trap all the sun's energy inside my coat and this will cause my snow to melt into water

1. Which snowman do you think will melt first?
2. Why have you decided this?
3. Do you agree with the science behind Birt's argument?
4. Why?
5. Using the pieces of evidence given to you try to rewrite Fred's argument on the next diagram so that it is more convincing. (Be careful. Not all information is necessarily useful!)

Individual task

1) Read the statements constructed by Fred and Birt and decide which snowman (one wearing a coat and another not wearing a coat) will melt first

2) Why have you decided this?.

Pair task

a) Share your argument with the pre-service teacher next to you.

b) Write your reasons for why you believe in your argument in the writing frame displayed below.

Our Argument

Our group supports _______ argument. We believe this because: ______________________________ ______________________________ ______________________________ ______________________________ ______________________________ ______________________________

Pair to four

a) Share your argument with the pair next to you.

b) Use the evidence sheet to write an improved argument

Additional Evidence

- Woollen coats are insulators
- The sun's rays have both heat and light energy in them
- Heat energy needs to be stopped from escaping from the coat
- Heat energy from outside needs to be slowed from getting to the inside of the coat
- Heat is conducted by molecular vibrating and passing on the heat energy in the next molecule
- Water is a poor conductor of heat energy
- The snowman must reduce the amount of heat energy transferred to him from the sun if he isn't going to melt
- The snowman can reflect heat energy better if he is white and wearing coat

Table M1: Individual PT’s performance with reference to stating learning goals

S.No.	PT’s Identity	Lesson 1			Lesson 2			Lesson 3		
		P	**I**	**E**	**P**	**I**	**E**	**P**	**I**	**E**
1	PT1		x				x			x
2*	PT2	X			x			x		
3	PT3			x			X			X
4	PT4	X				x				x
5*	PT5	X			x			x		
6	PT6	X					X			X
7	PT7	X			x			x		
8	PT8			x			X			X
9	PT9			x			X			X
10	PT10			x			X			X
11	PT11	X				x			x	
12*	PT12		x				X			X
13*	PT13			x			X			X
14	PT14	X					X			X
15	PT15	X				x			x	
16*	PT16		x				X			X
17	PT17		x				X			X
18	PT18	X					X			X
19	PT19	X			X					X
20	PT20	X			x					X
21	PT21			x			X			X
22	PT22	X			x					X
23*	PT23			x			X			X
24	PT24	X			x					x
25	PT25			x			x			x
	Total	**13 (52%)**	**4(16%)**	**8 (32%)**	**7 (28%)**	**3(12%)**	**15 (60%)**	**3 (12%)**	**2 (8%)**	**20 (80%)**

Key: P=Poor I= Intermediate E= Excellent * PTs selected for deeper qualitative analysis

‘X’ specifies performance indicators of individual PT’s with reference to the rating scales described in the rubric (see Appendix K)

Table M2: Individual PT’s performance with reference to stating aims of the task

S.No.	PT’s Identity	Lesson 1			Lesson 2			Lesson 3		
		P	**I**	**E**	**P**	**I**	**E**	**P**	**I**	**E**
1	PT1		x				x			x
2*	PT2	X			x			x		
3	PT3			x			X			X
4	PT4	X				x				x
5*	PT5	X			x			x		
6	PT6	X					X			X
7	PT7	X			x			x		
8	PT8			x			X			X
9	PT9			x			X			X
10	PT10			x			X			X
11	PT11	X				x			x	
12*	PT12		x				X			X
13*	PT13			x			X			X
14	PT14	X					X			X
15	PT15	X				x			x	
16*	PT16		x				X			X
17	PT17		x				X			X
18	PT18	X					X			X
19	PT19	X			X					X
20	PT20	X			x					X
21	PT21			x			X			X
22	PT22	X			x					X
23*	PT23			x			X			X
24	PT24	X			x					x
25	PT25			x			x			x
	Total	**13 (52%)**	**4(16%)**	**8(32%)**	**7 (28%)**	**3 (12%)**	**15 (60%)**	**3 (12%)**	**2 (8%)**	**20 (80%)**

Key: P=Poor I= Intermediate E= Excellent * PTs selected for deeper qualitative analysis

‘X’ specifies performance indicators of individual PT’s with reference to the rating scales described in the rubric (see Appendix K)

Table M3: Individual PT's performance with reference to outlining and/explaining the task

S.No.	PT's Identity	Lesson 1			Lesson 2			Lesson 3		
		P	**I**	**E**	**P**	**I**	**E**	**P**	**I**	**E**
1	PT1			x			x			x
2*	PT2		x			x				x
3	PT3			X			X			X
4	PT4	x			x					x
5*	PT5		x				x			x
6	PT6			X			X			X
7	PT7		x		x				x	
8	PT8			X			X			X
9	PT9			X			X			X
10	PT10			X			X			X
11	PT11		x			x				x
12*	PT12			X			X			X
13*	PT13			X			X			X
14	PT14	x					x			x
15	PT15	x			x				x	
16*	PT16			X			X			X
17	PT17			X			X			X
18	PT18			X			X			X
19	PT19	x					x			x
20	PT20	x				x				X
21	PT21			X			X			X
22	PT22	x			x					x
23*	PT23			X			X			X
24	PT24	x			x				x	
25	PT25		x				x			x
	Total	**7 (28%)**	**5(20%)**	**13(52 %)**	**5(20%)**	**3(12 %)**	**17(68 %)**	**0(0%)**	**3(12%)**	**22(88%)**

Key: P=Poor I= Intermediate E= Excellent * PTs selected for deeper qualitative analysis

'X' specifies performance indicators of individual PT's with reference to the rating scales described in the rubric (see Appendix K)

Table M4: Individual PT's performance with reference to provision of individual task

S.No.	PT's Identity	Lesson 1			Lesson 2			Lesson 3		
		P	**I**	**E**	**P**	**I**	**E**	**P**	**I**	**E**
1	PT1			x			x			x
2*	PT2		X			x	x		x	x
3	PT3			X			X			X
4	PT4			x			x			x
5*	PT5		X			x	x			x
6	PT6			X			X			X
7	PT7		x			x			x	
8	PT8			X			X			X
9	PT9		x				X			X
10	PT10			X			X			X
11	PT11		x				x			x
12*	PT12			X		x	X			X
13*	PT13			X			X			X
14	PT14			x			x			x
15	PT15		x			x			x	
16*	PT16			X			X			X
17	PT17			X			X			X
18	PT18		x				X			X
19	PT19			x			x			x
20	PT20		x			x	X		x	X
21	PT21			X			X			X
22	PT22			x			x			x
23*	PT23		x			x	X			X
24	PT24			x						
25	PT25		x	x			x			x
	Total	**0(0%)**	**10(40%0**	**15(60 %)**	**0(0%)**	**7(28 %)**	**18(72 %)**	**0(0%)**	**4(16%)**	**21(84%)**

Key: P=Poor I= Intermediate E= Excellent * PTs selected for deeper qualitative analysis

'X' specifies performance indicators of individual PT's with reference to the rating scales described in the rubric (see Appendix K)

Table M5: Individual PT’s performance with reference to provision of group task

S.No.	PT’s Identity	Lesson 1			Lesson 2			Lesson 3		
		p	I	E	P	I	E	P	I	E
1	PT1			x			x			x
2*	PT2	x			x				x	
3	PT3			X			X			X
4	PT4	x					x			x
5*	PT5	x			x				x	
6	PT6			X			X			X
7	PT7			x		x				x
8	PT8			X			X			X
9	PT9	x			x				x	
10	PT10			X			X			X
11	PT11	x					x			x
12*	PT12			X			X			X
13*	PT13			X			X			X
14	PT14			x			x			x
15	PT15	x					x			x
16*	PT16			X			X			X
17	PT17			X			X			X
18	PT18			X			X			X
19	PT19			x			x		x	
20	PT20	x				x				x
21	PT21			X			X			X
22	PT22			x			x		x	
23*	PT23	x			x					x
24	PT24			x			x			x
25	PT25	x			x					x
	Total	**9(36%)**	**0(0%)**	**16(64 %)**	**5(20%)**	**2(8%)**	**18(72 %)**	**0(0) %)**	**5(20%)**	**20(80%)**

Key: P=Poor I= Intermediate E= Excellent * PTs selected for deeper qualitative analysis

‘X’ specifies performance indicators of individual PT’s with reference to the rating scales described in the rubric (see Appendix K)

Table M6: Individual PT’s performance with reference to facilitation of group presentation and mediation of whole class discussion

S.No.	PT’s Identity	Lesson 1			Lesson 2			Lesson 3		
		P	I	E	P	I	E	P	I	E
1	PT1		x				x			x
2*	PT2	x				x			x	
3	PT3			X			X			X
4	PT4	x					x			x
5*	PT5	x				x			x	
6	PT6			X			X			X
7	PT7		x				x			x
8	PT8			X			X			X
9	PT9	x				x			x	
10	PT10			X			X			X
11	PT11	x				x				x
12*	PT12			X			X			X
13*	PT13			X			X			X
14	PT14		x				x			x
15	PT15	x				x			x	
16*	PT16			X			X			X
17	PT17			X			X			X
18	PT18		x				X			X
19	PT19		x				x			x
20	PT20	x				x			x	
21	PT21			X			X			X
22	PT22		x				x			x
23*	PT23	x				x			x	
24	PT24		x				x			x
25	PT25	x				x				x
	Total	**9(36%)**	**7(28%)**	**9(36%)**	**0 (0%)**	**8(32 %)**	**17(68 %)**	**0 (0%)**	**6(24%)**	**19(76%)**

