An examination of science teachers' pedagogical perceptions and orientations in relation to student centred learning in science education in Gambian Upper Basic Schools

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Abstract

In 2004 the Gambian Ministry of Basic and Secondary Education (MoBSE) policy (2004) highlighted the necessity of shifting from traditional teacher - centred to student - centred approaches, to improve teaching quality and help students to acquire high order thinking. In order to make such a shift the MoBSE made several interventions to develop the capacities of teachers in order to enhance the teaching and learning of science in schools. Some of these interventions were in the form of workshops spearheaded by the Science and Technology Education Directorate (STED) - a directorate responsible for the enhancement of the teaching and learning of science in schools in Gambia. Since this intervention no research had been undertaken into science teachers' classroom practice in the Gambia to gain a better understanding of whether teachers' classroom practices are in any way linked to student centred learning approaches as outlined in the education policy. This study addresses this gap by critically examining how teachers' pedagogical perceptions and orientations influence their classroom practices with reference to student centred learning.

Using a small-scale qualitative research, lesson observation and interview data were collected from twelve experienced, science teachers. Focus group data was collected from forty-eight students from six Upper Basic Schools (UBS) within Greater Banjul Area and West Coast Region in the Gambia. Each teacher was observed and interviewed face to face. Four students were selected from each teacher's class as a focus group. The data obtained was transcribed verbatim and analysed using a combination of Magnusson, Krajcik, Borko.'s (1999) model of Pedagogical Content Knowledge (PCK), and Friedrichsen, Van Driel, and Abell.'s (2011) model of science teaching orientations (STOs).

The interpretive method of qualitative data analysis suggested a number of findings from students' perspectives, the most notable of which include teacher centred dominated lessons. Students pointed out that they hardly do practical work during their science lessons. Additionally, the findings also indicated students' perceived difficulties and challenges in the learning of science in some schools, primarily concerned with resources, and which resonated with many teachers' perspectives. In general science teachers perceived student centred learning as a good pedagogy but hardly practised due to a range of factors that impede its usage in the classroom. The findings also indicated that teacher pedagogical orientations have greatly influenced teachers' classroom practices although this has been hindered by the lack of resources among other constraints. This study argues for the need for Upper Basic Schools to be better equipped with the basic science materials that the students require for teachers to effectively practise SCL in the classroom.

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Glossary

ASEI-PDSI	Activity, Student, Experiment, Improvisation- Plan, Do, See & Improve
BERA	British Educational Research Association
CPD	Continuing Professional Development
ECD	Early Childhood and Development
EI	Education International
EO	Education Officer
ESL	English Second Language
ESU	The European Students' Union
GABECE	The Gambia Basic Education Certificate Examination
GDPR	General Data Protection Regulatory
HTC	Higher Teachers' Certificate
LBS	Lower Basic School
MATAG	Mathematics Teachers' Association the Gambia
MoBSE	Ministry of Basic and Secondary Education
NAT	National Assessment Test
NOS	Nature of Science
PCK	Pedagogical Content Knowledge
PPARBD	Planning, Policy Analysis, Research and Budget Directorate
SCC	Student Centred Classroom
SCL	Student Centred Learning
SCM	Student Centred Method
SCOs	Student Centred Orientations
SEO	Senior Education Officer
SIG	School Improvement Grant
SSS	Senior Secondary School
STAGAM	Science Teachers' Association the Gambia
STED	Science and Technology Education Directorate

STOs	Science Teaching Orientations
TCC	Teacher Centred Classroom
TCL	Teacher Centred Learning
TCM	Teacher Centred Method
TCOs	Teacher Centred Orientations
UBS	Upper Basic School
UTG	University of The Gambia
WAEC	West African Examinations Council
WASSCE	West Africa Senior School Certificate

Chapter 1: Introduction

1.1 Introduction

The research consulted students to gain their accounts of their science lessons. This was done to gather an in-depth understanding of their teachers' classroom practices. Furthermore, teachers' perceptions of student centred learning (SCL) and teachers' pedagogical orientations were critically examined in order to develop a detailed comprehension of how these influence their classroom practices. Findings for the research were achieved by conducting primary research with teachers and their students in classroom settings in six different Upper Basic Schools. Science teachers were observed teaching classes and then interviewed about their classroom practices. Students were consulted via focus groups to obtain their views of their science lessons, in particular their opinions about if and how teachers applied SCL in classes. This research is the first of its kind conducted in the Gambia, and at the Upper Basic School (UBS) level. Therefore, the research makes an original contribution to knowledge by being the first small-scale qualitative research into SCL in UBS science education in Gambia.

The theoretical framework for the research is a novel combination of Magnusson et al.'s (1999) model of Pedagogical Content Knowledge (PCK) and Friedrichsen et al.'s (2011) science teaching orientations (STOs). This framework was adopted for the research because Magnusson et al.'s model accommodates a continuum of teaching approaches, from didactic through to participatory, student centred approaches; whilst Friedrichsen et al.'s model contributes the categories STOs. Friedrichsen et al. define STOs as teachers' beliefs about the goals and purposes of science teaching, views of science, and beliefs about science teaching and learning. This multifaceted definition of orientation deals with various aspects of teacher beliefs, which in turn affect their practices. These three main dimensions of STOs supplement Magnusson et al.'s model of PCK, which lack such orientations. As the research focuses on science teachers' teaching styles and classroom practices, inclusive of their content knowledge and teaching orientations, a synthesis of both models was needed to analyse the primary data. Synthesis of Magnusson et al.'s model of PCK and Friedrichsen et al.'s science teaching orientations is a second original contribution to knowledge made through the research because it creates a novel analytical tool to examine relationships between teachers' orientations, their classroom practices, and their application of student centred learning approaches.

This chapter explains the development of SCL; the rationale, motivation and significance of the study; the research aims, objectives and questions; the context of the study; and finally the thesis structure.

1.1.1 The Development of SCL

This section demonstrates that SCL is a complex and contested approach to teaching and learning. The Gambia and other developing countries are trying to promote student centred learning (SCL) approaches in their informal education (Schweisfurth, 2011). The term SCL has been interpreted and defined differently by many scholars. As a result, it is difficult and challenging to come up with a working definition of SCL for the purpose of this research. Costa (2013) argued that SCL is much easier to understand than to define. Common key features of SCL include the role of the teacher as facilitator and guide in the process of learning, activity based lessons, high level of students' participation, interaction and involvement during lessons, group work and practical work, particularly in science lessons. Other teaching approaches that are associated with SCL include learner centred learning, peer-led team learning, cooperative/collaborative learning, problem-based learning/enquiry-based learning, minimal guidance approach, discovery learning, child centred learning, constructivism and progressive education (Brinkmann, 2015; Zain, Rasidi, & Abidin., 2012; Schweisfurth, 2013; Baeten, Kyndt, Struyven, & Dochy., 2010). The definition of SCL used in this study is found in Chapter two, The Literature Review, under section 2.2.3.

Student centred learning, according to Brodie, Lelliott & Davis (2002, p.542), has a longstanding history reflecting back to Plato's Socratic Dialogue where teachers drew out ideas from students through strategic questioning. This infers the significance of the teacher having a good questioning technique to find out students' prior knowledge and understanding of a particular topic. Darling (as cited in Brodie et al., 2002, p.542), explains the comprehensive presentation of student centred ideas by Rousseau in the 18th century on the theme of Rousseau's 'Emile', where it was argued that individual difference and development should be considered in the process of learning because learners come with their own experiences. This point is still important for teachers to consider, especially in mixed ability classes. The teacher in an SCL classroom should share time and attention fairly between pupils at all ability levels. In the 19th century, an experimental school established by Dewy in the US had its curriculum focused on learners' interests. Learners were given the opportunity to make decisions and take responsibility for their learning practically and cooperatively, to work in groups and try to make links between their learning and their daily lives. According to Brandes and Ginnis (1999), students are more likely to remember what they learn if they link learning to their daily lives.

SCL was attributed to Hayward in 1905 and Dewey's work in 1956. The approach was later developed in 1965 by Carl Rogers with his theory of client-centred

counselling (Zain et al., 2012, p.319). Rogers's theory was based on the assumption that the teacher cannot teach an individual directly, but instead should facilitate student learning (Zain et al., 2012, p.320). This learning approach was also linked to the work of Piaget's developmental learning, which argues that learners construct their own meaning, as well as to Malcom Knowles's self-directed learning (EI & ESU, 2016). SCL practice is shaped by the nature of the curriculum, pedagogy and the relationship between students, teachers and materials (Brodie et al., 2002, p.543). The 1967 report of the Central Advisory Council for Education in England, known as the Plowden Report, reviewed primary education in England. It promoted student centred approaches to education and emphasised the need for students to be the focus of the learning process. This led to the widespread adoption of SCL in English primary schools in the 1960s (O'Sullivan, 2004).
SCL is a preferred approach to teaching for some teachers because it claims to promote meaningful learning and deep understanding (Baeten et al., 2010). During lessons, students are active and engaged in constructing their own knowledge through talking, listening, writing and reading, and reflecting on content, ideas and problems they simultaneously solve together (McCabe & O'Connor, 2014).

A more detailed discussion on the definitions and interpretations of SCL is found in the next chapter under section 2.2.3.

In this research SCL is defined as a pedagogical approach that puts the students at the core of the learning process, where the teacher facilitates, guides or coaches and students take an active role to participate, cooperate and collaborate among themselves, in groups or individually through discussions and exchange of ideas and experiences.

This section finds that SCL is not a new approach to teaching and learning. SCL is seen as complex, with many and varied interpretations and meanings. Its usage in the classroom is based on how it has been perceived by individual teachers. The next section discusses the rationale of the study.

1.1.2 Motivation and rationale of the study

I taught as a qualified science and mathematics teacher at UBS level from 1997 to 2002 (five years). I was also a tutor in the teacher training programme at the Gambian College for six years between 2007 and 2013. I worked as an Education Officer (EO) from 2006 to 2008 and a Senior Education Officer (SEO) from 2009 to 2013 under the Science and Technology Education Directorate (STED) mandated to enhance the effective teaching and learning of science and mathematics education at basic and secondary level under the Ministry of Basic and Secondary Education (MoBSE).

The new education policy (2004 - 2015) was already in existence before I started work at the MoBSE. This policy came under the second republic, a new government that implemented radical changes of policy particularly in education. There were key elements that were the main pillars of the education policy. These were access, relevance, equity and quality. One radical move under the second republic was to build a lot of schools both in the urban and poor /rural areas within the country for students to have easy access to school without having to travel a long distance or to migrate from the rural to the urban areas. The girls' scholarship scheme was introduced to encourage more girls to be educated. This was later followed by the school improvement grant (SIG) which gives free education to all students at Upper Basic level to enhance equal opportunities among students, so that children from the poorest homes could go to school without having to pay any school fees. The quality of education was a great challenge since in 2004 over 90% of candidates failed Mathematics, English and Science at both West African Senior School Certificate Examination (WASSCE) and Gambia Basic Education Certificate Examination (GABECE) (Save the Children-Sweden, 2005, p.50). Performance in these exams reflects the quality of education in the Gambia. This poor performance influenced how the relevance of education was perceived; the human resources required to improve the economy of the nation were not expected to be generated at secondary school. These were among the reasons why MoBSE now requires delivery of curricula to be underpinned by key pedagogy. Thus, this research was triggered by Gambian education policies: firstly, the Ministry of Basic and Secondary Education (MoBSE, 2004) policy; and secondly the Science and Technology Education Directorate (STED, 2011) policy. Both policies called on teachers to shift from a teacher centred method to student centred methods of lesson delivery to promote and encourage collaborative learning, classroom participation and student engagement in practical activities and experiments. The education policy of the MoBSE (2004) maintains that:

The sector will promote a gradual paradigm shift from teacher - centred and textbook based teaching towards interactive learner - centred approach that will include digitalising teaching and learning materials across all level and types.

The teaching and learning materials will be organised in such a way that learners are guided to acquire the ability to learn how to learn and develop generic skills such as communication, creativity and critical thinking; and that teachers will be supported to develop a wide repertoire of teaching and learning resources to enable them to adjust their teaching to cater for various needs, abilities and learning styles of their children (p, 18).

The policy sets out an expectation that learning will be promoted and enhanced so that through the process learners will develop their own skills, knowledge and concepts through the active engagement of learners and collaborative learning

(MoBSE, 2004). However, this study is not interested in the teachers' use of digitalised resources as SCL practices, but instead focuses on exploring the relationship between teachers' perceptions, orientations and practice. It seeks to discover the extent to which science teachers practise SCL in their lessons in particular.

It is outlined in both MoBSE and STED policy that traditional, teacher centred learning promotes repetitive learning and memorisation of facts and discourages collaborative learning and learners' participation during lesson delivery. The policy identified traditional teacher centred methods as didactic - mainly talk and chalk - and levels of student engagement as low. Hence, students are passive listeners and receivers of knowledge (MoBSE, 2004). Such methods of teaching were linked to the poor results attained over the past years in the WASSCE and GABECE before the draft of the new education policies in 2004 and 2015, which brought the hope of increasing performance as well as attaining quality and relevance in the Gambian education system. The ministry of education wanted a particular strand of knowledge that would develop students' creative, critical thinking and problem solving skills and where students would work together and learn critical values such as questioning authority, mutual respect and making their own decisions freely (Save the Children-Sweden, 2005). In this way, students would be able to view and analyse the real world by evaluating options and creating solutions to problems. For these reasons, the MoBSE advocated for teachers to use student centred learning methods, in the belief that they encourage students' active participation and engagement in their learning through, for example, group activities and discussions. This education policy in Gambia challenged teachers to be innovative in facilitating students in the process of learning. Support was given to teachers, particularly science and mathematics specialists, to further their education at university level through scholarship grants from MoBSE and the government. Improvisation manuals were made by STED of which I was resource person. These manuals were provided and distributed to all UBS in the Gambia for science teachers to use as reference. Countrywide workshops were conducted to train these science teachers on the improvisation of basic science resources using the local available materials within their environment. These improvised materials were to be used as substitutes for conventional materials to enhance learning.

Therefore, this research is of significant interest to my professional development as a SEO and as a researcher in science education. I was fortunate to have attended a series of international training and technical workshops involving student centred learning techniques and approaches, such as the Activity Student Experiment Improvisation/ Plan Do See and Improve (ASEI/PDSI) approach (Wambui, 2006). I was able to disseminate the skills and knowledge gained from this training to science teachers in the Gambia through local workshops funded by the Ministry with the intention for teachers to adopt and apply such practices in their classrooms. Since the MoBSE showed the need for a shift from didactic to SCL in its education policy, a lot of efforts were made by the MoBSE to effect this change. To effect this change, the Science and Technology Education Directorate (STED), a directorate I worked under, in collaboration with Mathematics and Science teachers' associations in the Gambia known as MATAG and STAGAM respectively, provided a series of in-service training for teachers to achieve the aims and objective of the Ministry. I equally receive international training with individuals from these associations, which provides opportunities for us to come together and organise workshops for teachers based on the knowledge and skills we gained abroad towards adopting and implementing new practices. However, there has not been a proper follow up or monitoring exercise to ascertain some of the practices in teachers' classrooms. This motivated me to look into science teachers' classroom practices at UBS level because the majority of the policy interventions were targeted at this crucial level because it is a transitional stage for students from Junior to Senior Secondary level. The research unpicks teachers' understanding of SCL and some of the constraints they are faced with in their classroom practices.