Key: P=Poor I= Intermediate E= Excellent * PTs selected for deeper qualitative analysis

‘X’ specifies performance indicators of individual PT’s with reference to the rating scales described in the rubric (see Appendix K)

Table M7: Individual PT's performance with reference to ascertaining students' understanding of scientific concepts

S.No.	PT's Identity	Lesson 1			Lesson 2			Lesson 3		
		P	I	E	P	I	E	P	I	E
1	PT1	x					x			x
2*	PT2		x			x				x
3	PT3			x			x			x
4	PT4			x		x				x
5*	PT5		x		x					x
6	PT6		x				x		x	
7	PT7	X			x					x
8	PT8			x			x			x
9	PT9		x				x			x
10	PT10			x			x			x
11	PT11	X					x			x
12*	PT12			x			x			x
13*	PT13			x			x			x
14	PT14		x				x			x
15	PT15		x		X				x	x
16*	PT16			X			X			X
17	PT17			X			X			X
18	PT18			x		x				x
19	PT19	X				x			x	
20	PT20	X					x			x
21	PT21		x				x			x
22	PT22		x			x				x
23*	PT23		x				x			x
24	PT24			x		x			x	
25	PT25		x				x			x
	Total	**5(20%)**	**10(40%)**	**10(40 %)**	**3(12%)**	**6(24 %)**	**16(64 %)**	**0**	**4(16%)**	**21(84%)**

Key: P=Poor I= Intermediate E= Excellent * PTs selected for deeper qualitative analysis

'X' specifies performance indicators of individual PT's with reference to the rating scales described in the rubric (see Appendix K)

Table M8: Individual PT's performance with reference to assessing the quality of students' argument

S.No.	PT's Identity	Lesson 1			Lesson 2			Lesson 3		
		P	I	E	P	I	E	P	I	E
1	PT1	x					x			x
2*	PT2	x			x			x		
3	PT3			x			x			x
4	PT4		x			x				x
5*	PT5	x			x			x		
6	PT6	x					x			X
7	PT7	x			x					x
8	PT8			x			x			x
9	PT9	X			X			X		
10	PT10			x			x			x
11	PT11	X				x				x
12*	PT12			x			x			x
13*	PT13			x			x			x
14	PT14		x		X				x	
15	PT15	X			X					x
16*	PT16			X			X			X
17	PT17			X			X			X
18	PT18		x			x			x	
19	PT19	X				x				X
20	PT20	X				X			x	
21	PT21		x				x		x	
22	PT22	x					x			x
23*	PT23	x			x			x		
24	PT24	x					x			x
25	PT25	x			x			x		
	Total	**14(56%)**	**4(16%)**	**7 (28%)**	**8(32%)**	**5(20 %)**	**12(48 %)**	**5 (20%)**	**4(16%)**	**16(64%)**

Key: P=Poor I= Intermediate E= Excellent * PTs selected for deeper qualitative analysis

'X' specifies performance indicators of individual PT's with reference to the rating scales described in the rubric (see Appendix K)

Table M9: Individual PT's performance with reference to provision of quality feedback

S.No.	PT's Identity	Lesson 1			Lesson 2			Lesson 3		
		P	**I**	**E**	**P**	**I**	**E**	**P**	**I**	**E**
1	PT1	x				x				x
2*	PT2	x			x			x		
3	PT3		x				x			x
4	PT4	x			x					x
5*	PT5	x			x			x		
6	PT6	x					x			X
7	PT7	x			x					x
8	PT8			x			x			x
9	PT9	X			X			X		
10	PT10			x			x			x
11	PT11	X			X				x	
12*	PT12	x			x					x
13*	PT13			x			x			x
14	PT14		x		X					x
15	PT15	X			X					x
16*	PT16			X			X			X
17	PT17			X			X			X
18	PT18		x			x				x
19	PT19	X			X					X
20	PT20	X			X				x	
21	PT21	x					x			x
22	PT22	x			x					x
23*	PT23	x			x			x		
24	PT24	x			x					x
25	PT25	x			x			x		
	Total	**17(68%)**	**3(12%)**	**5 (20%)**	**15(60%)**	**2(08 %)**	**8(32 %)**	**5 (20%)**	**2(8%)**	**18(72%)**

Key: P=Poor I= Intermediate E= Excellent * PTs selected for deeper qualitative analysis

'X' specifies performance indicators of individual PT's with reference to the rating scales described in the rubric (see Appendix K)

Table M10: Individual PT's performance with reference to rounding off the argument-based lesson

S.No.	PT's Identity	Lesson 1			Lesson 2			Lesson 3		
		P	**I**	**E**	**P**	**I**	**E**	**P**	**I**	**E**
1	PT1			x			x			x
2*	PT2	x			x			x		
3	PT3			x			x			x
4	PT4	x				x			x	
5*	PT5	x			x			x		
6	PT6	x					x			x
7	PT7	x			x				x	
8	PT8			x			x			x
9	PT9		x		X			X		
10	PT10			x			x			x
11	PT11	X			X			X		
12*	PT12			x		x				x
13*	PT13			x			x			x
14	PT14	X			x					x
15	PT15	X				x			x	
16*	PT16			X			X			X
17	PT17			X			X			X
18	PT18		x				x			x
19	PT19	X				x			x	
20	PT20	X					x			x
21	PT21	x				x				x
22	PT22			x			x		x	
23*	PT23		x				x			x
24	PT24	x				x				x
25	PT25		x				x			x
	Total	**12 (48%)**	**4(16%)**	**9 (36%)**	**6(24%)**	**6(24 %)**	**13(52 %)**	**4(16 %)**	**5(20%)**	**16(64%)**

Key: P=Poor I= Intermediate E= Excellent * PTs selected for deeper qualitative analysis

'X' specifies performance indicators of individual PT's with reference to the rating scales described in the rubric (see Appendix K)

Table M1: Individual PT's performance with reference to stating learning goals

S.No.	PT's Identity	Lesson 1			Lesson 2			Lesson 3		
		P	I	E	P	I	E	P	I	E
1	PT1		x				x			x
2*	PT2	X			x			x		
3	PT3			x			X			X
4	PT4	X				x				x
5*	PT5	X			x			x		
6	PT6	X					X			X
7	PT7	X			x			x		
8	PT8			x			X			X
9	PT9			x			X			X
10	PT10			x			X			X
11	PT11	X				x			x	
12*	PT12		x				X			X
13*	PT13			x			X			X
14	PT14	X					X			X
15	PT15	X				x			x	
16*	PT16		x				X			X
17	PT17		x				X			X
18	PT18	X					X			X
19	PT19	X			X					X
20	PT20	X			x					X
21	PT21			x			X			X
22	PT22	X			x					X
23*	PT23			x			X			X
24	PT24	X			x					x
25	PT25			x			x			x
	Total	**13 (52%)**	**4(16%)**	**8 (32%)**	**7 (28%)**	**3(12%)**	**15 (60%)**	**3 (12%)**	**2 (8%)**	**20 (80%)**

Key: P=Poor I= Intermediate E= Excellent * PTs selected for deeper qualitative analysis

'X' specifies performance indicators of individual PT's with reference to the rating scales described in the rubric (see Appendix K)

Table M2: Individual PT's performance with reference to stating aims of the task

S.No.	PT's Identity	Lesson 1			Lesson 2			Lesson 3		
		P	I	E	P	I	E	P	I	E
1	PT1		x				x			x
2*	PT2	X			x			x		
3	PT3			x			X			X
4	PT4	X				x				x
5*	PT5	X			x			x		
6	PT6	X					X			X
7	PT7	X			x			x		
8	PT8			x			X			X
9	PT9			x			X			X
10	PT10			x			X			X
11	PT11	X				x			x	
12*	PT12		x				X			X
13*	PT13			x			X			X
14	PT14	X					X			X
15	PT15	X				x			x	
16*	PT16		x				X			X
17	PT17		x				X			X
18	PT18	X					X			X
19	PT19	X			X					X
20	PT20	X			x					X
21	PT21			x			X			X
22	PT22	X			x					X
23*	PT23			x			X			X
24	PT24	X			x					x
25	PT25			x			x			x
	Total	**13 (52%)**	**4(16%)**	**8(32%)**	**7 (28%)**	**3 (12%)**	**15 (60%)**	**3 (12%)**	**2 (8%)**	**20 (80%)**

Key: P=Poor I= Intermediate E= Excellent * PTs selected for deeper qualitative analysis

'X' specifies performance indicators of individual PT's with reference to the rating scales described in the rubric (see Appendix K)

Table M3: Individual PT's performance with reference to outlining and/explaining the task

S.No.	PT's Identity	Lesson 1			Lesson 2			Lesson 3		
		P	I	E	P	I	E	P	I	E
1	PT1			x			x			x
2*	PT2		x			x				x
3	PT3			X			X			X
4	PT4	x			x					x
5*	PT5		x				x			x
6	PT6			X			X			X
7	PT7		x		x				x	
8	PT8			X			X			X
9	PT9			X			X			X
10	PT10			X			X			X
11	PT11		x			x				x
12*	PT12			X			X			X
13*	PT13			X			X			X
14	PT14	x					x			x
15	PT15	x			x				x	
16*	PT16			X			X			X
17	PT17			X			X			X
18	PT18			X			X			X
19	PT19	x					x			x
20	PT20	x				x				X
21	PT21			X			X			X
22	PT22	x			x					x
23*	PT23			X			X			X
24	PT24	x			x				x	
25	PT25		x				x			x
	Total	**7 (28%)**	**5(20%)**	**13(52 %)**	**5(20%)**	**3(12 %)**	**17(68 %)**	**0(0%)**	**3(12%)**	**22(88%)**

Key: P=Poor I= Intermediate E= Excellent * PTs selected for deeper qualitative analysis

'X' specifies performance indicators of individual PT's with reference to the rating scales described in the rubric (see Appendix K)

Table M4: Individual PT's performance with reference to provision of individual task

S.No.	PT's Identity	Lesson 1			Lesson 2			Lesson 3		
		P	I	E	P	I	E	P	I	E
1	PT1			x			x			x
2*	PT2		X			x	x		x	x
3	PT3			X			X			X
4	PT4			x			x			x
5*	PT5		X			x	x			x
6	PT6			X			X			X
7	PT7		x			x			x	
8	PT8			X			X			X
9	PT9		x				X			X
10	PT10			X			X			X
11	PT11		x				x			x
12*	PT12			X		x	X			X
13*	PT13			X			X			X
14	PT14			x			x			x
15	PT15		x			x			x	
16*	PT16			X			X			X
17	PT17			X			X			X
18	PT18		x				X			X
19	PT19			x			x			x
20	PT20		x			x	X		x	X
21	PT21			X			X			X
22	PT22			x			x			x
23*	PT23		x			x	X			X
24	PT24			x						
25	PT25		x	x			x			x
	Total	**0(0%)**	**10(40%0**	**15(60 %)**	**0(0%)**	**7(28 %)**	**18(72 %)**	**0(0%)**	**4(16%)**	**21(84%)**

Key: P=Poor I= Intermediate E= Excellent * PTs selected for deeper qualitative analysis

'X' specifies performance indicators of individual PT's with reference to the rating scales described in the rubric (see Appendix K)

Table M5: Individual PT's performance with reference to provision of group task

S.No.	PT's Identity	Lesson 1			Lesson 2			Lesson 3		
		p	I	E	P	I	E	P	I	E
1	PT1			x			x			x
2*	PT2	x			x				x	
3	PT3			X			X			X
4	PT4	x					x			x
5*	PT5	x			x				x	
6	PT6			X			X			X
7	PT7			x		x				x
8	PT8			X			X			X
9	PT9	x			x				x	
10	PT10			X			X			X
11	PT11	x					x			x
12*	PT12			X			X			X
13*	PT13			X			X			X
14	PT14			x			x			x
15	PT15	x					x			x
16*	PT16			X			X			X
17	PT17			X			X			X
18	PT18			X			X			X
19	PT19			x			x		x	
20	PT20	x				x				x
21	PT21			X			X			X
22	PT22			x			x		x	
23*	PT23	x			x					x
24	PT24			x			x			x
25	PT25	x			x					x
	Total	**9(36%)**	**0(0%)**	**16(64 %)**	**5(20%)**	**2(8%)**	**18(72 %)**	**0(0) %)**	**5(20%)**	**20(80%)**

Key: P=Poor I= Intermediate E= Excellent * PTs selected for deeper qualitative analysis

'X' specifies performance indicators of individual PT's with reference to the rating scales described in the rubric (see Appendix K)

Table M6: Individual PT's performance with reference to facilitation of group presentation and mediation of whole class discussion

S.No.	PT's Identity	Lesson 1			Lesson 2			Lesson 3		
		P	I	E	P	I	E	P	I	E
1	PT1		x				x			x
2*	PT2	x				x			x	
3	PT3			X			X			X
4	PT4	x					x			x
5*	PT5	x				x			x	
6	PT6			X			X			X
7	PT7		x				x			x
8	PT8			X			X			X
9	PT9	x				x			x	
10	PT10			X			X			X
11	PT11	x				x				x
12*	PT12			X			X			X
13*	PT13			X			X			X
14	PT14		x				x			x
15	PT15	x				x			x	
16*	PT16			X			X			X
17	PT17			X			X			X
18	PT18		x				X			X
19	PT19		x				x			x
20	PT20	x				x			x	
21	PT21			X			X			X
22	PT22		x				x			x
23*	PT23	x				x			x	
24	PT24		x				x			x
25	PT25	x				x				x
	Total	**9(36%)**	**7(28%)**	**9(36%)**	**0 (0%)**	**8(32 %)**	**17(68 %)**	**0 (0%)**	**6(24%)**	**19(76%)**

Key: P=Poor I= Intermediate E= Excellent * PTs selected for deeper qualitative analysis

'X' specifies performance indicators of individual PT's with reference to the rating scales described in the rubric (see Appendix K)

Table M7: Individual PT's performance with reference to ascertaining students' understanding of scientific concepts

S.No.	PT's Identity	Lesson 1			Lesson 2			Lesson 3		
		P	I	E	P	I	E	P	I	E
1	PT1	x					x			x
2*	PT2		x			x				x
3	PT3			x			x			x
4	PT4			x		x				x
5*	PT5		x		x					x
6	PT6		x				x		x	
7	PT7	X			x					x
8	PT8			x			x			x
9	PT9		x				x			x
10	PT10			x			x			x
11	PT11	X					x			x
12*	PT12			x			x			x
13*	PT13			x			x			x
14	PT14		x				x			x
15	PT15		x		X				x	x
16*	PT16			X			X			X
17	PT17			X			X			X
18	PT18			x		x				x
19	PT19	X				x			x	
20	PT20	X					x			x
21	PT21		x				x			x
22	PT22		x			x				x
23*	PT23		x				x			x
24	PT24			x		x			x	
25	PT25		x				x			x
	Total	**5(20%)**	**10(40%)**	**10(40 %)**	**3(12%)**	**6(24 %)**	**16(64 %)**	**0**	**4(16%)**	**21(84%)**

Key: P=Poor I= Intermediate E= Excellent * PTs selected for deeper qualitative analysis

'X' specifies performance indicators of individual PT's with reference to the rating scales described in the rubric (see Appendix K)

Table M8: Individual PT's performance with reference to assessing the quality of students' argument

S.No.	PT's Identity	Lesson 1			Lesson 2			Lesson 3		
		P	I	E	P	I	E	P	I	E
1	PT1	x					x			x
2*	PT2	x			x			x		
3	PT3			x			x			x
4	PT4		x			x				x
5*	PT5	x			x			x		
6	PT6	x					x			X
7	PT7	x			x					x
8	PT8			x			x			x
9	PT9	X			X			X		
10	PT10			x			x			x
11	PT11	X				x				x
12*	PT12			x			x			x
13*	PT13			x			x			x
14	PT14		x		X				x	
15	PT15	X			X					x
16*	PT16			X			X			X
17	PT17			X			X			X
18	PT18		x			x			x	
19	PT19	X				x				X
20	PT20	X				X			x	
21	PT21		x				x		x	
22	PT22	x					x			x
23*	PT23	x			x			x		
24	PT24	x					x			x
25	PT25	x			x			x		
	Total	**14(56%)**	**4(16%)**	**7 (28%)**	**8(32%)**	**5(20 %)**	**12(48 %)**	**5 (20%)**	**4(16%)**	**16(64%)**

Key: P=Poor I= Intermediate E= Excellent * PTs selected for deeper qualitative analysis

'X' specifies performance indicators of individual PT's with reference to the rating scales described in the rubric (see Appendix K)

Table M9: Individual PT's performance with reference to provision of quality feedback

S.No.	PT's Identity	Lesson 1			Lesson 2			Lesson 3		
		P	**I**	**E**	**P**	**I**	**E**	**P**	**I**	**E**
1	PT1	x				x				x
2*	PT2	x			x			x		
3	PT3		x				x			x
4	PT4	x			x					x
5*	PT5	x			x			x		
6	PT6	x					x			X
7	PT7	x			x					x
8	PT8			x			x			x
9	PT9	X			X			X		
10	PT10			x			x			x
11	PT11	X			X				x	
12*	PT12	x			x					x
13*	PT13			x			x			x
14	PT14		x		X					x
15	PT15	X			X					x
16*	PT16			X			X			X
17	PT17			X			X			X
18	PT18		x			x				x
19	PT19	X			X					X
20	PT20	X			X				x	
21	PT21	x					x			x
22	PT22	x			x					x
23*	PT23	x			x			x		
24	PT24	x			x					x
25	PT25	x			x			x		
	Total	**17(68%)**	**3(12%)**	**5 (20%)**	**15(60%)**	**2(08 %)**	**8(32 %)**	**5 (20%)**	**2(8%)**	**18(72%)**