The next section focuses on the significance of the study. This outlines the contribution of knowledge that this study has made.

1.1.3 Significance of the study

The findings from this research contribute to new knowledge in teaching and learning, educational theory and the conceptualisation and application of SCL in the context of Gambian science education. My extensive literature search did not reveal any published literature on teachers' classroom practice at the Upper Basic School level of the Gambian education system, or on Gambian students reflecting on their own science education. My research addresses both of these themes. The research also contributes towards understanding of SCL by constructing a definition of SCL in the context of Gambian science education. Equally, the findings from this research may inform policy and practice for teacher education. The new understanding and knowledge gained from this study is of significance to the MoBSE and my colleagues at STED, who are responsible for the enhancement of teaching and learning about science in schools. The findings of the research draw attention to continuing professional development (CPD) needs of teachers for the Ministry to consider. Hence, knowledge gained from the study may, in the long term, contribute to providing appropriate training for teachers to implement SCL effectively in their classrooms to make learning more interesting and meaningful to learners.

The next section presents the research aims and objections.

1.1.4 Research aim and objectives

The overall aim of the research is to critically examine science teachers' classroom teaching and learning practices at the UBS level of the Gambian education system. The research is interested in face-to-face teaching between teachers and students in class and student material interaction and not for example curriculum design, assessment, etc. It is interested in examining teachers' knowledge of curriculum, assessment, students' understanding of science and knowledge of instructional strategies. These are confined to the topics they teach in class only.

The objectives of the research are:

1. To investigate UBS students' views of their science lessons;
2. To investigate UBS science teachers' perceptions of SCL;
3. To examine relationships between UBS teachers' perceptions and their classroom practices;
4. To investigate UBS science teachers' teaching orientations;
5. To examine relationships between UBS teachers' orientations and their classroom practices.

Research Questions

1. To what extent do Gambian Upper Basic School students' perceptions of their science classes relate to student centred learning pedagogies?
2. In what ways do science teachers' own perceptions of student centred learning influence their practice in the classroom?

3. In what ways do science teachers' own pedagogical orientations influence their classroom practices?

The next section discusses the study context.

1.2 The study context

This section gives a geographical and historical description of the Gambia, an overview of the Gambian education system and explains the status of science education in the country.

1.2.1 A brief geographical and historical view of The Gambia

Figure 1. Map of the Gambia: Source from MoBSE (2014)

The Gambia is located in West Africa and surrounded by Senegal on three sides, except for the coast of the Atlantic Ocean. The capital city is called Banjul. The Gambia has a population of 1.849 million (MoBSE, 2014) with a geographical coordination of 13° 28' N 16° 34' W, and a total area of 11,295km^2, of which 10,000km^2 is land and 1295 km^2 is covered by water. The Gambia has distinct seasons, mainly rainy and dry seasons. The rainy season starts in June and ends in

October while the dry season begins in November and ends in May. Temperatures range from 23°C in January to 32°C in May. Temperatures rise during the rainy season period to above 40°C but go down to 16°C in the Greater Banjul Area between mid-November and January.

The Gambia gained her independence in 1965, led by Sir Dawda Kairaba Jawara as the first President of the Republic. He was ousted from office in 1994 by a group of military officers led by Lieutenant Yaya Jammeh in a bloodless coup. Since then Jammeh has been the President of the Second Republic. The Gambia was withdrawn from the Commonwealth by the leadership in 2013, an organisation he described as a neo-colonial institute.

The change in government resulted in a tremendous transformation of the national education policy as well as the school curriculum. Fewer schools existed during the first republic in comparison to the second republic, in which education is considered key to national development. The leadership has given all young Gambians numerous opportunities to be educated. An indication of this was the establishment of the University of the Gambia (UTG) in 1999 (UTG, 2014) and the building of unprecedented numbers of Basic and Secondary Education Schools all over the country. Since 1994, under the new regime, there are 861 Lower Basic Schools, of which 389 are private and 472 are public (MoBSE, 2014). In total there are 325 Upper Basic schools, of which 173 are private and 152 are public, and 134 Senior Secondary schools, of which 71 are private and 63 are public schools (MoBSE, 2014). The number of high schools was not more than ten schools before 1994; there were few Junior Secondary Technical Schools. However, change in policy has led to total reform of the entire education system. The next section explains the education system of the Gambia.

1.2.2 An overview of the Gambian education system

The Gambian Basic and Secondary education system is a 3-6-3-3 system (illustrated in the table below). That is three years of Early Childhood and Development (ECD) (Levels 1–3); six years of Lower Basic education (Grades 1–6); three years of Upper Basic education (Grades 7–9); and three years of Senior Secondary education (Grades 10–12). The official school attending age for the ECD range is 3–6; for the Lower Basic age range: 7–12; for Upper Basic: 13–15; for Senior Secondary: 16–18 and 19 to 24 for College/University education.

A National Assessment Test (NAT) is given to candidates in Grades 3 and 5 at Lower Basic and Grade 8 at Upper Basic level to inform the education system of pupils' performance at these levels. At Grade 9, Upper Basic level candidates are given GABECE to take with the aim of selecting them to proceed into Senior Secondary School (SSS). It is from this level that some of the candidates who do not make it to Senior Secondary move to the vocational training. At the end of SSS, Grade 12 candidates take WASSCE and the results obtained from this are used for the admission of candidates into tertiary and higher educational institutions. Currently, in the Gambia, education is free for all from Grades 1 to 12. Senior Secondary schools that are grant-aided schools are supported by the government and these grant-aided, public and private schools are managed by boards. Students in the private schools pay for school fees while public school students are free from paying school fees, hence they are funded from the aid money received from donor agencies such as World Bank.

The table below indicates the type of school, grade, level of education and the age range of students in order to have a clear idea of the Gambia education system.

Table 1: The Structure of Gambia Education System

School type	Grade	Level of education	Legal age
Nursery (Public, Private and Madrassa)	Nursery 1-3	Early Childhood Development	3 to 6
		Basic Education	
Lower Basic School and Basic Cycle School (Public, Private, Grant-Aided and Madrassa)	Grade 1-6	Lower Basic Education	7 to 12
Upper Basic School and Basic Cycle School (Private, Public Grant-Aided and Madrassa)	Grade 7-9	Upper Basic Education	13 to 15
Senior Secondary School (Private, Public Grant-Aided and Madrassa)	Grade 10-12	Senior Secondary Education	16 to 18
	N/A	Vocational Education and Training Education	
College and University	N/A	Tertiary and Higher Education	19 to 20 and above

Source obtained from (MoBSE, 2014).

The next section gives a detailed explanation of the status of science education in the Gambia.

1.2.3 The status of science education in the Gambia

This section examines science education in the Gambia from Lower Basic School (LBS) to University level. In the Gambia science is taught at an introductory level from LBS. The subject at this level is referred to as integrated science. As the students move to the Upper Basic School (UBS), they study what is called General Science. This core subject area has three components: Physics, Biology and

Chemistry, which are usually taught at foundational level and which prepare students to specialise in science at Senior Secondary School (SSS) where students are allowed to opt for their field of specialisation. This level is crucial as it determines students' futures. The three main areas of specialisation at this level of the education system are Science, Commerce and Arts. Those students who specialise in science study Physics, Chemistry, and Biology as core subjects in addition to English and Mathematics, which are compulsory subjects to all students irrespective of their area of specialisation.

Availability and quality of science materials vary from one school to another. Schools at the Lower Basic level have neither science labs nor basic science materials. LBS teachers are not subject specialists like their counterparts at UBS. They teach all subject areas across the LBS Curriculum. Teachers rely mostly on teaching aids such as diagrams and improvised materials to teach science. At the UBS level, the state of resources also varies from one school to another. Some UBS are adequately equipped with science labs, some have basic science materials without labs, while others have labs but no science materials. At SSS, the schools with adequate and equipped science labs are the schools offering pure science subjects to students. These students, in most cases, proceed to College to become science teachers or to University to specialise in education, nursing, medicine and engineering.

Below is a breakdown of the enrolment of students at the Upper Basic School (UBS) and Senior Secondary School (SSS) level of Gambia's education system over the past 4 years and the number of teachers at UBS level: Source obtained from MoBSE (2014; 2015; 2016; 2017).

Table 2:

Enrolment at Upper Basic Schools			
YEAR	**Male**	**Female**	**Overall**
2014	43245	44146	87391
2015	44559	45617	90176
2016	44284	46554	90838
2017	44957	49400	94357

Table 3

Enrolment at Senior Secondary School			
YEAR	**Male**	**Female**	**Overall**
2014	25107	24006	49113
2015	25612	25613	51225
2016	27372	28629	56001
2017	28529	31781	60310

Table 2 and 3 in contrast, indicated a total difference of 146113 students from 2014 to 2017 not transiting from UBS to SSS. This raises a great concern to the Gambian education system. The student teacher ratio seems to be low comparing table 2 against table 4. The results of this indicated that one teacher to every eleven students.

Table 4

Number of Teachers at the Upper Basic Schools			
YEAR	**Qualified**	**Unqualified**	**Overall**
2014	6278	1186	7464
2015	6781	1121	7902
2016	7592	1138	8730
2017	7973	1076	9049

Table 5

Number of Equipped Science Lab at Secondary Schools	
Year	**Science Labs**
2014	285
2015	337
2016	374
2017	412

Science at the Teacher Training College:

This section gives a situational analysis of the institution responsible for teacher training in the Gambia with specific focus on science education.

The Gambia College is the only teacher training institution in the country. The school of education registered 234 trainee teachers across all subjects in 2016 (MoBSE, 2016). This number was four times more than the number of teachers trained in 1995. More science and mathematics teachers were given targeted training each year by the College. The science department had nine full-time lecturers and four part-time lecturers. Out of these two are currently pursuing a Master's degree. All the lecturers obtained a first degree in science.

Science at University of Gambia (UTG)

The faculty of science at the University of the Gambia (UTG) enrolled students doing physical and natural sciences (Biology, Physics, Chemistry and Mathematics). Below is the number of students enrolled between 2015 and 2017 academic year.

Table 6

Number of Science Students at the UTG		
2015/16 Academic year	**1st Semester**	272
	2nd Semester	315
2016/17 Academic year	**1st Semester**	358
	2nd Semester	423

Source obtained from (MoBSE, 2017)

There is a minimal increase in the number of student enrolment at UTG as indicated in table 6 above. However, considering the number of students transiting from SSS each year between 2004 and 2017 showed a massive decline in terms of student enrolment at the University of the Gambia. This showed a noticeable decline in students opting for science as they transit to senior secondary school. This aroused a general concern over students' attitudes towards science. Therefore, for the Ministry to achieve its policy aims for a move from teacher centred to SCL, particularly in science education, a lot of investment needs to be made to provide adequate teaching and learning resources to schools that will meet the demand and needs of the students, and to continue to provide CPD to science teachers in particular.

The next section focuses on the structure of the thesis.

1.3 The thesis structure

The thesis is comprised of nine chapters: Introduction and context of the study, literature review, theoretical framework used as an analytical tool to analyse the data obtained, the research design and methodology, data presentation and discussion, evaluation of the three research questions and the theoretical frameworks, and conclusion and recommendation.

The current chapter, the Introduction, explains the context, rationale, research aims and questions of the study.

Chapter two reviews published literature relevant to the research. These include reviews of the definitions, interpretations and principles of SCL, including teachers' perceptions of SCL, climate of SCL classrooms, SCL methods, benefits and criticisms of SCL, and students' perception of their science lessons. The third chapter explains the theoretical framework namely Magnusson et al.'s (1999) model of PCK and Friedrichsen et al.'s (2011) model of STOs used as an analytical tool to analyse the data obtained from lesson observation, interviews and focus groups.

Chapter four explains and justifies the research design. The methodology and methods of data collection are discussed, and the validity of the research design is explored along with my reflexivity and positionality and the ethical considerations of the research.

Chapters five, six and seven are the data presentation and discussion. Each research question is presented and discussed in turn; chapter five discusses research question 1, chapter six discusses research question 2 and chapter seven discusses research question 3.

Chapter eight gives an evaluation of the findings for each research question and the theoretical model used to interrogate the data.

Chapter nine draws together the conclusions and recommendations arising from the study, then explains how I intend to disseminate findings.

1.4 Summary

This introductory chapter has provided a backdrop to the research. SCL has been introduced as a long-standing teaching approach that claims to generate higher levels of student involvement, engagement and participation than didactic methods, but which evades a single definition. The theoretical framework for the study has been introduced as a synthesis of Magnusson et al.'s (1999) model of Pedagogical Content Knowledge (PCK) and Friedrichsen et al.'s (2011) science teaching orientations (STOs). The rationale and motivation for the research have been explained as being located in Gambian education policy and its quest to make learning more student focused, and in my role in supporting this move by exposing teachers to such techniques with the hope of them adopting and implementing them through recommendations for CPD for teachers. The original contribution to knowledge that the research makes has been stated. As the first study of its kind, findings from the research contribute meaningfully to new knowledge in the field of science education, particularly to SCL, theory and practice in the context of UBS in Gambia. The chapter has also explained the general context of the Gambia, its education system and its science education, noting in particular a big drop in students enrolling for science degrees at the University of Gambia. Finally, this chapter has mapped out the structure of the thesis.

Chapter Two: Literature Review

2.1 Introduction

Section 2.2 of this chapter focuses on understanding student centred learning. Constructivism is examined as the philosophical theory underpinning student centred learning. This philosophical position is explained first and then how it feeds into different features of SCL is discussed. This is followed by definitions of key terms in order to conceptualise student centred learning (SCL). This is achieved by discussing different ways in which SCL has been defined and interpreted by scholarship. As this chapter will demonstrate, a uniform definition of SCL is difficult to pin down because it is interpreted in different ways. Differences tend to rest on how SCL is understood and practised in the classroom; some scholars present SCL as students learning what they like in the classroom, while other scholars present it as students being guided and provided with the materials required for learning. The commonality is that the focus is on the student learning, rather than on the teacher teaching. Commonalities across the various definitions are discussed in section 2.2.3 which involved the student, teacher and the learning objectives and aims.

Section 2.3 of the chapter reviews published research conducted on teachers' perceptions of SCL; the outcomes are organised into positive and negative perceptions. The positive perceptions underline what teachers report as the importance and benefits of SCL practices. The teachers believe that with SCL, students are able to support and learn from each other. SCL according to teachers is the best approach and it develops students' thinking ability. The negative perceptions indicate the factors that teachers believe impede SCL practices. These factors include lack of resources, large class sizes, examination orientated syllabus, and inadequate time and training to practise SCL approaches.

Section 2.4 of the chapter examines the climate of student centred classrooms (SCCs). The key elements of SCCs discussed are group work, practical work and facilitation from the teacher. This is followed by section 2.5 which gives a detailed discussion about various student centred methods. These include differentiated instruction, cooperative learning, problem based learning and Activity Student Experiment Improvisation – the Plan Do See and Improve (ASEI-PDSI) approach. The chapter argues that these are all types of SCL because they are student focused.