Key: P=Poor I= Intermediate E= Excellent * PTs selected for deeper qualitative analysis

'X' specifies performance indicators of individual PT's with reference to the rating scales described in the rubric (see Appendix K)

Table M10: Individual PT's performance with reference to rounding off the argument-based lesson

S.No.	PT's Identity	Lesson 1			Lesson 2			Lesson 3		
		P	**I**	**E**	**P**	**I**	**E**	**P**	**I**	**E**
1	PT1			x			x			x
2*	PT2	x			x			x		
3	PT3			x			x			x
4	PT4	x				x			x	
5*	PT5	x			x			x		
6	PT6	x					x			x
7	PT7	x			x				x	
8	PT8			x			x			x
9	PT9		x		X			X		
10	PT10			x			x			x
11	PT11	X			X			X		
12*	PT12			x		x				x
13*	PT13			x			x			x
14	PT14	X			x					x
15	PT15	X				x			x	
16*	PT16			X			X			X
17	PT17			X			X			X
18	PT18		x				x			x
19	PT19	X				x			x	
20	PT20	X					x			x
21	PT21	x				x				x
22	PT22			x			x		x	
23*	PT23		x				x			x
24	PT24	x				x				x
25	PT25		x				x			x
	Total	**12 (48%)**	**4(16%)**	**9 (36%)**	**6(24%)**	**6(24 %)**	**13(52 %)**	**4(16 %)**	**5(20%)**	**16(64%)**

Key: P=Poor I= Intermediate E= Excellent * PTs selected for deeper qualitative analysis

'X' specifies performance indicators of individual PT's with reference to the rating scales described in the rubric (see Appendix K)

Table M1: Individual PT's performance with reference to stating learning goals

S.No.	PT's Identity	Lesson 1			Lesson 2			Lesson 3		
		P	**I**	**E**	**P**	**I**	**E**	**P**	**I**	**E**
1	PT1		x				x			x
2*	PT2	X			x			x		
3	PT3			x			X			X
4	PT4	X				x				x
5*	PT5	X			x			x		
6	PT6	X					X			X
7	PT7	X			x			x		
8	PT8			x			X			X
9	PT9			x			X			X
10	PT10			x			X			X
11	PT11	X				x			x	
12*	PT12		x				X			X
13*	PT13			x			X			X
14	PT14	X					X			X
15	PT15	X				x			x	
16*	PT16		x				X			X
17	PT17		x				X			X
18	PT18	X					X			X
19	PT19	X			X					X
20	PT20	X			x					X
21	PT21			x			X			X
22	PT22	X			x					X
23*	PT23			x			X			X
24	PT24	X			x					x
25	PT25			x			x			x
	Total	**13 (52%)**	**4(16%)**	**8 (32%)**	**7 (28%)**	**3(12%)**	**15 (60%)**	**3 (12%)**	**2 (8%)**	**20 (80%)**

Key: P=Poor I= Intermediate E= Excellent * PTs selected for deeper qualitative analysis

'X' specifies performance indicators of individual PT's with reference to the rating scales described in the rubric (see Appendix K)

Table M2: Individual PT's performance with reference to stating aims of the task

S.No.	PT's Identity	Lesson 1			Lesson 2			Lesson 3		
		P	**I**	**E**	**P**	**I**	**E**	**P**	**I**	**E**
1	PT1		x				x			x
2*	PT2	X			x			x		
3	PT3			x			X			X
4	PT4	X				x				x
5*	PT5	X			x			x		
6	PT6	X					X			X
7	PT7	X			x			x		
8	PT8			x			X			X
9	PT9			x			X			X
10	PT10			x			X			X
11	PT11	X				x			x	
12*	PT12		x				X			X
13*	PT13			x			X			X
14	PT14	X					X			X
15	PT15	X				x			x	
16*	PT16		x				X			X
17	PT17		x				X			X
18	PT18	X					X			X
19	PT19	X			X					X
20	PT20	X			x					X
21	PT21			x			X			X
22	PT22	X			x					X
23*	PT23			x			X			X
24	PT24	X			x					x
25	PT25			x			x			x
	Total	**13 (52%)**	**4(16%)**	**8(32%)**	**7 (28%)**	**3 (12%)**	**15 (60%)**	**3 (12%)**	**2 (8%)**	**20 (80%)**

Key: P=Poor I= Intermediate E= Excellent * PTs selected for deeper qualitative analysis

'X' specifies performance indicators of individual PT's with reference to the rating scales described in the rubric (see Appendix K)

Table M3: Individual PT's performance with reference to outlining and/explaining the task

S.No.	PT's Identity	Lesson 1			Lesson 2			Lesson 3		
		P	I	E	P	I	E	P	I	E
1	PT1			x			x			x
2*	PT2		x			x				x
3	PT3			X			X			X
4	PT4	x			x					x
5*	PT5		x				x			x
6	PT6			X			X			X
7	PT7		x		x				x	
8	PT8			X			X			X
9	PT9			X			X			X
10	PT10			X			X			X
11	PT11		x			x				x
12*	PT12			X			X			X
13*	PT13			X			X			X
14	PT14	x					x			x
15	PT15	x			x				x	
16*	PT16			X			X			X
17	PT17			X			X			X
18	PT18			X			X			X
19	PT19	x					x			x
20	PT20	x				x				X
21	PT21			X			X			X
22	PT22	x			x					x
23*	PT23			X			X			X
24	PT24	x			x				x	
25	PT25		x				x			x
	Total	**7 (28%)**	**5(20%)**	**13(52 %)**	**5(20%)**	**3(12 %)**	**17(68 %)**	**0(0%)**	**3(12%)**	**22(88%)**

Key: P=Poor I= Intermediate E= Excellent * PTs selected for deeper qualitative analysis

'X' specifies performance indicators of individual PT's with reference to the rating scales described in the rubric (see Appendix K)

Table M4: Individual PT's performance with reference to provision of individual task

S.No.	PT's Identity	Lesson 1			Lesson 2			Lesson 3		
		P	I	E	P	I	E	P	I	E
1	PT1			x			x			x
2*	PT2		X			x	x		x	x
3	PT3			X			X			X
4	PT4			x			x			x
5*	PT5		X			x	x			x
6	PT6			X			X			X
7	PT7		x			x			x	
8	PT8			X			X			X
9	PT9		x				X			X
10	PT10			X			X			X
11	PT11		x				x			x
12*	PT12			X		x	X			X
13*	PT13			X			X			X
14	PT14			x			x			x
15	PT15		x			x			x	
16*	PT16			X			X			X
17	PT17			X			X			X
18	PT18		x				X			X
19	PT19			x			x			x
20	PT20		x			x	X		x	X
21	PT21			X			X			X
22	PT22			x			x			x
23*	PT23		x			x	X			X
24	PT24			x						
25	PT25		x	x			x			x
	Total	**0(0%)**	**10(40%0**	**15(60 %)**	**0(0%)**	**7(28 %)**	**18(72 %)**	**0(0%)**	**4(16%)**	**21(84%)**

Key: P=Poor I= Intermediate E= Excellent * PTs selected for deeper qualitative analysis

'X' specifies performance indicators of individual PT's with reference to the rating scales described in the rubric (see Appendix K)

Table M5: Individual PT's performance with reference to provision of group task

S.No.	PT's Identity	Lesson 1			Lesson 2			Lesson 3		
		p	I	E	P	I	E	P	I	E
1	PT1			x			x			x
2*	PT2	x			x				x	
3	PT3			X			X			X
4	PT4	x					x			x
5*	PT5	x			x				x	
6	PT6			X			X			X
7	PT7			x		x				x
8	PT8			X			X			X
9	PT9	x			x				x	
10	PT10			X			X			X
11	PT11	x					x			x
12*	PT12			X			X			X
13*	PT13			X			X			X
14	PT14			x			x			x
15	PT15	x					x			x
16*	PT16			X			X			X
17	PT17			X			X			X
18	PT18			X			X			X
19	PT19			x			x		x	
20	PT20	x				x				x
21	PT21			X			X			X
22	PT22			x			x		x	
23*	PT23	x			x					x
24	PT24			x			x			x
25	PT25	x			x					x
	Total	**9(36%)**	**0(0%)**	**16(64 %)**	**5(20%)**	**2(8%)**	**18(72 %)**	**0(0) %)**	**5(20%)**	**20(80%)**

Key: P=Poor I= Intermediate E= Excellent * PTs selected for deeper qualitative analysis

'X' specifies performance indicators of individual PT's with reference to the rating scales described in the rubric (see Appendix K)

Table M6: Individual PT's performance with reference to facilitation of group presentation and mediation of whole class discussion