Section 2.6 of the chapter focuses on the benefits of SCL and section 2.7 reviews the criticisms of SCL. These topics are reviewed to understand current debates about SCL in order to situate the research within this academic discourse, and to facilitate meaningful analysis of the empirical data generated by the research. A close review of the literature indicates that benefits of SCL correspond with the teachers' positive perceptions of SCL, while the criticisms of SCL tend to focus on practical reasons why SCL is perceived as difficult to do.

Section 2.8 examines research into students' opinions about their science lessons. This leads into a review about students' perceptions of their science lessons. This discussion includes what students feel about practical work and the lack of practical work in their science lessons; hence student centred orientations and SCL have practical work as a common feature. This is followed by a section of this chapter which explores research about students' perceptions of science as a subject. The literature includes both positive and negative views, which resonate well with teachers' perceptions of SCL and their classroom practices. The final section gives a summary of the entire chapter.

2.2 Understanding Student Centred Learning

This section focuses on constructivism as a philosophical theory underpinning of SCL. This is because SCL shares common principles with constructivist learning, in which the students are the main focus in the process of learning where the teacher facilitates.

2.2.1 Constructivism as a philosophical theory underpinning of SCL

This sections explains constructivism as a philosophical position that feeds into the different features of SCL. The term constructivism is defined as “an approach to teaching and learning based on the premise that cognition (learning) is the result of mental construction” (Bada, 2015, p. 66). This means that new information students learn is built on what they already knew. Students constructing their knowledge, according to Bartlett and Burton (2012), must be facilitated by the teacher. This is because the constructivist model of learning means that the role of the teacher is to facilitate the students’ learning process. This means that the teacher is not there to transmit and transfer information to students but rather to facilitate, guide and support them (Bartlett & Burton, 2012). The constructivist approach to learning offers students the chance to be involved in activities that concentrate on meaningful learning in which the teacher plays the role of a facilitator (Yilmaz, 2008). According to constructivism, knowledge is neither passively received nor discovered from teachers, but actively constructed by learners (Yilmaz, 2008). This means that learners are expected to construct their own understanding and meaning. Constructivist conception of learning is drawn from the works of Dewey (1929), Bruner (1961), Vygotsky (1962) and Piaget (1980) (Bada, 2015, p.66). Constructivism is a learning theory that has its root in education, sociology and psychology. It gives an explanation of how individuals learn and obtain knowledge (Bada, 2015). Constructivist learning theory argues that individuals produce their own knowledge and form meaning based on their own previous experience. Constructivism is hands on, questioning and explorative, which gives students ownership of what they learn. Constructivism is concerned with learning how to think and understand since it theorises that education works best when it is not based on rote learning and memorisation but is instead focused on thinking and understanding (Bada, 2015). From this philosophical point of view, constructivism underpins student centred learning because students create their own knowledge through facilitation by the teacher, rather than being told the information, which is a feature of didactic methods. To sum up the discussion;

a constructivist view holds that an effective educator must first engage with and build upon the knowledge and beliefs about the world that learners already bring with them, without which learners may fail to fully grasp new concepts, or may revert to their previous positions once they leave the classroom (Brinkmann, 2015, p. 344).

This means that in constructivist classrooms teachers build on what students already know through interactive learning. The teacher does this through dialogue with students, thus supporting them to construct their own knowledge. This view is in accordance with Aristotle (384-322 BC)'s method of teaching which was based on teachers guiding the students to reach their potentials through their experiences and sharing these with their colleagues (Bates, 2016). In this regard dialogue was seen as vital between the teacher and students and this outlined what the students were able to do. In practice Aristotle pointed out that students must not be spoon-fed with information but rather they should find their solutions (Bates, 2016, p. 13). These views are also similar to John Dewey (1859-1952), who emphasised that students should share their experiences with their colleagues in the classroom (Bates, 2016, p.19), and students in this way would learn from each other by sharing the ideas and knowledge they obtained among themselves through group work and discussions.

Constructivism therefore feeds well into SCL since it puts the learner at the centre stage of learning where teacher–learner interaction is encouraged for learners to become actively involved in learning, the teacher acts as a guide or facilitator, not using ‘talk and chalk’, checking on student understanding as the lesson progresses and focusing on effective ways of making sure that learning has taken place (Henson, 2003 cited in Yilmaz, 2008, p. 38). In a student centred lesson, learners are encouraged to participate fully and are encouraged to asked and respond to questions, discuss and answer problems, taking into account their prerequisite knowledge and skills (Yilmaz, 2008). Learning also involves the use of prior knowledge and skills to construct a better understanding of new information. This is described by one of Magnusson et al.’s (1999) PCK components as ‘knowledge of student understanding of science’. As Froyd and Simpson (2010) emphasised, SCL foregrounds students’ prior knowledge as it influences future learning. Diagnosing what the students know before teaching them what they do not know is key in SCL practices. In science, for example, this is because science topics are interconnected; for example, students need to learn about the first twenty elements before proceeding to the electronic configuration and structure. This will minimise difficulties and foster student understanding in the learning process.

SCL is about learners discovering knowledge on their own with minimal dependency on the teacher as the owner of knowledge which may improve learning and enhance retention of the knowledge gained (Zian, Rasidi, & Abidin, 2012).

SCL involves group discussion and other types of activity-based learning. Zain et al. (2012) argued that the most effective learning methods and better retention of knowledge are attained through group discussions, practice by doing, and peer tutoring. Slavin (as cited in Zain et al., 2012, p. 320) points out that peer tutoring involves sharing of knowledge, gaining insight from the contribution of other members, better preparation, and desire and commitment to prove their capabilities. This encourages student participation and involvement in the lesson. Putting students into small groups instead of large groups may also enable them to interact with each other, share their ideas and experiences, and showcase a greater commitment towards their counterparts.

In conclusion constructivism is the philosophical theory underpinning SCL. This is because the way constructivism understands knowledge construction matches well with SCL pedagogies. Key among these is the teachers' role as a facilitator and guide. In the process of learning, teachers are not there to spoon-feed students, but rather to support and guide students in their own intellectual effort.

The next section defines key terms used in the conceptualisation of SCL.

2. 2.2 Definition of key terms

This section defines the terms pedagogy, instruction, student centred instruction, teacher centred instruction, student centred method and teacher centred method in order to give a clear meaning to each of them, before delving into the definition of SCL.

Pedagogy is the attention given to the nature in which the students' lives in the classroom are experienced (Va Manen, 1999, as cited in Darby, 2005, p.430).

According to Moyles, Adams and Musgrove (2002), “pedagogy encompasses both what practitioners actually Do and Think and the principles, theories, perceptions and challenges that inform and shape it” (p.10). Pedagogy is different from instruction; Hyun (2006) described ‘pedagogy’ as, “teaching with ethical and moral awareness that facilitates learning”, and ‘instruction’ as the “passing of pre-existing content on to the learners” (p. 141). Hyun’s (2006) definition of pedagogy therefore involves offering support to students and facilitating their process of learning, and instruction as knowledge transmission. Brown (2008, p.30) argues that instructions are student centred where they involve planning, teaching and assessing the students’ needs and abilities. Such student centred instructions would be taken to be student centred learning (SCL) in this study. For example, diagnosing students’ pre – requisite knowledge to be able to meet their needs. Furthermore, instruction, such as work sheets given to students during experiment to answer questions at the end of the practical work, would be considered student centred instructions. Instructions that are student centred are when the attention is on the students. On the other hand, teacher centred instruction is described as the teaching method in which the students (learners) are passive listeners and the teacher does all the talking and writing (Gibbs, 1981). This means the attention is on teacher. Gibbs (1981) described that teacher centred instruction is concerned with memorisation of information transmitted to students by the teacher (Gibbs, 1981). In this study, teacher centred instruction is classified as teacher centred learning (TCL). It is therefore important for this study to examine whether teachers in the Gambia prefer using didactic or student centred learning, or both, and why. Distinguishing student centred instruction from teacher centred instruction will therefore help to understand SCL practices.

Gibbs (1981) described teaching that involves practical work or experiment as student centred method - a method of teaching associated with student centred learning. Therefore, student centred method is seen as student centred learning in this study. This is because such teaching methods focus on learners, which match the definitions of student centred learning. In contrast, if the teaching method discourages student participation and engagement in the classroom, where the teacher takes charge of the lessons then it could be regarded as teacher centred method or teacher centred learning.

From this discussion, teacher centred learning is opposite to student centred learning. However, teacher's classroom practice runs between the two hence the distinction of the two is not as clear cut as suggested. Certain science topics are very abstract in nature and require the teacher to explain certain basic concepts and knowledge for students to understand. For example, teaching students the first twenty elements of the periodic table can be teacher centred hence students are taught to learn and remember the names of elements and symbols, atomic number, mass number, electronic configuration and diagram, group and period number of the elements. In addition to the explanations given, the teacher may give students the opportunity to work or discuss in groups or conduct individual task during the lesson. Therefore, teacher centred method to some degree cannot be completely excluded from teaching science lessons however this is sometimes blended with the use student centred approach such as group discussion. Thus it makes it impossible to separate the two methods in most science lessons that are particularly non-practical based lessons.

2.2.3 Definitions, interpretations and principles of Student Centred Learning

This section discusses definitions of Student Centred Learning (SCL) found in published literature, and then explains definitions and interpretations of SCL used in this study. This is to have a better understanding of what SCL entails, and to clarify its use in this study. This section argues that SCL does not have a unique definition as it means different things to individual scholars and is practiced differently, depending on the context in which it is applied. However, the different definitions of SCL share some common features, as this section points out.

SCL can mean “learning approach” (Zain et al., 2012, p.319); “instructional approach” (Lathika, 2016, p. 677), (Collins and O’Brien, 2003); “pedagogical approach” (Schweisfurth, 2013, p.20), or “model” (Singh, 2011, p. 276). This variation could be the reason why Costa (2013) argued that SCL is much easier to understand than to define. The type of SCL that might be practised in the context of Gambia may be different, since in the Gambian education system there is a specific syllabus that the teachers have to follow. This means that most formal education elsewhere, as well as in the Gambia has a set of curriculum of learning to follow. SCL approaches and techniques can still be used to help students learn about topics on the curriculum. However, even though there is this variation in the definition of SCL, there are some shared features taking into account its application in the classroom context.

Some of the common features of SCL which fit well with the outlook of this study are outlined by Brandes & Ginnis’s (1994) as:

a. students should take full responsibility for their own learning

b. the topic taught by the teacher should be relevant and meaningful to students

c. students’ involvement and participation are required for learning

d. teachers’ role should be facilitators and resource persons

e. the kind of interaction in the classroom should involve student-student, student-teacher and student-materials relationship.

According to Ashmore & Robinson (2015), learner participation is highly encouraged in a student centred pedagogy through activities conducted in most lessons by giving learners the opportunity to investigate, explore and answer problems with teacher support and guidance. Ashmore & Robinson (2015, p.23) point out the key principles associated with student centred learning that require putting into practice by the teacher. These include:

- Teacher acting as a facilitator, putting learners’ prior knowledge and skills into consideration
- Identifying learning preferences and needs of learners
- Motivating and supporting learners with activities and material resources
- Allowing learners to participate and reflect on the process of learning
- Encouraging learners to become self-autonomous

Idogho (2016) is of the view that the actual definition of SCL is still evolving; according to him, SCL refers to the approach that gives students opportunities to take a lead role in their learning activities; play an active role in discussions; design their own learning projects; explore topics that interest them and in a very general way design their own course of study.

In this research SCL is defined as a pedagogical approach that puts the students at the core of the learning process where the teacher facilitates, guides or coaches and students take an active role to participate, cooperate and collaborate among themselves, in groups or individually through discussions and exchange of ideas and experiences. SCL as pedagogy, therefore, puts students at the centre of the learning process, thereby taking into account students' pre-requisite knowledge and skills, as well as their individual learning differences; the use of relevant teaching and learning resources, using creative classroom activities that would enhance learners' engagement, participation, collaboration, interest and motivation, and meaningful learning.

To understand SCL there are key similarities that I have identified as common characteristics based on the literature. These are student, teacher and learning aims. This is because with SCL the student is the main focus of the learning process where the teacher is seen as a facilitator with the aim of students having to construct their own learning which is in accordance with the constructivist approach to learning. The subsequent sections give a detailed discussion on each of the common characteristics of SCL.

2.2.3.1 Student

This section argues that students are the main focus in the process of learning and should be encouraged to actively participate in class discussions and activities. In the study conducted by Zeki and Güneyli (2014), learning is seen as a very social process that involves students and not a one-way transfer of pre-packaged knowledge from teacher to students. This means that students are not supposed to be receivers of knowledge but instead should be able to build on their own knowledge through the sharing of ideas and experiences. SCL is an approach in which students have control over the learning process. A similar definition was given by Loggerenberg-Hattingh (2003) which stated that SCL is an approach in which the teacher sets the lessons with minimal control over what and how students learn in a less structured, less predictable learning environment than with teacher centred approaches. Schunk & Zimmerman (1994) focus on freedom and thus associate the concept with self-generated thoughts, feelings and actions which are systematically orientated towards students' attainment of their goals. All the foregoing puts the student at the centre of everything that relates to learning.

According to Herranen, Vesterinen and Aksela, (2018) SCL shifts dynamics of power from teachers to students. The shift leads to students having a choice in what and how they learn. The following are associated with this concept: flexible learning, experiential learning and self-directed learning. There still seems to be a tension that SCL cannot happen where there is a prescribed curriculum. This line of argument is unconvincing as formal education normally has a set of curricula. For example, the Gambia has fixed curriculum and teachers are expected to practice SCL in their classrooms. This therefore give no room for students to choose what and how they want to learn.

Zain et al. (2012, p. 319), referred to SCL as 'student centred team based learning' (SCTL). They define it as a learning approach that encourages students' active participation in the classroom. The definition of SCL further suggests that students are extrinsically motivated and learn important skills such as measuring, observing, predicting and recording and problem solving. However, extrinsic motivation, according to Bennett (as cited in Brandes & Ginnis, 1994, p.11), involves external rewards, such as the use of grades, which is considered a traditional teacher centred method. Bennett (as cited in Brandes & Ginnis, 1994, p.11), maintains that SCL approaches are intrinsically motivated and therefore, "external rewards and punishment are not necessary”. In this regard, the view of SCL being extrinsic by Zain et al. (2012) opposes Brandes & Ginnis’s (1994) interpretation. This is because Zain et al.’s (2012) understanding of SCL as extrinsic links to a traditional teacher centred approach, which is usually concerned with motivating learning through grades instead of cultivating a love of learning and discovery.

The definition of SCL by Lathika (2016, p. 677) suggested SCL is an instructional approach where students take control of the content, activities, materials and pace of learning and emphasise the students as the focus of the learning process. Pace of learning is viewed by Lathika (2016) as a means in which the teacher increases the level of the students’ understanding when teaching a specific topic. In the same vein, Schweisfurth (2013, p. 20) gave a similar definition of SCL as a pedagogical approach and argued that the learner takes “active control over the content and the process of learning” since “what is learnt, and how, are therefore shaped by the learners’ needs, capacities and interests”. However, students taking active control in class, according to Brown (2008), implies giving them a choice in the decision making process in the classroom. Students can probably opt to select a class prefect and be involved in making class rules, but the choice of the topic to be taught entirely comes from a prescribed syllabus and depends on the teacher who has mastery of the content and connections of the topics within the curriculum, in particular in the area of science as the main area of this study and other subject disciplines too. Students at the Upper Basic Level of the Gambian Education system, considering their level of education and age, need some form of support and guidance from the teacher during lessons. Teachers have a national curriculum to follow which requires certain pre-requisite skills that the students need to have before they able to teach them a particular subject matter. For this study, students taking responsibility for their own learning would involve inquiry and discovery processes where students independently conduct practical activities on their own.

Brandes & Ginnis (1994) pointed out that the kind of learning process that takes place in SCL enables learners to assess or evaluate the learning outcome in the classroom. A similar view is shared by Singh (2011, p.276) who viewed that with SCL, learners take full responsibility, autonomy and accountability for their own learning. Furthermore, Singh's (2011, p. 276) definition of SCL refers to "cooperative and collaborative learning" and emphasises that learning should relate to real life situations. For example, topics such as food chain or figuring out the energy transfers that takes place between organisms are real life topics that the students can easily make a connection with. Such types of learning encourage learners to be independent and discourage the teacher from telling students or showing them what to do.

To further understand SCL, some relevant SCL principles underline the significance of learning through student involvement and participation (Brandes & Ginnis, 1994, p.13). The involvement and participatory environment of discussion and practical activities are regarded by Brandes & Ginnis (1994) as sources of joy that exist between the students and their teachers. Brandes and Ginnis (1994) argued that they are fun and rewarding by being challenging, discovery-led, questioning and through completion of self-initiated tasks and competency in new areas. Another key principle highlights that the "relationship between learners is more equal, promoting growth and development" (Brandes & Ginnis, 1994, p. 15). Student involvement in group work is encouraged which increases student-student interaction to be able to exchange or share their ideas.

It can be concluded that with SCL, students are the main focus of learning. Their active involvement and participation in class is significant. Students are intrinsically motivated and are able to take responsibility of their own learning. Such responsibilities are attained through experiment/practical work that is conducted during their lessons. This gives students the autonomy in their learning. The next section focuses on the teacher as facilitator.

2.2.3.2 Teacher

This section argues that SCL demands a shift in the teacher's role from knowledge transmitter to that of facilitator, guide and support. Brandes and Ginnis (1994, p. 15) further clarify the role of the teacher as a facilitator and resource person, involving the expertise, knowledge, attitudes, training and resources the teacher provides to students. Collins and O'Brien (2003) define SCL as an instructional approach, which clarifies the role of the teacher as a provider and coach for students to learn and acquire skills. According to Zeki and Güneyli (2014) SCL is where a teacher is no longer an active presenter of knowledge, but a creative guide who monitors suitable opportunities and contexts. Shaffer (2016) made a similar view about SCL instruction as an "instructional format where the teacher becomes more of a facilitator of the learning process and the learners take on the leading role in their educational experiences" (p.1). The teacher as a facilitator is there to guide the students and improvise materials for them to use where necessary. The teachers as a result will need a mastery of their subject knowledge and content in order to appropriately facilitate and guide their students. The next section focuses on the learning objectives and aims.

2.2.3.3 Learning objectives and aims

This section argues the relevance and meaningfulness of a learning objective set for any SCL objective and aims to be attained. Brandes & Ginnis (1994, p.12) point out that topics taught in lessons should be relevant and meaningful to students. Relevance and meaningfulness according to Weinstein (as cited in Brandes & Ginnis, 1994, p.13) depends on “what is taught and how it is taught”. This involves the appropriateness of the teaching and learning materials and the teaching strategies used in the classroom. If the materials provided to students are not relevant it will not achieve what it set out to achieve, thus the learning objective that is set for the students will not be achieved. Brandes & Ginnis (1994) pointed out that the relevance and meaningfulness of the subject matter takes into account students’ pre-requisite skills and knowledge. This principle seems to sit well with Magnusson et al.’s (1999) model of PCK with particular reference to knowledge of students’ understanding of science and teachers’ knowledge of instructional strategies. This is because science topics are interconnected and as a teacher if you understand what the students already know before teaching a particular topic you will be able to develop it from there to what they need to know.

In conclusion, the learning objective of a student centred lesson should be relevant and meaningful to students. Through the learning objective the teacher is able to identify the appropriate materials required for the students to use in a specific topic. Therefore, in general the position of student, teacher and learning objective is important in SCL.

2.3 Research on teachers' perceptions of Student Centred Learning

This section focuses on scholarly research about teachers' perceptions, beliefs and views on SCL, which are categorised in this chapter as positive perceptions and negative perceptions. According to Flutter and Rudduck (2004) exploring teachers' perceptions of teaching and learning about science is crucial because it could help teacher educators to have a better understanding of what works in the classroom. This is because the way teachers perceive teaching and learning tends to influence their practice in the classroom and as Yilmaz (2008) pointed out that if you want to know about teachers' practice it is useful to explore their perceptions. The findings from my study may help the Ministry of Basic and Secondary Education (MoBSE) and colleagues at the Science and Technology Education Directorate (STED) in The Gambia to outline a continuing professional development (CPD) for teachers with the aim of improving the teaching and learning of science in schools. This will enhance the identification of specific matters considered by students and teachers for meaningful learning. Investigating teachers' perceptions is therefore significant, and teacher educators may use it to support teachers to be more innovative and implement techniques that may help improve the teaching and learning of science (Flutter & Rudduck, 2004). The next section focuses on teachers' positive perceptions of SCL.

2.3.1 Teachers' Positive Perceptions of SCL

This section discusses literature about teachers' positive perceptions of SCL. Yilmaz (2008) indicates that the best way to comprehend teachers' practices in the classroom is to explore their perceptions and thoughts. However, teachers' perceptions about SCL are numerous and varied, perhaps due to the different definitions and interpretations attached to SCL by various scholars as discussed as well as variation in teachers' own experiences and beliefs in section 2.2.3 of this chapter. Yilmaz (2008) conducted a qualitative study in which he used semi-structured interviews with teachers and inductive qualitative data analysis to analyse the interview transcripts. The study used a purposeful sampling method to select participants for the study. Participants were chosen from three public middle and high schools located in three cities in a south-eastern state in the United States. The social studies teachers' views of student centred methods and theories indicated teachers' "positive attitudes towards student centred instructions which they believed have the potential to make instruction engaging, enjoyable, involving, challenging and relevant to students' learning. These teaching orientations were more with cognitive and constructivist approach than behaviourist approach" (Yilmaz, 2008, p.35). Yilmaz's study indicated the teachers' belief that student involvement in a lesson is well attained through SCL strategies in which students are actively engaged in their learning. Teachers' perceptions were that their instructional goals are better achieved through the student centred instruction due to the active and involving nature of the approach (Yilmaz, 2008, p.43). Teachers regarded student centred instruction as more effective than teacher centred instruction since what the students learn is retained longer and they are able to apply this in their daily life (Yilmaz, 2008, p.43). This is linked to constructivism underpinning SCL since it is more likely that the students will remember information that they have constructed (i.e. worked out) for themselves, than information received passively by being told. Teachers perceived that with student centred instruction they act as a guide and facilitator of student learning (Yilmaz, 2008, p.43).

Seng (2014) conducted a qualitative study in Malaysia to investigate teachers' views on SCL. A total of fifteen secondary school teachers were selected from both urban and provincial schools for individual, in-depth interviews. The study examined what teachers said about how SCL has been used in the classroom and the problems they reported in its implementation. The study suggested that with SCL students are able to learn independently; students become autonomous learners; students learn from their own experiences and also promote equal learning opportunities to their peers.

Shaffer's doctoral thesis (2016) focused on elementary teachers' perceptions and experience of SCL. The qualitative study was to gain a deeper understanding of teachers' perspectives and experiences in student centred learning. The findings indicated teachers' positive attitudes towards SCL as similar to that that of Yilmaz (2008) and Seng (2014).

In conclusion teachers' perceptions of SCL have outlined the benefits of using SCL in the classroom. These perceived benefits focus on teaching and learning since teachers believe that SCL makes lessons enjoyable, engaging, involving, challenging and relevant to learning. Teachers perceived that students learn from their own experience in a student centred lesson. The teachers indicated their role as a guide and facilitator using SCL approaches. It is also perceived that that SCL enhances independent learning and students becomes autonomous learners.

The next section discusses teachers' perceptions, focusing on the practicalities of SCL.

2.3.2 Challenges/Constraints in the implementation of SCL

This section highlights teachers' negative perceptions of SCL which entail some of the factors that impedes their classroom practices. These include: lack of resources, large class size, and examination orientated syllabus/curriculum, time constraints and inadequate training. Indication from my investigation of SCL shows that teachers broadly perceived SCL to be resource-heavy compared to teacher centred learning and this is a unique and true assumption in many education systems particularly in developing countries such as the Gambia.

2.3.2.1 Lack of resources

Sikoyo (2010) conducted research in Uganda which investigated factors affecting the implementation of SCL. The sixteen teachers who were involved in the study reported inadequate resources in their schools as a main factor affecting implementation. Practical science work was observed in only four lessons out of the sixteen lessons observed during the research. One teacher reported that lack of materials for experiments leaves no other option than teaching based on talk and chalk. Teachers in the study said that they improvise materials under difficult challenges such as large class size and time constraints. Teachers had to fend for themselves in improvising materials, which was an additional workload for them.

2.3.2.2 Large class size

A study conducted by Mtika and Gates (2010) in Malawi on trainee teachers' capabilities of using SCL in their classrooms showed large number of students in a class as a factor impeding the practice of SCL. Teachers perceived that a class of 80 students was too challenging for group work or to involve students in other types of participatory lesson activities. Trainee teachers also stated the difficulties in managing such large class sizes and ensuring that all students participate during the lessons. Consequently, group activities were difficult to do in class due to the large number of students in a class.

2.3.2.3 Examination orientated syllabus/ curriculum

Aswegen and Dreyer's (2004) study examined the extent to which English Second Language (ESL) teacher educators implemented a SCL approach in South African Universities. Their study used questionnaires, interviews and lesson observations for data collection. The findings from this study revealed curriculum coverage and lack of time as an obstacle to the practice of SCL. Participating teachers felt that they were under pressure to cover the curriculum; this arose from the fact that the courses were content heavy and the teachers could not risk leaving some part of the syllabus unattended, most especially within a policy of reduced contact time. This means that using SCL required more time and therefore it took longer to cover topics in the syllabus.

A qualitative case study conducted by Mtika and Gates (2010) examined the challenges in the implementation of learner centred education to better understand the complexity of adopting learner centred education in the context of teaching and learning in Malawi. Their study used face to face interviews, critical incident logs and lesson observations to obtain its data. The findings revealed teachers' perceptions that SCL was a slower approach in terms of syllabus coverage compared to traditional teacher centred approaches. The traditional teacher centred method was therefore used by teachers to be able to cover the full syllabus before the students were able to take their final examination with the hope of achieving better results. If academic success is measured by exam results, then maybe teacher centred / rote learning is most efficient. However, if academic success is judged by students' complete engagement with their learning and creating long-term knowledge, then maybe SCL is better. It is a tension between what education 'should' be and what institutionalised schooling often becomes because assessment is regarded as the metric of success or failure. Students' progress in Gambia is determined by the grades they obtain during exams. Mtika and Gates (2010) pointed out that in an overloaded examination-orientated curriculum, teachers were forced to focus on the examination syllabus for their students to obtain optimum results. For these reasons the use of teacher centred method was dominant in their study.

2.3.2.4 Lack of time

Seng's (2014) study explored Malaysian Secondary School teachers' views of SCL approaches through individual in-depth interviews. The findings indicated key challenges and constraints faced by teachers in the implementation of SCL. This included time factors, as more time was required to conduct SCL activities, which hindered them from completing the syllabus. This finding was similar to that of Aswegen and Dreyer (2004) in which teachers perceived that more time was required for them to prepare and plan lessons using SCL approaches. In one of the interview comments made by a teacher in Aswegen and Dreyer's study, SCL approach is time consuming because it involves preparing for different teaching styles and students' different needs within a lesson.

2.3.2.5 Inadequate training

Darsih’s (2018) study examined teachers’ efforts and roles in the implementation of SCL in Indonesian Junior High Schools. The study obtained its data through interviews and lesson observations. The study findings indicated teachers’ lack of responsibility and total misinterpretation of SCL due to insufficient training on SCL as factors negatively affecting SCL. Teachers interpreted SCL as learning without any teacher support; they came to class, gave out topics to be discussed, left the class almost immediately and then came back at the end. What was missing was: guidance, assistance and supervision by the teachers. A similar finding was made by Aswegen and Dreyer’s (2004) study which indicated that lack of teachers’ exposure to the use of SCL pedagogies made it difficult for them to practice SCL effectively.

In conclusion, comparing teachers’ perceptions of SCL discussed above and the characteristics of SCL discussed in section 2.2.3, it is noticed that teachers’ positive perceptions match the characteristics of SCL. Teachers perceived that in SCL students are more engaged and their involvement in lessons is greater. The focus is on the students and not the teacher. What the teacher does in SCL is to guide and facilitate the learning process, which concurs with constructivism as a model of learning. However, the reality on the ground is that achieving such lessons can be difficult due to lack of time, large class sizes, inadequate resources, examination orientated syllabus and lack of adequate training, as mentioned by teachers in the studies discussed. This is why what teachers perceive and what actually happens in reality may vary practically due to these constraints. The next section focuses on the climate of the student centred classroom.

2.4 Climate of student centred classroom

I know I cannot teach anyone anything, I can only provide an environment in which he can learn (Rogers, 1965, p.389 as cited in Brandes and Ginnis, 1994, p.12).

This section focuses on the student centred classroom (SCC) environment to have a better idea of what a SCC consists of. It compares and contrasts the teacher centred and student centred classroom environment in order to develop a better understanding of the type of environment one may find his/herself in when it comes to teaching and observing lessons in a classroom situation. Group work is considered first, as it is key in SCL practices.

2.4.1 Group work

Group work is pointed out by Brandes and Ginnis (1994, p.33) as a key element of a SCL environment where students sit in circular groups and are able to speak freely, express their opinions, share their feelings, and have no fear of being ridiculed whether or not they have contributed towards a discussion, and with a sense that there are no right or wrong answers. However, seating arrangements, especially in a circular form, may be problematic in some teaching environments due to the kind of furniture and teaching space available. Some students may also feel shy about taking part in the discussion (Brandes & Ginnis, 1994). The SCC is usually noisy and students are allowed to freely move about in class (Brandes & Ginnis, 1994). This according to Brandes and Ginnis (1994) does not mean a lack of teacher control in the classroom but is geared towards achieving the aims and objective of the lesson.

SCCs are unlike teacher centred classrooms (TCCs) where the teachers are frequently seen standing next to the board talking and writing. The teachers in the SCCs are seen in most cases sitting with the groups of students during discussions or group tasks. In SCCs, students are encouraged to support one another and there is a positive cooperation and trust (Brandes & Ginnis, 1994).