S.No.	PT's Identity	Lesson 1			Lesson 2			Lesson 3		
		P	I	E	P	I	E	P	I	E
1	PT1		x				x			x
2*	PT2	x				x			x	
3	PT3			X			X			X
4	PT4	x					x			x
5*	PT5	x				x			x	
6	PT6			X			X			X
7	PT7		x				x			x
8	PT8			X			X			X
9	PT9	x				x			x	
10	PT10			X			X			X
11	PT11	x				x				x
12*	PT12			X			X			X
13*	PT13			X			X			X
14	PT14		x				x			x
15	PT15	x				x			x	
16*	PT16			X			X			X
17	PT17			X			X			X
18	PT18		x				X			X
19	PT19		x				x			x
20	PT20	x				x			x	
21	PT21			X			X			X
22	PT22		x				x			x
23*	PT23	x				x			x	
24	PT24		x				x			x
25	PT25	x				x				x
	Total	**9(36%)**	**7(28%)**	**9(36%)**	**0 (0%)**	**8(32 %)**	**17(68 %)**	**0 (0%)**	**6(24%)**	**19(76%)**

Key: P=Poor I= Intermediate E= Excellent * PTs selected for deeper qualitative analysis

'X' specifies performance indicators of individual PT's with reference to the rating scales described in the rubric (see Appendix K)

Table M7: Individual PT's performance with reference to ascertaining students' understanding of scientific concepts

S.No.	PT's Identity	Lesson 1			Lesson 2			Lesson 3		
		P	**I**	**E**	**P**	**I**	**E**	**P**	**I**	**E**
1	PT1	x					x			x
2*	PT2		x			x				x
3	PT3			x			x			x
4	PT4			x		x				x
5*	PT5		x		x					x
6	PT6		x				x		x	
7	PT7	X			x					x
8	PT8			x			x			x
9	PT9		x				x			x
10	PT10			x			x			x
11	PT11	X					x			x
12*	PT12			x			x			x
13*	PT13			x			x			x
14	PT14		x				x			x
15	PT15		x		X				x	x
16*	PT16			X			X			X
17	PT17			X			X			X
18	PT18			x		x				x
19	PT19	X				x			x	
20	PT20	X					x			x
21	PT21		x				x			x
22	PT22		x			x				x
23*	PT23		x				x			x
24	PT24			x		x			x	
25	PT25		x				x			x
	Total	**5(20%)**	**10(40%)**	**10(40 %)**	**3(12%)**	**6(24 %)**	**16(64 %)**	**0**	**4(16%)**	**21(84%)**

Key: P=Poor I= Intermediate E= Excellent * PTs selected for deeper qualitative analysis

'X' specifies performance indicators of individual PT's with reference to the rating scales described in the rubric (see Appendix K)

Table M8: Individual PT's performance with reference to assessing the quality of students' argument

S.No.	PT's Identity	Lesson 1			Lesson 2			Lesson 3		
		P	**I**	**E**	**P**	**I**	**E**	**P**	**I**	**E**
1	PT1	x					x			x
2*	PT2	x			x			x		
3	PT3			x			x			x
4	PT4		x			x				x
5*	PT5	x			x			x		
6	PT6	x					x			X
7	PT7	x			x					x
8	PT8			x			x			x
9	PT9	X			X			X		
10	PT10			x			x			x
11	PT11	X				x				x
12*	PT12			x			x			x
13*	PT13			x			x			x
14	PT14		x		X				x	
15	PT15	X			X					x
16*	PT16			X			X			X
17	PT17			X			X			X
18	PT18		x			x			x	
19	PT19	X				x				X
20	PT20	X				X			x	
21	PT21		x				x		x	
22	PT22	x					x			x
23*	PT23	x			x			x		
24	PT24	x					x			x
25	PT25	x			x			x		
	Total	**14(56%)**	**4(16%)**	**7 (28%)**	**8(32%)**	**5(20 %)**	**12(48 %)**	**5 (20%)**	**4(16%)**	**16(64%)**

Key: P=Poor I= Intermediate E= Excellent * PTs selected for deeper qualitative analysis

'X' specifies performance indicators of individual PT's with reference to the rating scales described in the rubric (see Appendix K)

Table M9: Individual PT's performance with reference to provision of quality feedback

S.No.	PT's Identity	Lesson 1			Lesson 2			Lesson 3		
		P	I	E	P	I	E	P	I	E
1	PT1	x				x				x
2*	PT2	x			x			x		
3	PT3		x				x			x
4	PT4	x			x					x
5*	PT5	x			x			x		
6	PT6	x					x			X
7	PT7	x			x					x
8	PT8			x			x			x
9	PT9	X			X			X		
10	PT10			x			x			x
11	PT11	X			X				x	
12*	PT12	x			x					x
13*	PT13			x			x			x
14	PT14		x		X					x
15	PT15	X			X					x
16*	PT16			X			X			X
17	PT17			X			X			X
18	PT18		x			x				x
19	PT19	X			X					X
20	PT20	X			X				x	
21	PT21	x					x			x
22	PT22	x			x					x
23*	PT23	x			x			x		
24	PT24	x			x					x
25	PT25	x			x			x		
	Total	**17(68%)**	**3(12%)**	**5 (20%)**	**15(60%)**	**2(08 %)**	**8(32 %)**	**5 (20%)**	**2(8%)**	**18(72%)**

Key: P=Poor I= Intermediate E= Excellent * PTs selected for deeper qualitative analysis

'X' specifies performance indicators of individual PT's with reference to the rating scales described in the rubric (see Appendix K)

Table M10: Individual PT's performance with reference to rounding off the argument-based lesson

S.No.	PT's Identity	Lesson 1			Lesson 2			Lesson 3		
		P	I	E	P	I	E	P	I	E
1	PT1			x			x			x
2*	PT2	x			x			x		
3	PT3			x			x			x
4	PT4	x				x			x	
5*	PT5	x			x			x		
6	PT6	x					x			x
7	PT7	x			x				x	
8	PT8			x			x			x
9	PT9		x		X			X		
10	PT10			x			x			x
11	PT11	X			X			X		
12*	PT12			x		x				x
13*	PT13			x			x			x
14	PT14	X			x					x
15	PT15	X				x			x	
16*	PT16			X			X			X
17	PT17			X			X			X
18	PT18		x				x			x
19	PT19	X				x			x	
20	PT20	X					x			x
21	PT21	x				x				x
22	PT22			x			x		x	
23*	PT23		x				x			x
24	PT24	x				x				x
25	PT25		x				x			x
	Total	**12 (48%)**	**4(16%)**	**9 (36%)**	**6(24%)**	**6(24 %)**	**13(52 %)**	**4(16 %)**	**5(20%)**	**16(64%)**

Key: P=Poor I= Intermediate E= Excellent * PTs selected for deeper qualitative analysis

'X' specifies performance indicators of individual PT's with reference to the rating scales described in the rubric (see Appendix K)

Appendix H: Exemplary argumentation-based learning material prepared to support PTs to teach science as an argument in middle school

Appendix J: Episodes extracted from small group and whole class discussion for the three selected argument-based tasks

Task One: Everyday argumentation

Group's argument

Group A: Episode 1

PT3 (M): I am against it because it has negative or adverse consequences. Among others, it has mental, social and physical impact

PT1 (M): Yes….students may not be productive citizens

PT18(F): Emm…..

PT6(F): Yes punishment has negative consequences. For example, punishment increases dropout rate of students

PT3(M): You said it increases dropout rate of students. Can you substantiate it please?

PT6(F): Yes, because punishment reduces students interest

PT5(F): Yes, Yes, I agree

PT23(M):I totally support your view. Punishment could causes low self-esteem, low confidence, psychological problem and develop bad attitude

PT3(M): I think we need to think of another evidence to support our position or our claim

PT6(F): yes, Punishment may lead to anxiety, aggressiveness among the students. We need to think of a another better mechanism to maintain school discipline

PT23(M): you said … we have to think of another strategy….

PT5(F): well, you are right.

PT18(F). Punishment may correct bad behaviour for a short period of time. It can only be a temporary mechanism to control students' misbehaviour. It is better to use negative reinforcement to develop a good behaviour.

Group C: Episode 2

PT13 (M): I am for it because punishment is used to decrease the occurrence of a behaviour that is undesirable".

PT9(M): I am against it. Punishment is not an appropriate mechanism to control school discipline because punishment has negative consequences. For example, it increases dropout rate of students.

PT16(M): I am against it. Punishment could cause many adverse effects. Among others, it could cause low self-esteem.

PT19(F): Yes I agree. I am against it. Because students will develop negative attitude towards the punisher, the subject matter and even to the school compound. Consequently, students will withdraw from school.

PT13 (M): Is there another argument for what you believe?

PT12 (F): I am in favour of punishment. Punishment is an appropriate mechanism to control school discipline, because it corrects misbehaving students. This will make the school environment more appealing to teachers and learners.

PT9(M): In my earlier teaching days I have tried punishment for several years with my students but it didn't work out …..

PT12: I am also against corporal punishment because it may create physical damage or injury

PT9(M) : Does that mean there is no other means to control students discipline other than punishment?

PT12 (F): There is but is not as effective as punishment".

PT2(M): Emm….

PT16(M) I strongly argue against your view. Punishment is not an effective means to control school discipline although it may correct bad behaviour under specific condition. Punishment cannot helps students to develop good behaviour, thus it is not an effective means to maintain school discipline".

PT19(F): As prospective teachers we need to emphasis on how to help students develop a good behaviour.