According to Schuh (2004, p.836), student centred practices have more or equal student talk and questions than teacher-talk, more individual and small group size instruction, wide-ranging instructional materials, evidence of students' choice and organisation of content, classroom rules and a physical arrangement of the classroom that allows for students to work in groups.

An SCC encourages teamwork and ethics (Schuh, 2004). Students in this regard listen to each other's contributions in sharing knowledge during group discussions. Students in SCCs are clearly responsible for the actual arrangement of the classroom where students are seated in clusters, interacting and discussing (Peters, 2010). These skills are encouraged when teachers move around the room, make eye contact and ask students direct questions; students are more engaged in their tasks as indicated by Weinstein and Mignano (2003 as cited in Peters, 2010, p. 343). The teacher is hardly seen standing in front of the class next to the chalk board, talking and writing as in the case of the traditional teacher centred method. In SCC, the teacher is seen as a facilitator and is there to set efficient group work and render guidance and support where applicable (Peters, 2010). The next section focuses on practical work, which is another student centred practice.

2.4.2 Practical work / Performing experiment

This section discusses practical work as one of the key student centred practices that teachers engaged students with in the classroom to enable them to discover key basic concepts and knowledge in science without being told. This section focuses on

SCL in teaching science in particular. SCC involves learning by practice and thus makes it more unpredictable and fluid compared to teacher centred classrooms (Peters, 2010). Students learning by doing could be achieved by conducting experiments, obtaining results and writing them up, which may improve the writing, observation and measuring skills of students. In SCC it is expected that students will have adequate teaching and learning materials to conduct practical-based activities (Peters, 2010). In comparison, a classroom might be adequately resourced, but the teacher may still choose not to adopt SCL methods. Peters (2010) pointed out that in TCC, practical topics that could be engaging to the students are taught by the use of talk and chalk method. This means that even though there are materials available for students to conduct practical, the teacher will instead use the didactic method to teach. The next section focuses on the role of the teacher as another key element of student centred practices.

2.4.3 The role of the teacher as a facilitator

In SCC, according to Peters (2010), the role of the teacher is to create a favourable environment for learning rather than just transmitting knowledge. Students are expected to be active seekers of knowledge in SCC; for example, topics to be covered are given to students to research prior to the lesson, which, according to Peters, encourages students' independence and increases their motivation. In this way teachers are usually not prescriptive by telling the students the solutions, but rather engaging them in the process of learning through varieties of learning activities. This is done through the teachers' guidance and facilitation to enhance efficient support for students. Students have equal access to materials with the advice and information from the teacher (Brandes & Ginnis, 1994).

In conclusion, the categories discussed here align well with the definition of SCL given in section 2.2.3 confirming the usefulness and accuracy of these as characteristic features of SCL. As discussed above, Brandes and Ginnis (1994), Schuh (2004) and Peters (2010) stated these features as common to SCL; the role of the teacher as a facilitator, a guide and support; students working in groups where they interact, discuss and support each other; and adequate materials for students to access, particularly for conducting experiments or practical activities. These differ from teacher centred instructions, which, according to Cuban (as cited in Schuh (2004, p.835), involved teacher talk and students as passive listeners. There is usually a whole group instruction and teacher and students rely on textbooks used as support, recall of factual information and a classroom in which students' desks are in rows facing a board with the teacher desk nearby. The next section focuses on the varieties of method used in a SCL classroom.

2.5 Student centred methods of learning

There are four principle teaching techniques for discussion in this section and are considered student centred learning approaches. These teaching methods are: differentiated instruction, cooperative learning, problem based learning, learner centred learning and Activity Student Experiment Improvisation/ Plan Do See and Improve (ASEI/ PDSI) approach. The reasons for considering these techniques is that they have key elements in common that are hallmarks of SCL. These elements are activity based and they encourage student participation and discussion. The discussion of these strategies specifies the kind of techniques that the teachers employ in their SCL classroom practices.

2.5.1 Differentiated Instruction

Differentiated instruction is considered as a student centred learning approach (Arends and Kilcher, 2010). This is because it has the characteristic features of SCL, notably the use of a variety of teaching techniques, which take into account students' individual differences in the classroom. “Differentiated instruction is a practice of adjusting the curriculum, teaching strategies, assessment strategies and the classroom environment to meet the needs of all students” (Arends and Kilcher, 2010, p.106). Differentiated instruction takes into account teaching approaches that are “responsive and proactive” rather than “prescriptive and reactive” (Arends and Kilcher, 2010, p.106). This means taking into consideration the mix of abilities in a group and also encouraging students' participation. Differentiated classrooms use a variety of instructional formats such as whole group, small group, pairs and independent study. Planning differentiated lessons involves finding out what the student already knows and being able to link that to what they do not know (Arends & Kilcher, 2010). It uses varied teaching and learning strategies which qualifies it to become a SCL approach. Unlike teacher centred approach in which the teacher teaches a topic at the same pace, in the same way and at the same time, differentiated instruction is based on learning preferences and academic readiness (Arends & Kilcher, 2010, p.110). However, recognising individual differences and meeting those needs could be daunting particularly in large class sizes where teacher-student ratio is very high- one teacher to lots of students. The next section discusses cooperative learning, which is another SCL approach.

2.5. 2 Cooperative learning

Cooperative learning specifies the role of the teacher and group work as a key strategy, and it is therefore considered by Arends and Kilcher (2010) as an SCL approach. Cooperative learning is a “teaching model or strategy that is characterised by cooperative task, goal, and reward structures, and requires students to be actively engaged in discussion, debate, tutoring, and teamwork” (Arends & Kilcher, 2010, p.306). Cooperative learning theory asserts that students learn better when working together, encouraging and tutoring each other and are not individually held accountable for their work. In this type of strategy students are allowed to interact and move about freely in class (Arends & Kilcher, 2010, p.306). Cooperative lessons involve goal clarification and student motivation, presentation of materials and/or information, organising students into learning teams, assisting with teamwork and study, presentation of group work or testing over materials and recognition of individuals and group effort and achievements. The role of the teacher is that of a facilitator, coach and guide. The teacher prepares materials to be used by students and support groups in need of help where necessary (Arends & Kilcher, 2010). These teacher roles were earlier discussed in section 2.4.3 as a key element of SCL practices. The next SCL approach to be discussed is problem based learning.

2.5.3 Problem – based learning

Problem-based learning (PBL) is defined as a “student-centred approach that organises curriculum and instruction around carefully crafted ‘well-structured’ and real-world problem situations” (Arends & Kilcher, 2010, p.326). There is a complete shift from traditional teacher centred to SCL where students work in small groups, have shared responsibilities for learning together, critical thinking and developing problem solving skills and skills for collaboration and management. Teachers are seen as role models, coaches, questioners, guides and mentors (Arends & Kilcher, 2010, p. 327). PBL is based on constructivist theories on how people learn through the works of Jean Piaget, Lev Vygotsky and Jon Dewey (Arends & Kilcher, 2010). PBL aims to promote student motivation and learning because its lessons involve problem presentation, planning and conducting investigation, learning demonstration, and debriefing and reflection (Arends & Kilcher, 2010).

The final SCL approach, discussed below, is the Activity Student Experiment Improvisations - Plan Do See and Improve (ASEI-PDSI) approach.

2.5.4 Activity Student Experiment Improvisation (ASEI) - Plan, Do See Improve (PDSI) approach

This section discusses ASEI/PDSI approach which is seen a hallmark of SCL. The ASEI-PDSI approach is a SCL approach which was locally introduced and exposed to some teachers in the Gambia after it was initiated and established by Kenyan educators in 1998 (Irungu & Mercy, 2013). Therefore, it is significant to bring to this discussion since ASEI was practised by some of the sample teachers who participated in my study. By definition the term ASEI–PDSI means Activity Student Experiment Improvisation-Plan, Do See and Improve (Kamau, Wilson & Thinguri, 2014). The term ASEI seeks the move from teacher-centred to student-centred methods, while PDSI promotes the culture of continuous improvement (Mwelese & Atwoto, 2014, p.147). The ASEI idea was established by personnel from the Strengthening of Mathematics and Science in Secondary Education (SMASSE) after conducting a baseline survey in 1998 in Kenya-Nairobi, aimed at moving from less effective classroom practices to more effective classroom practices (Irungu & Mercy, 2013).

The ASEI-PDSI pedagogic paradigm is simply a move from pre-ASEI ineffective practices, to ASEI condition effective practices based on four main principles (Irungu & Mercy, 2013).

The first principle seeks to shift from a knowledge/content-based approach to activity-based teaching and learning. From this particular principle, teachers are expected to prepare meaningful learning activities that will arouse students' interests and develop their skills, knowledge and ability to understand concepts (Wambui, 2006). Activity-based learning makes learners interested in what they do and also makes science lessons enjoyable and lively (Yilmaz, 2008).

The second principle seeks to discourage the use of the teacher centred methods and embraces the use of the student centred methods (Ogwel, Odhiambo, & Kibe., 2008). This is because the student centred methods focus more on the learner than the teacher (Mwelese & Atwoto, 2014), thus allowing learners the opportunity to take charge of their own learning (Ogwel, et al., 2008). In this regard, lesson plans prepared by teachers take into account students' individual differences in classes so that both higher and lower achieving learners are given the appropriate support required to obtain knowledge (Mwelese & Atwoto, 2014). Thus ASEI-PDSI shares similar features with the differentiated learning discussed earlier in section 2.5.1.

The third principle aims to move from theoretical talk chalk/talk and talk/talk methods to an experiment/practical-based approach, which offers learners the opportunity to discover key facts, concepts and knowledge on their own (Wambui, 2006). The use of teacher centred methods in a science class in the form of the teacher talking to learners and writing on the chalkboard for them to copy, may not be a good way of communicating knowledge. It is believed that students learn better when they are engaged and involved in class lessons (Yilmaz, 2008).

Finally, the fourth principle aims to move from typical or ‘recipe type’ experiments and teacher demonstrations, to improvisation and small scale experiments (Ogwel et al., 2008). The term ‘improvisation’ is: “the process of consciously searching the students’ immediate environment for materials and their appropriate arrangements in order to generate familiar events for the students’ sensory, perceptual experience antecedent to, or concomitantly with, and for purposes of, instruction” (Oduor, Orado and Gathambiri, 2008, p.51). Put simply, improvisation is the use of locally available materials from the environment as substitutes for conventional materials in order to engage the learners in practical activities. A plastic bottle may be used to make a beaker and funnel by cutting the lower and the top part of the bottle respectively. In the absence of a filter paper, a piece of light cloth may be used to conduct experiment on filtration as separating technique method. In the absence of electricity or gas as a source of heat, a charcoal pot could be used as a source of heat in place of a Bunsen burner normally used in a conventional science laboratory setting.

Improvisation is therefore a vital component of ASEI, and Oduor et al. (2008), pointed out three purposes that improvisation offers. Firstly, it serves as an alternative or a supplement to conventional apparatus. Therefore, the locally improvised apparatus may be used to actively engage students in practical work to foster their level of understanding since lessons abstract in nature could be difficult for students to follow. Secondly, it minimises the cost of educational expenses since the materials improvised are locally available and cheap (Oduor et al., 2008). Scientific apparatus is not easy to come by due to being expensive. For this reason teachers are encouraged to use the available resources efficiently by employing the use of a small quantity of expensive reagents and chemicals instead of using them in large quantities where the same results could be obtained (Wambui, 2006). This, according to Ogwel et al. (2008), will enable the resources to last longer and make them available for use by more learners, especially in large class sizes. Thirdly, improvisation makes the teaching and learning process more meaningful and interesting to the learners (Oduor et al., 2008).

To conclude, according to Mwelese and Atwoto (2014), the concept of ASEI-PDSI enhances the SCL atmosphere, which encourages the full participation of learners in the process of learning. Such an encouraging atmosphere enables the learners to retain what is learnt and the skills and the concepts acquired are better compared to those acquired in a teacher centred atmosphere (Mwelese & Atwoto, 2014). However, the practice of ASEI could be problematic especially when the teachers are not fully equipped and knowledgeable in the use of the approach. It requires a lot of effort for teachers to prepare and deliver an ASEI lesson.

The next section discusses the benefits of SCL.

2.6 Benefits of Student Centred Learning

This section focuses on the benefits of SCL when put into good practice. Brooks and Brooks (as cited in Zain et al., 2012, p.324) argued that the best way to enhance learning is by allowing students to construct their own knowledge, which can be done by relating what is learnt to the immediate environment, through class participation, discussions and talking to each other. Here, the content is not there to be memorised; students' pre-requisite skills and knowledge are used to build upon from the known to the unknown and they are challenged to think critically and to reason, and it is therefore a constructivist learning model. Melese, Tadesse, and Asefa. (2010), in findings of a study conducted in some upper primary schools in Ethiopia, wrote that there are a lot of advantages for teaching and learning when it comes to SCL. It helps the teacher to be able to draw objectives that are at the exact level of difficulty that meets the students' needs. This helps students to improve on their thinking and problem solving skills. This is interesting because these researchers feel that the thinking and problem solving must be at the level of the student.

SCL is not about the teachers' performance in class, but rather about promoting the effectiveness of learning (Di Napoli, 2004 as cited in Zain et al., 2012, p.325). SCL promotes and enables students to succeed through various learning styles – visual, auditory and kinaesthetic. In SCL lessons, visual and auditory students learn through presentations and discussions. A clear picture of the concept being explained can be visualised. Games and short quizzes and hands-on activities such as simple experiments are helpful to students with a kinaesthetic learning style. SCL is said to be group-based and can help students to answer problems or tasks jointly thus allowing them to be responsible for their solutions (Zain et al., 2012, p.325).

The benefits of SCL as outlined by Zain et al. (2012), seem to include the use of multiple methods in SCL classrooms to meet the learning styles that students might require since they learn differently. SCL learning could also be of great importance where students' pre-requisite skills and knowledge are taken into consideration in order to build on what they know to what is unknown; i.e. in constructing new knowledge. SCL seems to be of great benefit to students if what is learnt is related to the students' daily life through participation and discussions.

More benefits of SCL pointed out by Mills (1991) and Sogomo (2001) as cited in Metto and Makewa (2014, p.24) are that the student centred approach aims to discourage teachers from being authoritative, but rather encourages them to involve the learners in the decision making process in the classroom. It is a teaching approach that enhances the effective learning and achievement of students through hands, eyes, ears and minds on activities. SCL enables teachers to use different kinds of methods thereby increasing students' interest, motivation and involvement; supporting learners to think critically and to take up the responsibility of their learning and retention of what they have learnt (Kim, 2005; Li, 2012 as cited in Metto and Makewa, 2014, p.24).

Ashmore & Robinson, (2015) point out good things about SCL as it encourages teacher–student, student–student and student–material interactions. Students are allowed to participate fully in the lesson by asking and answering questions. This increases their collaboration and communication skills through working in groups, increasing motivation and interest in what they do. The teacher in this type of approach takes the role of a facilitator taking into account student needs and abilities (Ashmore & Robinson, 2015). The learners' pre-requisite skills and knowledge are taken into consideration thereby building from what is known to the unknown (Ashmore & Robinson, 2015). Since some science topics are linked or connected to each other, knowing these connections as a teacher may help in identifying the prior knowledge or skills required for a particular topic that could help learners link their experiences easily.

Both Ashmore & Robinson (2015) and Metto and Makewa (2014) suggest that SCL could increase students' interest, motivation and involvement through the use of multiple methods. This is because students learn differently and in various learning styles. Some students are better at conceptualising diagrams, and others understand better when they are engaged in group discussions and presentations, while some students learn better by doing mainly hands on activities such as practical work. The students' pre-requisite skills and knowledge are taken into account which also resonates with Zain et al. (2012), thereby enabling students to construct new knowledge. This means that SCL does not encourage content memorisation but rather it enables students to construct new knowledge from their own experiences and this concurs with the constructivism theory of learning. The next section delves into the criticism of SCL.

2.7 Criticism of Student Centred Learning

SCL is criticised even though it is regarded as a positive approach by many scholars. These criticisms are related to teachers' negative perceptions of SCL as initially discussed in section 2.3.2. These include lack of resources, large class sizes, examination orientated syllabus, time constraints and inadequate training for teachers, as challenges in implementing SCL lessons.

2.7.1 Lack of resources

Guthrie (as cited in O'Sullivan, 2004, p.600), argued that the student centred approach is inappropriate in most African schools due to the lack of teaching and learning resources. Guthrie's view is contested by ASEI-PDSI approach which encourages teachers to improvise basic science materials where necessary in order to make teaching and learning very interesting and meaningful to the students. These improvised materials are used by students in conducting their practical lessons which arouses their interest in the lessons and increases autonomous learning.

Guthrie is an Australian aid worker and academic who worked in universities, aid management and consultancy in Asia, Africa and the South Pacific, including as Australian Aid Counsellor in Beijing 1988-90. He argued that the teacher centred method (TCM) is more suitable for developing countries due to the inadequate teaching and learning resources. However, Africa is a huge continent and classroom environments and educational practices cannot be so broadly generalised, hence ASEI-PDSI seems to challenge Guthrie's argument.

It can be argued that SCL approach is hardly practised in the absence of adequate teaching learning resources. To practice SCL, teachers have to be creative and innovative to make their lessons interesting to students. This may require the teacher to improvise basic scientific materials in order to engage the students into practical activity. Such locally improvised basic science materials may be used as substitutes for the conventional materials as a remedy to the inadequate resourcing that Guthrie argued about, since SCL requires a lot more resources, particularly in science teaching, than other methods such as the traditional teacher centred method (Lea, Stephenson, & Troy., 2003). Therefore, a lack of resourcefulness and imagination in these teachers could limit the use of SCL in the classroom.

2.7.2 Large class size

O'Sullivan (2004) argued large class size was inappropriate for SCL. A large class may present difficulties when working in small groups. This according to O'Sullivan would require the provision of more teaching and learning materials and classroom management and control skills by the teacher. Song (2015, p.42) points out that large class size makes it difficult for teachers to monitor and control students' behaviour when working in groups.

2.7.3 Inadequate time

Another problematic factor in using SCL approach is the time taken to plan and prepare student centred lessons and delivering these lessons to learners/students. As alluded to by Simon (as cited in O'Neill & McMahon, 2005, p.33): "If each child is unique, and each requires a specific pedagogical approach appropriate to him or her and not to the others, the construction of an all-embracing pedagogy or general principles of teaching becomes an impossibility". This may be time-consuming if every individual child needs to be attended to. Wang (2011) points out the time constraints in Chinese schools as teachers are held responsible for covering the entire content of a textbook within a semester in each of the subjects they teach. For this reason teachers prefer to use teacher centred method than SCL approaches for easy completion of content in the textbook they are assigned to cover and also to maintain effective control over the students.

2.7.4 Cultural differences

Another key factor to consider with SCL approaches is the difference in cultural norms, which may have an effect on teaching practices. According to Schweisfurth (2011), in some cultures students are expected to be respectful and obedient to their elders and not to question their authority. This kind of attitude may not accommodate SCL approaches in which learners are encouraged to ask questions and participate fully in class. Research indicates that in India the classrooms are completely dominated by the traditional teacher centred method, which is mainly ‘talk and chalk’ (Government of India, 2010 as cited in Brinkmann, 2015, p.343). This was as a result of the quality of training and cultural beliefs that hinder a shift towards the learner centred approach. In China, the teacher is regarded as the source of knowledge to the students and no one argues with the teacher (Doyle, 2005 as cited in Clarke, 2010, p.16). As Hessler (as cited in Clarke, 2010, p.16) pointed out, “In China, a teacher is absolutely respected without being questioned by the students”. According to Burnard (2006 as cited in Clarke, 2010, p. 16), in many Asian countries including China it is unusual to criticise a text or to question a teacher. This form of teaching is part of the Chinese tradition referred to as Confucianism, thus teachers’ instructions are by use of knowledge transmission rather than facilitating the learning process (Clarke, 2010). This type of tradition does not conform with SCL approach principles, which encourage student involvement, participation, critical thinking and questioning, and therefore the use of SCL is limited in Chinese classrooms. For SCL to be observed in these classrooms, there is the need for a cultural shift that encourages students to talk freely in class by asking and answering questions during lessons. Without this it will be impossible for student centred practices to prevail in such traditions.

2.7.5 Use of multiple methods

Darling-Hammond (as cited in Sikoyo, 2010, p.248) referred to SCL as ‘progressive pedagogy’, which requires a more complex form of practice by the teacher, unlike the traditional teacher centred methods, which does not require any teacher facilitation. Metto and Makewa (2014) argue that teachers’ lack of experience in using student centred approaches, guiding and asking of relevant questions by teachers, and examination focus all make SCL a challenging pedagogy for teachers.

According to Darsih (2018), learner-centred teachers do not employ a single teaching method but a variety of methods, and this approach transfers the role of the teachers from givers of information to facilitators in student learning. This apparent transfer of roles makes some teachers become complacent, such that their roles as facilitators take a back seat; as Darsih (2018, p.34) puts it, it becomes a "learning method without teacher". One problem therefore is that SCL is vulnerable to misinterpretation by teachers. According to Thanh's (2010) study in Vietnam, which examined the factors affecting the application of student-centred approach at Vietnamese higher institutions, SCL requires no new principles, but rather needs a change in school infrastructure and teachers' perceptions. This means that for teachers to practise SCL there should be a change in the classroom setting and type of furniture used so that students can easily sit in groups. This will minimise the rigid ways in which students sit in classrooms, usually horizontally facing the board with the teacher standing directly in front of the classrooms next to the board. Furthermore, SCL starts with teachers, and teachers are central in providing an effective learner-centred teaching environment. This means that teachers' understanding, appreciation and application of SCL is necessary for it to work. In SCL approaches teachers are expected to provide highly engaging core content that caters for students' needs. Further to this, they provide feedback to help students improve. On a final note, teachers provide multiple teaching techniques tailor-made for students' learning goals which can be difficult and challenging especially in large class sizes.

2.7.6 Inadequate training to use SCL

This section argues that SCL requires adequate training by teachers for it to be successfully implemented. Schweisfurth (2013) identifies inadequate training for teachers on student centred techniques as a challenge. Teachers need to have a good understanding of the principles and practice of the pedagogy for it to work. As O'Neill and McMahon (2005) point out, teachers who are used to teacher-centred methods and who are inadequately trained in SCL approaches may be reluctant to change.

Horn (2009) provided an interesting critique of SCL, which focuses on learning implications and the oppositions to practical implication of SCL. Horn examined SCL in order to ascertain why it was proving difficult to improve academic achievement in South African Schools. Horn's study recognised that SCL approaches in these schools were failing to improve academic achievement, despite arguments that SCL is beneficial for learning. Horn cited that attempts were made to implement SCL approaches in American Schools around the 20th century which also failed. Such persistent failure was attributed to the fact that SCL principles were wrongly implemented and that the fundamental philosophy of SCL did not correspond to reality (Horn, 2009). He argued that "a theory with wrong premises can never be successfully implemented" (Horn, 2009, p.512). Self-discovery is an integral aspect of SCL and in order for this to happen it must do so in the right manner to be effective (Horn, 2009). There is the possibility that what the teacher intends as a positive outcome of learning may not be what will happen with the students because they may do the wrong things. However, from the constructivist learning models which is the underpinning epistemology of SCL, there is no wrong and right answer coming from the students as the teacher is there to rectify students' misconceptions and errors during the lesson. It is through this way of learning that students are able to construct their own knowledge with the support from the teacher. Therefore, teachers' adequate knowledge on the theory underpinning SCL and principles of SCL are vital for SCL practices.

The next section focuses on students' views of their science lessons.

2.8 Students' views of their science lessons

This part of the literature discusses students' views about their science lessons. This is important to the study because the students are regarded as key when it comes to teachers' classroom practices. Since one of the key features of SCL is that it is centred on the student, it is of great significance that students are given the chance to talk about their daily science lessons. This gives me the opportunity, as a researcher, to learn more about students' perspectives on what prevails in science classrooms. This section therefore justifies the reasons for listening to students' voices, which has not been widely researched. It discusses research on students' views of their science lessons, which touches on key areas such as conducting practical work in lessons and the absence of this in lessons due to inadequate materials. It also discusses what students felt about science as a subject.

The inclusion of the student voice into the science classroom is significant for the learning and teaching of science (Laux, 2018). For this reason, Toplis (2012) pointed out that students' voices could be used to examine general aspects of teaching and learning. Allowing students to speak about their lessons could be used as a method of obtaining feedback or an opportunity for students to showcase their views about teaching and learning (Gomez- Arizaga, Bahar, Maker, Zimmerman, Pease., 2016). In this way I was able to draw on the primary data gathered with a view to concluding whether teachers' practices were student centred or not. The next section focuses on students' perception of their science lessons.

2.8.1 Students' perceptions of their science lessons

Students' perceptions of their science lessons is categorised in this section based on commonly perceived events that take place in their science lessons. The literature showed that students' participation in practical work is an important feature in keeping them engaged and motivated in their science lessons. Students whose lessons lacked practical work perceived science as difficult and abstract in nature.

2.8.1.1 Practical work

According to Toplis (2012) practical science has been part of traditional science lessons and usually conducted in school laboratories. It involves the use of equipment, making observations and inferences about real objects and how they behave. Toplis assumed that it is a norm to conduct practical lessons in science which is vital to student learning. The interpretive study conducted by Toplis (2012) examined the students' views about the role that practical work plays in their school science lessons. A sample of 29 students aged between thirteen and sixteen years were selected from three secondary schools in England and data obtained was through lesson observations and interviews. The findings indicated the significance of practical work in their school science lessons, notably: "for interest and activity, including social and personal features such as participatory and autonomy"; "as an alternative to other forms of science teaching involving pedagogy of transmission" and a "way of learning including, memorising and recall" (p.531). The transmission type of pedagogy, according to Toplis (2012, p.537), involved learning and recalling science content, listening and writing notes. Practical work provides a sense of ownership for students and student participation in groups. There exists a relationship of trust between the teacher and student when students conduct practical work on their own (Toplis, 2012, p.541). Students mentioned that practical work enabled them to better retain what they have learnt in science compared to other learning approaches (Toplis, 2012). Practical work, as Toplis (2012) invokes, seems to offer students the chance to be engaged which influences their learning.

The study conducted by Abrahams and Millar (2008) examined the effectiveness of practical work as a teaching and learning method in school science. The study involved students between eleven and sixteen years old from eight secondary schools in England. Observation data was collected from 25 typical science lessons involving practical work in secondary schools in England, and tape recorded interviews with teachers and students. The findings suggested that practical work was effective in getting students to do what was intended with physical objects. Thus students were able to interact with physical materials to accomplish their goals instead of reflecting on specific data and the use of scientific ideas.

From the study conducted by Wellington (2005 as cited in Lyons, 2006, p.534), it was reported by students that practical work was fun, interesting and enabled them to work together instead of listening to the teacher, reading or writing notes. A similar finding was also made in the study conducted by Braund and Driver, (2005) which explored pupils' perceptions and experiences of science practical work before and after they move to secondary school. Practical work was noted by students as enjoyable, motivating and making the learning of science fun.

In their study that investigated the decline of children's interest in school science at secondary level, Murphy and Beggs (2003, p.113) indicated experiments as the part of science teaching that students like best. Their study involved 44 schools in Northern Ireland which selected 32 children aged between eight and eleven for interviews regarding their views about their science lessons, out of 1000 children targeted through questionnaires. Students regard experiments as fun and they enjoy learning things that they found on their own. Practical science, according to students in the study, helps them to remember new things and enables them to understand more detail compared to copying notes. This was similar to the findings made by Osborne and Collins (2000), which indicated students' interest in practical work as it helps them retain what they have learnt, develops autonomous learning and pupils describe it as fun.

The comments obtained from students in the studies reviewed indicated the crucial role that practical work plays in their science classrooms. Practical work is considered to be an aspect of SCL. This is because the activities involving practical work are mainly hands-on activities in which the teacher facilitates. In this way students are able to discover and learn basic facts and concepts without being told by the teacher. The students learn by doing and this increases students' interest and autonomy in learning. This concurs with constructivism as the underlying principle of SCL. The conduct of experiment or practical work is key in the teaching and learning science and an absence of practical work can lead to student lack of interest in science. The next section discusses the lack of practical work and how students felt about its absence in their science lessons.

2.8.1.2 Lack of Practical work

The lack of practical work in science lessons can be traced back to the inadequate science materials in schools. This is a potential obstacle to SCL in classrooms and corresponds with critiques of SCL approaches discussed earlier in the chapter. Thus students and teachers shared a common view to this effect. Toplis (2012, p.532) pointed out that the lack of basic science apparatus, inadequate models and limited laboratory experience hinders conducting experiments during science lessons. Barmby, Kind and Jones, (2008, p.1088) conducted a qualitative study to examine the variation of attitudes towards science in England Secondary Schools. There were two groups of students; students not exposed to practical work and students exposed to practical work. The findings revealed the students not introduced to practical work during lessons indicated that the lack of practical work /experiment makes their lessons boring. Additionally, the lack of practical work led students to perceive science as irrelevant to their everyday life. On the other hand, Barmby et al.'s (2008) findings indicated that students introduced to practical work perceived science as interesting and were able to link what is learnt to their everyday life. In contrast Osborne and Collins (2000), revealed that repetition, copying and the use of teacher centred methods were reported by students as the least enjoyable activities of science lessons. Thus teachers who engage and involve students in activities were more valued by students than teachers who did not use activity-based teaching. The next section discusses students' perceptions of science.

2.8.1.3 Students' perceptions of science as a subject

This section examines students' perception of science as a subject. The discussion below reveals both students' positive and negative perceptions of science as a subject.

Osborne, Simon,& Collins (2003) offered a review of the literature about student attitudes to science and its implications. The review pointed out students' perceptions of science as a difficult subject and this in turn can inform their decision not to specialise in science. One reason for this negative perception is mathematical calculations involved in science subjects such as in Physics for example. Physics according to Williams et al. (2003,as cited in Owen, Dickson, Stanisstreet, Boyes., 2008, p. 114) as indicated in their study was not only difficult but rather boring and irrelevant.