Whole class discussion

Episode 3

In support of the claim "Punishment is an appropriate mechanism to control the discipline of students in a school setting". PT13 and PT12 from Group C stated the following statements

PT13 (M) from Group C: We are for it because punishment is used in different organizations other than school setting to decrease the occurrence of a behaviour that is undesirable. Thus, if students fail to obey schools rules and regulations they have to be punished.

PT12 (F) from Group C: : I am in favour of punishment. It corrects misbehaving students. This will make the school environment more appealing to teachers and learners

All the statements from arguers PT3 and PT18, (From Group A) PT 19 and PT16 (from Group C) illustrated below are arguments against the claim: "Punishment is an appropriate mechanism to control the discipline of students in a school setting"."

PT3 (M) from Group A:We are not for it because punishment reduces students' productivity.

PT18 (F) from Group A:If students are punished they could develop low self-esteem and lose confidence. This will make them unproductive.

PT19 (F) from Group C: If punished, students could develop negative attitude towards the punisher and the subject matter. As a consequence they will withdraw from school.

PT16 (M) from Group C: Punishment is not an appropriate mechanism to control the discipline of students. Punishment cannot produce desirable behaviour and cannot secure discipline of students in schools.

The following statements from the other arguers in response to the above arguers were
Counter-claims/ rebuttals

PT17 (F) from Group D: No, we are against it. Even if punishment is used in other organizations it should not be used in school setting because it will increase dropout rate of students (counterargument to statement from arguer PT13).

PT8 (M) from Group B: What about if a student severely disturbs and distracts other students to the extent that that they could not concentrate any more, do you give him/her another chance to disturb or punish him/her for what he/she does? (counterargument to statement from arguers PT3, PT18, PT15 and PT16).

The debate further continued as indicated below

PT9 (M) from Group C: No, no, no… We don't give him/her opportunities to keep on disturbing

PT17(F) from Group D: So you have to punish him/her

PT12(F) from Group C: No what we are saying is we have to use planned ignorance as a strategy for some time until he/she disturb two or three days

PT21from Group D: So, you said that we should only punish students who repeat the same mistake. How are you going to determine which are repeat disturbers if you don't give them a chance to disturb again?

Towards the end of the debate Group A and C intended to reduce the force of each other's counterargument by critiquing it, thereby restoring force to one's own argument. For example:

Group A PT18: offers the critique that punishment may correct bad behaviour for a short period of time, but it neither helps students to develop good behaviour nor to maintain school discipline

Group C PT2: punishment does prevent further distraction not to occur in the classroom.

Appendix I: Demography of PTs involved in this study

S. No.	Name	G	Age	Teaching Experience	Birth place	Place they grow up	Language and Ethic group	Religion
1.	PT1	M	20	No	Sudan	Sudan	Tigre	Muslim
2.*	PT2	M	20	No	Habero	Habero	Nara	Muslim
3	PT3	M	37	10	Shimbila	Sahel	Kunama	Muslim
4	PT4	F	21	No	Asmara	Asmara	Tigrigna	Christian
5.*	PT5	F	21	No	Adi-neamn	Asmara	Tigrigna	Christian
6	PT6	F	21	No	Asmara	Asmara	Tigrigna	Christian
7	PT7	M	20	No	Asseb	Massawa	Tigrigna	Christian
8	PT8	M	31	12	Asmara	Asmara	Tigrigna	Christian
9	PT9	M	35	11	Asmara	Asmara	Tigrigna	Christian
10	PT10	M	39	10	keren	keren	Blen	Christian
11.	PT11	F	22	No	Amader	Addis Abeba	Tigrigna	Christian
12.*	PT12	F	22	No	Addis Abeba	Asmara	Tigrigna	Christian
13*	PT13	M	38	11	Asmara	Asmara	Tigrigna	Christian
14	PT14	M	21	No	Asmara	Asmara	Tigrigna	Christian
15.	PT15	M	19	No	Asmara	Asmara	Tigrigna	Christian
16.*	PT16	M	23	No	Asmara	Asmara	Tigrigna	Christian
17	PT17	F	23	No	Sudan	Mendefera	Saho	Moslem
18	PT18	F	20	No	Massawa	Massawa	Afar	Moslem
19	PT19	F	19	No	Adi-Hdug	Adi-Qula	Tigrigna	Christian
20	PT20	F	21	No	Zagre	Asmara	Tigrigna	Christian
21	PT21	M	29	9	Asmara	Asmara	Tigrigna	Christian
22	PT22	M	24	No	Ethiopia	Daro Paulos	Tigrigna	Christian
23*	PT23	M	34	11	Adi-Teklay	Adi-Teklay	Tigrigna	Christian
24	PT24	F	22	No	Asmara	Asmara	Tigrigna	Christian
25	PT25	M	33	10	Qandeba	Qandeba	Tigrigna	Christian

* PTs selected for deeper qualitative analysis

Appendix J: Episodes extracted from small group and whole class discussion for the three selected argument-based tasks

Task One: Everyday argumentation

Group's argument

Group A: Episode 1

PT3 (M): I am against it because it has negative or adverse consequences. Among others, it has mental, social and physical impact

PT1 (M): Yes….students may not be productive citizens

PT18(F): Emm…..

PT6(F): Yes punishment has negative consequences. For example, punishment increases dropout rate of students

PT3(M): You said it increases dropout rate of students. Can you substantiate it please?

PT6(F): Yes, because punishment reduces students interest

PT5(F): Yes, Yes, I agree

PT23(M):I totally support your view. Punishment could causes low self-esteem, low confidence, psychological problem and develop bad attitude

PT3(M): I think we need to think of another evidence to support our position or our claim

PT6(F): yes, Punishment may lead to anxiety, aggressiveness among the students. We need to think of a another better mechanism to maintain school discipline

PT23(M): you said … we have to think of another strategy….

PT5(F): well, you are right.

PT18(F). Punishment may correct bad behaviour for a short period of time. It can only be a temporary mechanism to control students' misbehaviour. It is better to use negative reinforcement to develop a good behaviour.

Group C: Episode 2

PT13 (M): I am for it because punishment is used to decrease the occurrence of a behaviour that is undesirable".

PT9(M): I am against it. Punishment is not an appropriate mechanism to control school discipline because punishment has negative consequences. For example, it increases dropout rate of students.

PT16(M): I am against it. Punishment could cause many adverse effects. Among others, it could cause low self-esteem.

PT19(F): Yes I agree. I am against it. Because students will develop negative attitude towards the punisher, the subject matter and even to the school compound. Consequently, students will withdraw from school.

PT13 (M): Is there another argument for what you believe?

PT12 (F): I am in favour of punishment. Punishment is an appropriate mechanism to control school discipline, because it corrects misbehaving students. This will make the school environment more appealing to teachers and learners.

PT9(M): In my earlier teaching days I have tried punishment for several years with my students but it didn't work out …..

PT12: I am also against corporal punishment because it may create physical damage or injury

PT9(M) : Does that mean there is no other means to control students discipline other than punishment?

PT12 (F): There is but is not as effective as punishment".

PT2(M): Emm….

PT16(M) I strongly argue against your view. Punishment is not an effective means to control school discipline although it may correct bad behaviour under specific condition. Punishment cannot helps students to develop good behaviour, thus it is not an effective means to maintain school discipline".

PT19(F): As prospective teachers we need to emphasis on how to help students develop a good behaviour.

Whole class discussion

Episode 3

In support of the claim "Punishment is an appropriate mechanism to control the discipline of students in a school setting". PT13 and PT12 from Group C stated the following statements

PT13 (M) from Group C: We are for it because punishment is used in different organizations other than school setting to decrease the occurrence of a behaviour that is undesirable. Thus, if students fail to obey schools rules and regulations they have to be punished.

PT12 (F) from Group C: : I am in favour of punishment. It corrects misbehaving students. This will make the school environment more appealing to teachers and learners

All the statements from arguers PT3 and PT18, (From Group A) PT 19 and PT16 (from Group C) illustrated below are arguments against the claim: "Punishment is an appropriate mechanism to control the discipline of students in a school setting"."

PT3 (M) from Group A:We are not for it because punishment reduces students' productivity.

PT18 (F) from Group A:If students are punished they could develop low self-esteem and lose confidence. This will make them unproductive.

PT19 (F) from Group C: If punished, students could develop negative attitude towards the punisher and the subject matter. As a consequence they will withdraw from school.

PT16 (M) from Group C: Punishment is not an appropriate mechanism to control the discipline of students. Punishment cannot produce desirable behaviour and cannot secure discipline of students in schools.

The following statements from the other arguers in response to the above arguers were
Counter-claims/ rebuttals

PT17 (F) from Group D: No, we are against it. Even if punishment is used in other organizations it should not be used in school setting because it will increase dropout rate of students (counterargument to statement from arguer PT13).

PT8 (M) from Group B: What about if a student severely disturbs and distracts other students to the extent that that they could not concentrate any more, do you give him/her another chance to disturb or punish him/her for what he/she does? (counterargument to statement from arguers PT3, PT18, PT15 and PT16).