Bennett and Hogarth (2009) also conducted a study that focused on high school students' attitudes to science and school science. Their results concurred with those in Osborne et al.'s (2003) review that students found science difficult and so reviewed it negatively. Bennett and Hogarth (2009) also reported a decline of interest in science at secondary school in England and Wales. In contrast, Jenkins and Nelson (2005) conducted a study that examined students' views on their experiences of science at school in England, and their findings indicated the relevance, significance and interest that students attribute to science. The students see their science lessons as useful for their daily life and in how to take care of their health. Students in England perceived science as easy, useful and beneficial (Jenkins and Nelson, 2005. p 55), which differs from the review made by Osborne et al. (2003) and Bennett and Hogarth's (2009) study findings. Owen et al. (2008) conducted a study to investigate students' perceptions of the different learning activities used in their physics lessons. The findings indicated the joy students find in group work, discussion and experiments. These activities were viewed by students as supportive of their learning in science.

In their qualitative study, Bolshakova, Johnson and Czerniak (2011) explored the teaching techniques employed by three middle school science teachers in the United States. The findings reported the use of single method and multiple methods of teaching. The traditional, teacher centred method, which is single method, was mainly talking and writing. Students from such teacher centred classrooms described their science lessons as taking notes and lacking in fun or experiments, since the teacher told them what to do and expected them to memorise the information given (Bolshakova et al., 2011). In this type of environment, students claimed to learn science best by copying notes. In contrast, students from the classes whose teacher used multiple methods of science instruction such as experiment, discussion, student presentation, group work, and reading described their science lesson as fun and enjoyed the class more than all other lessons. Students claimed to learn science best by doing experiments, reading, and doing work individually or in groups (Ibid).

Logan and Skamp (2013) examined students' interest in connection with their teachers' classroom practice. In their research students said that teachers with a sense of humour are more likely to make them interested in science. Also, students view teachers as good because they have taken their time to explain things. Darby's (2005, p. 430) study of science students' perceptions of engaging pedagogy showed that explanation by the teacher, class discussion and clarification were the contexts in which students make contributions towards knowledge construction. Explanation is regarded as vital by students in order that the teacher make certain scientific concepts clear to the students. It is sometimes necessary to scaffold prior to SCL-style activities to ensure SCL is knowledge-focussed. However, such explanation should be accompanied by teaching aids to avoid the lesson being abstract and difficult for students to follow. Students indicated that they are able to interact with their peers and are able to share their ideas or knowledge during class discussions (Darby, 2005, p. 432). Students are able to listen to each other, develop their ideas and give their responses. Students appreciate teachers giving clarifications on topics that are covered. Such review helps students at the beginning or end of every lesson, in understanding concepts and assignments given to them (Darby, 2005, p. 432). The students indicated that if teachers are passionate about science and teaching science then the students become interested and enthusiastic. Students like teachers who are friendly and not threatening. This is about developing a rapport between teacher and student, so that the student feels confident to engage in class discussions. The students indicated they appreciate teacher support in the form of encouragement, listening and attending to their learning needs. A supportive learning environment is key to conducive learning (Fraser, 1994 as cited in Darby, 2005). According to Harahan (as cited in Darby, 2005, p.440) “learning in science may be facilitated by paying attention to student needs to be treated with dignity and be heard and answered in their difficulties”.

It can be concluded from the literature that students’ views of their science lessons is both positive and negative. Their positive view corresponds with SCL definitions and teachers’ positive perceptions of their classroom practices. These include group work, discussions and conduct of experiment/practical work, which support students in the learning of science. It is through group work that the discussions and the sharing and exchanging of ideas takes place, thus learning from each other. The perception students have of practical work is similar to that of their teachers, that they retain what is learnt through experiment more effectively than what they are being told. This is because they interact with physical objects and do the activities with minimal support from the teacher and this promotes independent learning and builds their confidence. Students seems to like science because they know the significance of science and are able to relate it to their daily life. Students' negative perceptions corresponded to those of teachers, from the literature. Students regard science as difficult and abstract in nature when science lessons lack practical work. Students therefore engage in practical work more than copying notes and listening to the teacher in class, and they enjoy and see experiment as fun as well as improving their learning. Science is viewed as difficult because of the calculations involved. Practical work may help students who are weak in mathematics to develop an increased interest in science.

2.9 Chapter Summary

This chapter concludes that SCL does not have a unique definition as it is interpreted and understood differently by many scholars. However, examination of the definitions and interpretations of SCL revealed key common denominators such as the student, the teacher and the learning objectives and aims. In the definition of SCL there is a common understanding that the students are the main focus and at the centre of learning while the role of the teacher is that of a facilitator, guide or coach, and the learning objectives and aims are geared towards active students' involvement and participation and engagement through small group discussions and experiments. This is attained through relevant and meaningful learning objective set by the teacher. These elements of SCL are considered relevant and suitable in the context of the Gambia, and do not create a situation where learners are left on their own to choose whatever they wish to do and learn in class. This is because in The Gambia teachers are required to follow a specific science syllabus outlined by the Ministry of Basic and Secondary Education (MoBSE) and the West African Examinations Council (WAEC) syllabus. However, this does not mean the application of SCL has to be restricted since teachers can still choose topics and make lessons that are student centred. Equally, the level of the education system on which the study focuses is at junior secondary level and therefore students need support and guidance from the teacher during the process of learning to equip them with the necessary skills and knowledge required at the end of their basic education. Therefore, student centred practices could be employed to reach this goal.

The discussion on teachers' perceptions of SCL is mixed. Teachers' positive perceptions about SCL are linked to the benefits of SCL such as encouraging students' involvement and participation in class, and the opportunity for students to retain what they have learnt through practical work. From this chapter, however, SCL still remains a dilemma for its adoption and implementation in the classroom due to numerous factors that the teachers are confronted with, such as resource constraint, large classroom sizes, and the broad syllabus that needs coverage before the final examinations, lack of time to use SCL as the employment of multiple methods takes longer, and the inadequate training on SCL practices.

As a result of all these problems some teachers prefer the use of traditional, teacher centred approaches, which are didactic, and that they perceive to be a faster teaching method for completing the syllabus. It also requires minimal time with little or no teaching and learning resources as it is talk and chalk method where students are passive listeners and talk less in class.

The chapter covers the climate for student centred classrooms, which explains the importance of group work, practical work and the role of the teacher in the classroom. Literature demonstrates that group work, practical work and the role of the teacher as a facilitator are seen as integral to SCL practices. The chapter also gives a full description of SCL classrooms, which are said to be more engaging, participatory, involving in nature, student focused and resourceful.

The chapter highlights the four learning approaches that are considered as SCL, including differentiated instruction, cooperative learning, problem based learning, and Activity Student Experiment Improvisation – Plan Do See and Improve (ASEI-PDSI) approach. These are discussed to help identify the types of learning approaches that science teachers put into practice.

The chapter also discusses the benefits of SCL which uses multiple methods to allow for the varied abilities in the classroom. The use of the approach also takes into consideration students' pre-requisite knowledge and skills before they are exposed to a new lesson. The use of practical work/experiment allows student-materials interaction and learning by doing supports more effective retention of learning than what they are being told by the teacher. SCL encourages classroom participation and involvement. These are carried out through small group work and discussions.

There were some detailed criticisms of SCL which focus on practical barriers. SCL lessons call for adequate material resources, a limited number of students in a classroom, adequate time, the technical know-how, and the skills and knowledge to use SCL techniques. These resources involve conventional science apparatus and reagents as well as classroom or lab sizes and appropriate furniture that could be easily used to sit students into groups. Large class size would require more materials and more time for proper planning and presentation of group work at the end of each activity.

In this chapter students' voices about their science lessons were reviewed in order to develop a better understanding of their reactions to their teachers' classroom practices. Students who viewed their science lessons as enjoyable, interesting, motivating, and fun were those from science classes whose teachers conducted practical work, which is key to student engagement in the classroom. Students reported that conducting experiments enables them to more easily retain what they have learned compared to other forms of learning that involve recall of science content, listening and writing notes. A student centred description given by students in some of the studies conducted cited use of multiple methods, experiment, group work, discussions, presentations, fun and enjoyment in the classrooms. This is in comparison to the description of teacher centred lessons which were mainly reading, doing work individually, teacher talking and telling the students and writing for the students to take notes, lack of experiments and lack of fun. The lack of practical work as discussed in this chapter makes science boring to students. This was as a result of inadequate materials in schools, as alluded to both by students and teachers and resulted in a lack of interest by most students in science, hence students' belief that science is a difficult subject as it is abstract in nature and mathematical. The chapter concludes that SCL is perceived to be a good pedagogy but resource-heavy. SCL is a pedagogy of the privileged and this is outlined from the barriers that the teachers and the critics of SCL scholars pointed out throughout the review. It is important to note that most of the literature on SCL talks positively about SCL approaches despite the difficulties in its implementation. It is therefore of interest to my study to critically examine science teachers' perceptions of SCL to gain an in-depth understanding of this pedagogy in the context of the Gambia. The next chapter focuses on the theoretical framework used in my study.

Chapter 3: Theoretical Framework

3.1 Introduction

This chapter explains how I constructed the theoretical framework that underpins the research enquiry and interpretation of data. The model employed in the study is a synthesis of Magnusson, Krajick and Borkos (1999) and Friedrichsen, Van Driels and Abellet (2011). This theoretical framework is used as the lens for the data analysis. The chapter begins with an explanation and evaluation of Magnusson et al.'s (1999) model of Pedagogical Content Knowledge (PCK). It then justifies the use Friedrichsen et al.'s (2011) science teaching orientations (STOs) as a supplement to Magnusson et al.'s model to better understand teachers' orientations and practices in the classrooms.

3.2 Theoretical Framework: Pedagogical Content Knowledge (PCK)

The study focuses on science teachers' perceptions of student centred learning (SCL) and how these perceptions influence their classroom practices, and also seeks to explore how science teachers' own pedagogical orientations influence their classroom practices. The term "perception" here refers to teachers' beliefs about the efficacy of SCL while the term "orientation" refers to how science teaching is conceptualised. In this regard, the study adopts a combination of both Magnusson et al.'s (1999) Pedagogical Content Knowledge (PCK) model which have five components including nine science teaching orientations (STOs) and Friedrichsen et al.'s (2011) science teaching orientations (STOs) as its theoretical framework. This is because both models are effective for my research. Since the study seeks to examine teachers' perception of SCL and how those influence their classroom practices, it is deemed suitable to use the nine science teaching orientations from Magnusson et al.'s (1999) model to analyse the data in response to research questions one and two. The suitability of the nine STOs by Magnusson et al. (1999) sits well with SCL because seven out of the nine orientations are classified as student centred while the remaining two are categorised as teacher centred, thus, it gives a clear distinction between student centred and teacher centred practices. The three dimensions of science teachers' orientation as proposed by Friedrichsen et al. (2011) are used as an additional framework to analyse teachers' orientations and how these impact on their classroom practices, thus providing a lens to analyse in response to research question three. Teachers' orientations involve their views about their lessons and practices. These components are discussed in more detail in section (3.2.1 to 3.4.4).

According to Jing-Jing (2014, p. 412), PCK was initially introduced by Shulman (1986) whose work was later developed by Grossman (1990), Tamir (1988) and Magnusson et al. (1999). Shulman's model of PCK comprised three components which include teachers' knowledge of students' understanding of the topics, knowledge of topics taught regularly in one subject area, and knowledge of forms of representation of those ideas (Jing- Jing, 2014, p. 412). What Shulman's original model failed to include was orientation to teaching a subject. It was Grossman (1990) who developed Shulman's (1986) work to include knowledge of conception of purposes for teaching subject matter, which, according to her, influence three other PCK components, namely: knowledge of students' understanding, knowledge of curricular and knowledge of instructional strategies. In contrast with Shulman (1986) and Grossman (1990), Tamir's (1988) extended work included teacher knowledge of assessment, which was absent from Shulman and Grossman. Magnusson et al.'s

(1999) model of PCK synthesises both Grossman's (1990) and Tamir's (1988) PCK components to construct a model of PCK for teaching science that consist of five key components: "Orientation to teaching science; knowledge of assessment of scientific literacy; knowledge of instructional strategies; knowledge of student understanding of science and knowledge of science curriculum" (Demirdöğen, 2016, p. 497).

According to Jing- Jing (2014, p.415) other PCK models focus on language such as Andrew's (2001), while Mark's (1990) PCK components focus on mathematics. However, Magnusson et al.'s (1999) model of PCK was developed specifically for research into science education, although it has also been applied in research conducted in mathematics teachers' knowledge (Jing- Jing, 2014). Since my research focuses on science teachers' orientations and classroom practices it is deemed suitable to use Magnusson et al.'s (1999) model as the theoretical framework. This is because the knowledge teachers used during the process of their classroom practices are represented by their PCK (Kind, 2009). Hence PCK according to Kind (2009) is a combination of both pedagogy and content knowledge of the teacher.

Pedagogical knowledge refers to the knowledge that the teacher possesses in teaching and learning a topic and content knowledge implies how much the teacher knows about a topic (Kind, 2009). Having the content knowledge is one thing, but to put that knowledge across to students is something different since the teacher also needs appropriate methodology, or understanding of pedagogy and teaching strategies. This is why PCK is referred to as pedagogical professional knowledge for teachers, which refers to the knowledge that differentiates a scientist from a science teacher (NRC, 1996 as cited in Demirdöğen, 2016, p. 497). PCK is conceptualised as "knowledge that distinguishes a teacher from someone with a solely academic understanding about a subject" (Shulman, 1986a, 1986b, 1987 as cited in Kind, 2015, p. 124). Hence the scientist is employed to apply scientific knowledge to circumstances, for example in research or industry, whereas the teacher gives support to students to acquire scientific skills and knowledge. It is pointed out by Abell (2008 as cited in Demirdöğen, 2016, p. 497), that the PCK model by Magnusson et al. (1999), as a theoretical framework, is capable of enabling the researcher to capture teachers' knowledge of teaching. PCK is defined by Shulman as the "transformation of subject matter knowledge to the knowledge with pedagogical dimension which is understandable to the students" (Jing- Jing, 2014, p. 421).

The presumption of PCK in science education is that students come to science classes with ideas about the world, which is central and key to the constructivist learning theories (Shulman, 1986, p. 10 cited in Darby, 2005, p. 429). This indicates the link between PCK as a theoretical framework and constructivism as philosophical theory underpinning this study. This is because students are able to build new knowledge from what they already know through teachers' facilitation.

The next section discusses the PCK components and its relevance to the research.

3.2.1 Components of PCK

Magnusson et al.'s. (1999) model of PCK comprises of five key components: Orientation to teaching science; knowledge of assessment of scientific literacy; knowledge of instructional strategies; knowledge of student understanding of science and knowledge of science curriculum. Friedrichsen et al.'s (2011) STOs comprises three dimensions: belief about goals and purposes of teaching science, belief about nature of science, and belief about science teaching and learning. In this research, these are incorporated into one model of PCK to look into both SCL and teachers' orientations and practices in the classrooms. Both components and dimensions are discussed in the subsequent sections. Below is a new framework I created from the amalgamation of Magnusson et al.'s (1999) model for teaching science and Friedrichsen et al.'s (2011) proposed science teaching orientations (STOs).