The debate further continued as indicated below

PT9 (M) from Group C: No, no, no… We don't give him/her opportunities to keep on disturbing

PT17(F) from Group D: So you have to punish him/her

PT12(F) from Group C: No what we are saying is we have to use planned ignorance as a strategy for some time until he/she disturb two or three days

PT21from Group D: So, you said that we should only punish students who repeat the same mistake. How are you going to determine which are repeat disturbers if you don't give them a chance to disturb again?

Towards the end of the debate Group A and C intended to reduce the force of each other's counterargument by critiquing it, thereby restoring force to one's own argument. For example:

Group A PT18: offers the critique that punishment may correct bad behaviour for a short period of time, but it neither helps students to develop good behaviour nor to maintain school discipline

Group C PT2: punishment does prevent further distraction not to occur in the classroom.

Appendix L: Argumentation analytical framework as espoused by Simon et al (2006)

Argument process	**Codes for teacher facilitation**
Talking and listening	
	Encourages discussion
	Encourages listening
Knowing the meaning of argument	Defines argument
	Exemplifies argument
Positioning	Encourages ideas
	Encourages positioning
	Values different positioning
Justifying with evidence	Checks evidence
	Provide evidence
	Promote Justification
	Emphasises justification
	Emphasises further justification
	Plays devil's advocate
Constructing arguments	Using writing frame
	Presentations
Evaluating argument	Encourages evaluation
	Encourages arguments process
Counter-arguing/debating	Encourages anticipating counter argument
	Encourages debate (through role play)
Reflecting on argument process	Encourage reflection
	Asks about mind change

Appendix M: Individual PT's performance with reference to the examined domains and performance standards of argument-based lessons structure in three selected lessons

Table M1: Individual PT's performance with reference to stating learning goals

S.No.	PT's Identity	Lesson 1			Lesson 2			Lesson 3		
		P	**I**	**E**	**P**	**I**	**E**	**P**	**I**	**E**
1	PT1		x				x			x
2*	PT2	X			x			x		
3	PT3			x			X			X
4	PT4	X				x				x
5*	PT5	X			x			x		
6	PT6	X					X			X
7	PT7	X			x			x		
8	PT8			x			X			X
9	PT9			x			X			X
10	PT10			x			X			X
11	PT11	X				x			x	
12*	PT12		x				X			X
13*	PT13			x			X			X
14	PT14	X					X			X
15	PT15	X				x			x	
16*	PT16		x				X			X
17	PT17		x				X			X
18	PT18	X					X			X
19	PT19	X			X					X
20	PT20	X			x					X
21	PT21			x			X			X
22	PT22	X			x					X
23*	PT23			x			X			X
24	PT24	X			x					x
25	PT25			x			x			x
	Total	**13 (52%)**	**4(16%)**	**8 (32%)**	**7 (28%)**	**3(12%)**	**15 (60%)**	**3 (12%)**	**2 (8%)**	**20 (80%)**

Key: P=Poor I= Intermediate E= Excellent * PTs selected for deeper qualitative analysis

'X' specifies performance indicators of individual PT's with reference to the rating scales described in the rubric (see Appendix K)

Table M2: Individual PT's performance with reference to stating aims of the task

S.No.	PT's Identity	Lesson 1			Lesson 2			Lesson 3		
		P	**I**	**E**	**P**	**I**	**E**	**P**	**I**	**E**
1	PT1		x				x			x
2*	PT2	X			x			x		
3	PT3			x			X			X
4	PT4	X				x				x
5*	PT5	X			x			x		
6	PT6	X					X			X
7	PT7	X			x			x		
8	PT8			x			X			X
9	PT9			x			X			X
10	PT10			x			X			X
11	PT11	X				x			x	
12*	PT12		x				X			X
13*	PT13			x			X			X
14	PT14	X					X			X
15	PT15	X				x			x	
16*	PT16		x				X			X
17	PT17		x				X			X
18	PT18	X					X			X
19	PT19	X			X					X
20	PT20	X			x					X
21	PT21			x			X			X
22	PT22	X			x					X
23*	PT23			x			X			X
24	PT24	X			x					x
25	PT25			x			x			x
	Total	**13 (52%)**	**4(16%)**	**8(32%)**	**7 (28%)**	**3 (12%)**	**15 (60%)**	**3 (12%)**	**2 (8%)**	**20 (80%)**

Key: P=Poor I= Intermediate E= Excellent * PTs selected for deeper qualitative analysis

'X' specifies performance indicators of individual PT's with reference to the rating scales described in the rubric (see Appendix K)

Table M3: Individual PT's performance with reference to outlining and/explaining the task

S.No.	PT's Identity	Lesson 1			Lesson 2			Lesson 3		
		P	I	E	P	I	E	P	I	E
1	PT1			x			x			x
2*	PT2		x			x				x
3	PT3			X			X			X
4	PT4	x			x					x
5*	PT5		x				x			x
6	PT6			X			X			X
7	PT7		x		x				x	
8	PT8			X			X			X
9	PT9			X			X			X
10	PT10			X			X			X
11	PT11		x			x				x
12*	PT12			X			X			X
13*	PT13			X			X			X
14	PT14	x					x			x
15	PT15	x			x				x	
16*	PT16			X			X			X
17	PT17			X			X			X
18	PT18			X			X			X
19	PT19	x					x			x
20	PT20	x				x				X
21	PT21			X			X			X
22	PT22	x			x					x
23*	PT23			X			X			X
24	PT24	x			x				x	
25	PT25		x				x			x
	Total	**7 (28%)**	**5(20%)**	**13(52 %)**	**5(20%)**	**3(12 %)**	**17(68 %)**	**0(0%)**	**3(12%)**	**22(88%)**

Key: P=Poor I= Intermediate E= Excellent * PTs selected for deeper qualitative analysis

'X' specifies performance indicators of individual PT's with reference to the rating scales described in the rubric (see Appendix K)

Table M4: Individual PT's performance with reference to provision of individual task

S.No.	PT's Identity	Lesson 1			Lesson 2			Lesson 3		
		P	I	E	P	I	E	P	I	E
1	PT1			x			x			x
2*	PT2		X			x	x		x	x
3	PT3			X			X			X
4	PT4			x			x			x
5*	PT5		X			x	x			x
6	PT6			X			X			X
7	PT7		x			x			x	
8	PT8			X			X			X
9	PT9		x				X			X
10	PT10			X			X			X
11	PT11		x				x			x
12*	PT12			X		x	X			X
13*	PT13			X			X			X
14	PT14			x			x			x
15	PT15		x			x			x	
16*	PT16			X			X			X
17	PT17			X			X			X
18	PT18		x				X			X
19	PT19			x			x			x
20	PT20		x			x	X		x	X
21	PT21			X			X			X
22	PT22			x			x			x
23*	PT23		x			x	X			X
24	PT24			x						
25	PT25		x	x			x			x
	Total	**0(0%)**	**10(40%0**	**15(60 %)**	**0(0%)**	**7(28 %)**	**18(72 %)**	**0(0%)**	**4(16%)**	**21(84%)**

Key: P=Poor I= Intermediate E= Excellent * PTs selected for deeper qualitative analysis

'X' specifies performance indicators of individual PT's with reference to the rating scales described in the rubric (see Appendix K)

Table M5: Individual PT's performance with reference to provision of group task

S.No.	PT's Identity	Lesson 1			Lesson 2			Lesson 3		
		p	I	E	P	I	E	P	I	E
1	PT1			x			x			x
2*	PT2	x			x				x	
3	PT3			X			X			X
4	PT4	x					x			x
5*	PT5	x			x				x	
6	PT6			X			X			X
7	PT7			x		x				x
8	PT8			X			X			X
9	PT9	x			x				x	
10	PT10			X			X			X
11	PT11	x					x			x
12*	PT12			X			X			X
13*	PT13			X			X			X
14	PT14			x			x			x
15	PT15	x					x			x
16*	PT16			X			X			X
17	PT17			X			X			X
18	PT18			X			X			X
19	PT19			x			x		x	
20	PT20	x				x				x
21	PT21			X			X			X
22	PT22			x			x		x	
23*	PT23	x			x					x
24	PT24			x			x			x
25	PT25	x			x					x
	Total	**9(36%)**	**0(0%)**	**16(64 %)**	**5(20%)**	**2(8%)**	**18(72 %)**	**0(0) %)**	**5(20%)**	**20(80%)**

Key: P=Poor I= Intermediate E= Excellent * PTs selected for deeper qualitative analysis

'X' specifies performance indicators of individual PT's with reference to the rating scales described in the rubric (see Appendix K)

Table M6: Individual PT's performance with reference to facilitation of group presentation and mediation of whole class discussion

S.No.	PT's Identity	Lesson 1			Lesson 2			Lesson 3		
		P	I	E	P	I	E	P	I	E
1	PT1		x				x			x
2*	PT2	x				x			x	
3	PT3			X			X			X
4	PT4	x					x			x
5*	PT5	x				x			x	
6	PT6			X			X			X
7	PT7		x				x			x
8	PT8			X			X			X
9	PT9	x				x			x	
10	PT10			X			X			X
11	PT11	x				x				x
12*	PT12			X			X			X
13*	PT13			X			X			X
14	PT14		x				x			x
15	PT15	x				x			x	
16*	PT16			X			X			X
17	PT17			X			X			X
18	PT18		x				X			X
19	PT19		x				x			x
20	PT20	x				x			x	
21	PT21			X			X			X
22	PT22		x				x			x
23*	PT23	x				x			x	
24	PT24		x				x			x
25	PT25	x				x				x
	Total	**9(36%)**	**7(28%)**	**9(36%)**	**0 (0%)**	**8(32 %)**	**17(68 %)**	**0 (0%)**	**6(24%)**	**19(76%)**

Key: P=Poor I= Intermediate E= Excellent * PTs selected for deeper qualitative analysis

‘X’ specifies performance indicators of individual PT’s with reference to the rating scales described in the rubric (see Appendix K)

Table M7: Individual PT’s performance with reference to ascertaining students’ understanding of scientific concepts

S.No.	PT’s Identity	Lesson 1			Lesson 2			Lesson 3		
		P	**I**	**E**	**P**	**I**	**E**	**P**	**I**	**E**
1	PT1	x					x			x
2*	PT2		x			x				x
3	PT3			x			x			x
4	PT4			x		x				x
5*	PT5		x		x					x
6	PT6		x				x		x	
7	PT7	X			x					x
8	PT8			x			x			x
9	PT9		x				x			x
10	PT10			x			x			x
11	PT11	X					x			x
12*	PT12			x			x			x
13*	PT13			x			x			x
14	PT14		x				x			x
15	PT15		x		X				x	x
16*	PT16			X			X			X
17	PT17			X			X			X
18	PT18			x		x				x
19	PT19	X				x			x	
20	PT20	X					x			x
21	PT21		x				x			x
22	PT22		x			x				x
23*	PT23		x				x			x
24	PT24			x		x			x	
25	PT25		x				x			x
	Total	**5(20%)**	**10(40%)**	**10(40 %)**	**3(12%)**	**6(24 %)**	**16(64 %)**	**0**	**4(16%)**	**21(84%)**

Key: P=Poor I= Intermediate E= Excellent * PTs selected for deeper qualitative analysis

‘X’ specifies performance indicators of individual PT’s with reference to the rating scales described in the rubric (see Appendix K)

Table M8: Individual PT’s performance with reference to assessing the quality of students’ argument

S.No.	PT’s Identity	Lesson 1			Lesson 2			Lesson 3		
		P	**I**	**E**	**P**	**I**	**E**	**P**	**I**	**E**
1	PT1	x					x			x
2*	PT2	x			x			x		
3	PT3			x			x			x
4	PT4		x			x				x
5*	PT5	x			x			x		
6	PT6	x					x			X
7	PT7	x			x					x
8	PT8			x			x			x
9	PT9	X			X			X		
10	PT10			x			x			x
11	PT11	X				x				x
12*	PT12			x			x			x
13*	PT13			x			x			x
14	PT14		x		X				x	
15	PT15	X			X					x
16*	PT16			X			X			X
17	PT17			X			X			X
18	PT18		x			x			x	
19	PT19	X				x				X
20	PT20	X				X			x	
21	PT21		x				x		x	
22	PT22	x					x			x
23*	PT23	x			x			x		
24	PT24	x					x			x
25	PT25	x			x			x		
	Total	**14(56%)**	**4(16%)**	**7 (28%)**	**8(32%)**	**5(20 %)**	**12(48 %)**	**5 (20%)**	**4(16%)**	**16(64%)**

Key: P=Poor I= Intermediate E= Excellent * PTs selected for deeper qualitative analysis

‘X’ specifies performance indicators of individual PT’s with reference to the rating scales described in the rubric (see Appendix K)

Table M9: Individual PT’s performance with reference to provision of quality feedback

S.No.	PT’s Identity	Lesson 1			Lesson 2			Lesson 3		
		P	**I**	**E**	**P**	**I**	**E**	**P**	**I**	**E**
1	PT1	x				x				x
2*	PT2	x			x			x		
3	PT3		x				x			x
4	PT4	x			x					x
5*	PT5	x			x			x		
6	PT6	x					x			X
7	PT7	x			x					x
8	PT8			x			x			x
9	PT9	X			X			X		
10	PT10			x			x			x
11	PT11	X			X				x	
12*	PT12	x			x					x
13*	PT13			x			x			x
14	PT14		x		X					x
15	PT15	X			X					x
16*	PT16			X			X			X
17	PT17			X			X			X
18	PT18		x			x				x
19	PT19	X			X					X
20	PT20	X			X				x	
21	PT21	x					x			x
22	PT22	x			x					x
23*	PT23	x			x			x		
24	PT24	x			x					x
25	PT25	x			x			x		
	Total	**17(68%)**	**3(12%)**	**5 (20%)**	**15(60%)**	**2(08%)**	**8(32%)**	**5 (20%)**	**2(8%)**	**18(72%)**

Key: P=Poor I= Intermediate E= Excellent * PTs selected for deeper qualitative analysis

‘X’ specifies performance indicators of individual PT’s with reference to the rating scales described in the rubric (see Appendix K)

Table M10: Individual PT’s performance with reference to rounding off the argument-based lesson

S.No.	PT’s Identity	Lesson 1			Lesson 2			Lesson 3		
		P	**I**	**E**	**P**	**I**	**E**	**P**	**I**	**E**
1	PT1			x			x			x
2*	PT2	x			x			x		
3	PT3			x			x			x
4	PT4	x				x			x	
5*	PT5	x			x			x		
6	PT6	x					x			x
7	PT7	x			x				x	
8	PT8			x			x			x
9	PT9		x		X			X		
10	PT10			x			x			x
11	PT11	X			X			X		
12*	PT12			x		x				x
13*	PT13			x			x			x
14	PT14	X			x					x
15	PT15	X				x			x	
16*	PT16			X			X			X
17	PT17			X			X			X
18	PT18		x				x			x
19	PT19	X				x			x	
20	PT20	X					x			x
21	PT21	x				x				x
22	PT22			x			x		x	
23*	PT23		x				x			x
24	PT24	x				x				x
25	PT25		x				x			x
	Total	**12 (48%)**	**4(16%)**	**9 (36%)**	**6(24%)**	**6(24%)**	**13(52%)**	**4(16%)**	**5(20%)**	**16(64%)**

Key: P=Poor I= Intermediate E= Excellent * PTs selected for deeper qualitative analysis

‘X’ specifies performance indicators of individual PT’s with reference to the rating scales described in the rubric (see Appendix K)

Appendix N: Occurrences of categories and codes of argument processes utilized in PTs' utterance across three lessons

Argument process	Codes for PT facilitation	PT12			PT13			PT16			PT2			PT5			PT23		
Talking and listening		L1	L2	L3	L1	L2	L3	L1	L2	L3	L1	L2	L3	L1	L2	L3	L1	L2	L3
	Encourages discussion	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
	Encourages listening	x	x	x	x	x	x	-	x	x	-	-	x	-	x	x	-	-	x
Knowing the meaning of argument	Defines argument	x	-	-	-	x	-	x	-	-	-	x	x	-	X	x	-	x	x
	Exemplifies argument	-	x	x	x	x	x	-	x	x	x	x	x	-	-	-	-	x	x
Positioning	Encourages ideas	x	-	-	x	x	-	-	-	-	-	-	-	-	x	-	-	-	-
	Encourages positioning	x	x	x	x	x	x	x	x	x	x	x	x	x	-	x	x	-	-
	Values different positioning	-	x	x	-	x	x	x	x	x	-	x	-	-	-	x	-	-	-
Justifying with evidence	Checks evidence	x	-	-	x	x	x	-	x	-	-	x	-	x	-	-	x	x	x
	Provide evidence	x	x	-	x	x	-	x	x	x	x	-	x	x	-	x	-	x	x
	Promote Justification	x	-	-	x	x	-	x	-	-	x	x	x	x	x	x	x	x	x
	Emphasises justification	x	-	-	x	-	-	-	-	x	x	x	x	x	x	x	x	x	x
	Emphasises further justification (argument promote)	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
	Plays devil's advocate	-	x	x	-	-	x	-	-	-	-	-	-	-	-	-	-	-	-
Constructing arguments	Using writing frame	-	x	x	x	x	x	x	x	x	x				x				
	Presentations	x	x	x	x	x	x	x	x	x	-	x	x	-	x	x	-	x	x
Evaluating argument	Encourages evaluation				x	x	x	x	x	x	-	-	-	-	-	-	-	-	-
	Encourages arguments process	x	x	x				x	x	x	-	-	-	-	-	-	-	-	-
Counter-arguing/debating	Encourages anticipating counter argument	-	-	x	x	x	x	x	x	x	-	-	-	-	-	-	-	-	-
	Encourages debate (through role play)	-	-	-	-	x	x	x	-	x	-	-	-	-	-	-	-	-	-
Reflecting on argument process	Encourage reflection	x	-	-	x	X	-	x	-	-	-	-	-	-	-	-	-	-	-
	Asks about mind change	-	x	x	-	-	x	x	x	x	-	-	-	-	-	-	-	-	-

Key: PT = pre-service teacher; L1= Lesson one L1= Lesson two L1= Lesson three