Figure 2: Model of the framework

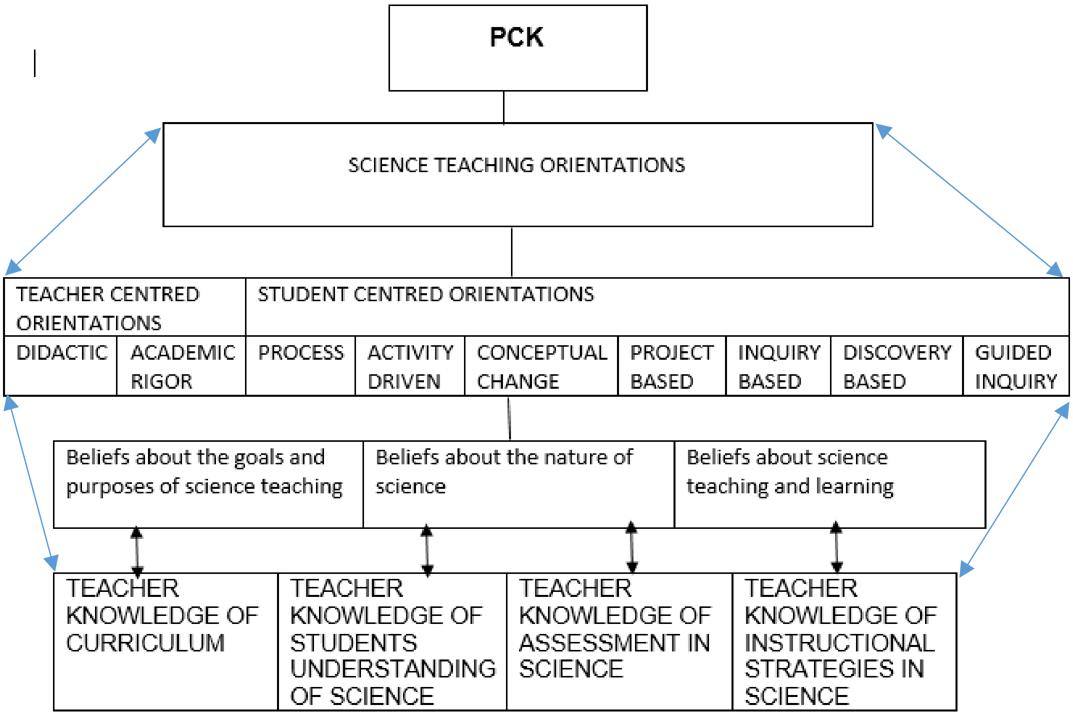


Figure 1 above shows Magnusson et al.'s (1999) PCK model in upper-case letters while science teaching orientations (STOs) suggested by Friedrichsen et al. (2011) are written in lower-case letters.

Magnusson et al.'s (1999) nine STOs are classified into teacher centred and student centred orientation which explores teachers' perceptions of SCL and how those influence their classroom practices. The three dimensions of STOs suggested by

Friedrichsen et al. (2011) complement the remaining four components of Magnusson et al.'s (1999) PCK model, to analyse teachers' orientations and influence in their classroom practices.

3.2.2 Science teaching orientations (STOs)

This section focuses on the definition of the term 'orientation' to science teaching. Science teaching orientations (STOs) are key components that have an impact on teaching. Orientation towards teaching science (STO) is defined as: "knowledge and beliefs about the purposes and goals for teaching science to specific age groups" (Magnusson et al., 1999, p. 97). The term "orientation" is generally a way of conceptualising or viewing the teaching of science (Magnusson et al., 1999, p. 97). Teachers' orientations are defined as "general patterns of thought and behaviour related to science teaching and learning" as a combination of teacher's cognition and action (Anderson and Smith, 1984, p. 99 as cited in Friedrichsen et al., 2011, p. 360). From the definition of the term 'orientation', knowledge and beliefs may be treated as synonymous and different in usage. Beliefs are fixed, personal and resistant to change. In contrast, "knowledge is learned and held according to established procedures". Nespor (as cited in Kind, 2015, p. 124) argues that cognitive and affective aspects of belief work autonomously. Change in beliefs therefore requires a shift in thinking, while knowledge is bounded by and has clear rules for rejecting or accepting information based on the quality of the evidence (Kind, 2015). Orientation, therefore, forms a lens through which teachers personalised their PCK, which influences what and how to teach, and how to assess (Magnusson et al., 1999). Orientation therefore implies an extremely personalised classroom stance impacting on teachers' day to day practices, in which the activities organised and the interaction between teacher–student and student-materials are dictated by the teachers (Magnusson et al., 1999). This framework sits well with my study, since I am interested in what teachers teach and how it is taught by unpicking their beliefs of teaching science at an Upper Basic level.

3.2.3 Using Magnusson et al.'s (1999) model of PCK

In their handbook (as cited by Friedrichsen et al. 2011, p. 360), Anderson and Smith (1987) include "activity-driven teaching, didactic teaching, discovery, teaching and conceptual-change teaching" to describe four different orientations. These orientations proposed by Anderson and Smith (1987) were extended to nine orientations by Magnusson et al.'s (1999) model of PCK, which this study adopts as a lens to examine teachers' perceptions of SCL and the impact it has on their practices. This is because SCL approaches are associated with seven of Magnusson et al.'s nine orientations, since they emphasise the teacher facilitating the learning process, more student involvement and practical based learning activities. Magnusson et al.'s nine orientations from the model above are: didactic, academic rigor, process, activity driven, conceptual change, project- based, inquiry, discovery and guided inquiry. Apart from didactic and academic rigour, a teacher practising SCL approach may be assigned to at least two of the remaining seven orientations. For example, a teacher engaging students in experiment could have both activity-driven and inquiry based orientation, while a teacher telling, showing and explaining could be assigned to didactic orientation only, hence it is teacher centred. For the purpose of the study the teaching orientation is classified into two categories: teacher centred orientations (didactic and academic rigor), which sit well with traditional teacher centred method (TCM), and student centred orientations (process, activity- driven, discovery, conceptual change, project based science, inquiry and guided inquiry), which sit well with student centred method (SCM) (Magnusson et al., 1999).

Therefore, in this study: process, activity-driven, discovery, conceptual change, project- based science, inquiry and guided inquiry are considered student centred orientations. I need these science teaching orientations since SCL approaches involve the use of multiple methods such as the use of activity or practice based lessons. Magnusson et al. (1999) offers a definition of each of the nine orientations based on their goal of teaching science and instructional strategies that the teachers may employ during their practice.

The next section gives a comprehensive discussion on each of the orientations in terms of their goals and characteristic features that will help to determine the type of practice teachers are engaged in their classrooms.

3.2.3.1 Teacher Centred Orientations

The teacher centred orientations (TCOs) involve didactic orientation and academic rigor orientation (Magnusson et al., 1999).

According to Magnusson et al. (1999, p.100), the main goal of the teacher with didactic orientation is to “transmit the facts of science”. Teachers’ practice involves presenting information in the form of talk and chalk or lectures. The teacher holds students accountable for the questions posed to them. The teacher “tells, shows, explains, questions students to verify knowledge; teacher presents content knowledge and focuses on students’ recall” (Magnusson et al., 1999, p.100). Adey (2001 as cited in Kind, 2015, p. 127) described didactic teaching as “I give them information, they write it down, they learn it". The didactic teacher emphasises memorisation of "factual content knowledge" (Anderson and Smith, 1987 as cited in Kind, 2015, p. 127).

The teacher with academic rigor orientation has the goal to "represent a particular body of knowledge" (Magnusson et al., 1999, p.100). This means that for example when science is represented as a body of knowledge and classroom practice form is such that students are challenged with difficult problems and activities without facilitation. (Magnusson et al., 1999, p.100).

TCO is therefore teacher focused based on knowledge transmission without facilitating the learning process. The next section discusses the remaining seven STOs, which are student-orientated.

3.2.3.2 Student Centred Orientations

Student centred orientations (SCOs) involve process, activity–driven orientation, discovery orientation, conceptual change, project based science, inquiry and guided inquiry (Magnusson et al., 1999). These orientations focus on the students and learning is facilitated by the teacher. The characteristic features of these orientations are therefore related to SCL which are explained in detail below.

Process orientation: The teacher's goal is to support students to develop "process skills" (Magnusson et al., 1999). The activities given to students help them to develop their thinking process skills (Magnusson et al., 1999). The process skills refer to the student's ability to predict, measure, communicate, infer and classify. "Science is a process creating new knowledge" (Magnusson et al., 1999, p.101). According to DeBoer (as cited in Friedrichsen et al., 2011, p.363), process orientation does not put emphasis on the students' scientific facts, but involve processes of science, such as classification, prediction, measurement and observation.

Activity–driven orientation: The goal of the teacher is to engage students actively with materials, hands-on experience (Magnusson et al., 1999, p.100). This is also used for discovery or verification of concepts and facts in science. Anderson and Smith (as cited in Friedrichsen et al., 2010, p.363) mention that activity driven practice involves experiments, reading textbooks, demonstrations, use of materials and answering questions.

Discovery orientation: The goal of the teacher, according to Magnusson et al. (1999, p.100) is to provide opportunities for students to discover science concepts on their own. "Students explore the natural world following their own interest and discover patterns of how the world works during their exploration" (Magnusson et al., 1999, p.101). Anderson and Smith (as cited in Kind, 2015, p.128) describe the discovery orientation as an activity-based program in which students are encouraged to develop their knowledge from experimental results without being told by the teacher.

Conceptual change: Magnusson et al. (1999, p.100) defined conceptual change as an orientation with the goal to "facilitate the development of scientific knowledge by confronting students with context to explain that challenge their naïve conceptions". This involves application of scientific concepts to new ideas, challenges to students' responses, correcting students' misconception and misunderstanding (Anderson & and Smith, 1987 as cited in Kind, 2015, p.128). The teacher facilitates and establishes valid knowledge claims through a comprehensive discussion

(Magnusson et al., 1999). This is explicitly through active learning rather than didactic learning.

Project–based science: This is defined by the goal to involve students in investigating solutions to authentic problems, instructional practice of which focused "around deriving questions" (Magnusson et al., 1999, p. 101). This involves the teacher using real-life objects such as plants or animals during the experiment (Magnusson et al., 1999).

Inquiry orientation: The instructional characteristic is investigative and to represent science as inquiry in which students assess knowledge (Magnusson et al., 1999, p. 101).

Guided inquiry orientation: According to Magnusson et al. (1999, p.101) the goal of guided inquiry is to "constitute a community of learners where members share responsibility for understanding the physical world, particularly by aspects with respect to using the tools of science". Guided inquiry encourages students to participate in an investigation which help them to attain independence in learning (Magnusson et al., 1999).

"Instructional strategies with these STOs require teachers to adopt a student centred approach on their practice" (Kind, 2015, p. 148). This is the reason why Magnusson et al.'s (1999) STOs will be useful as a theoretical framework to analyse the research question exploring teachers' perspective of SCL. Critically examining these student-centred orientations it is observed that they have a common similarity such as conducting practical work/ experiment through inquiry, discovery, hands on activity, project base or guided inquiry. This makes it possible for SCL practices to be assigned with more than a single orientation based on the kind of lessons that the teachers may present during the data collection exercise.

The next sections justify the reasons for using Friedrichsen et al.'s (2011) STOs as a supplement to Magnusson et al.'s (1999) model.

3.3 Considering Friedrichsen et al. (2011) suggested STOs as a supplementary framework

This section focuses on the rationale for the use of Friedrichsen et al.'s (2011) STOs as a supplemental framework to Magnusson et al.'s (1999) model of STOs to better conceptualise the teachers' orientations.

Going back to the PCK model above, science teaching orientations (STOs) consist of three dimensions as proposed by Friedrichsen et al. (2011), which are: beliefs about the goals and purposes of science teaching, the nature of science (NOS) and the learning and teaching of science. These dimensions, according to Borko and Puttanam (as cited in Kind, 2015), comprise "knowledge and beliefs and determines teachers' classroom practice". The question, "why do I teach science to students", is answered by teachers' beliefs about the goals or purposes of science. The nature of science (NOS) implies the "epistemology of science or the values and beliefs inherent to the development of scientific knowledge" (Lederman, 1992 as cited in Demirdöğen, 2016, p. 498). In this regard, beliefs about various dimensions of science, such as scientific method and scientific knowledge, would equate to teachers' beliefs about the nature of science or simply a teachers' belief about science (Friedrichsen et al., 2011, p. 372). The third dimension is the teachers' beliefs about science teaching and learning. This according to Friedrichsen et al. (2011) involves the beliefs about the role of the teacher, the role of the learner, how students learn science and how science can be taught to make it interesting, enjoyable and comprehensible.

In order to obtain these answers, interview data from teachers was analysed using Friedrichsen et al.'s (2011) STOs in combination with the remaining four PCK components by Magnusson et al.'s (1999) which are observable.

The next section conceptualises the remaining four components of Magnusson et al.'s (1999) model of PCK which were used for the analysis of research question three.

3.4 The four PCK components

The four remaining components are from Magnusson et al.'s (1999) and a detail explanation of the type of instructional strategies to be used by teachers are outlined in each component.

3.4.1 Knowledge of assessment in science

Teachers' knowledge of assessment comprises teachers' knowledge about what and how to assess. This, according to Magnusson et al. (1999) involves learning assessment methods and teachers' knowledge in relevant areas of science topics covered that are necessary to be evaluated.

3.4.2 Knowledge of instructional strategies

Knowledge of instructional strategy requires teachers to know subject specific and topic specific instructional strategies. Teachers should have a fair knowledge of learners' prior knowledge to address their misconceptions, difficulties and the requirements of learning science. Magnusson et al. (1999) mentioned that knowledge of instructional strategy is not limited to activities, strategies and representation, but equally involves knowledge of purpose of activities and the role they play in supporting students' understanding of the topic. This involves various ways of teaching topics and the advantages and disadvantages of approaches influenced by pedagogical knowledge (Shulman, 1987 as cited in Jing-Jing, 2014, p. 412).

3.4.3 Knowledge of Curriculum

The teachers’ knowledge of curriculum should be robust and they should know the interrelatedness or connectedness of the themes and topics they intend to teach within the same grade or different grades, and specific programs related to the topics they teach. This involves teachers’ knowledge of required objectives and goals of the subject being taught and teachers’ knowledge of the curriculum including learning goals and activities (Magnusson et al., 1999).

3.4.4 Knowledge of student understanding of science

This component is about the teacher identifying students’ areas of difficulties in science especially when teacher is teaching abstract topics, correcting students' misconception of the topic and problem solving nature of the topic. It also entails teachers’ knowledge about the pre-requisite skills and knowledge that the students need to learn a particular topic (Magnusson et al., 1999). Usually students bring to class their understanding and knowledge that the teacher needs to take into account (Nilsson and Vikström, 2015, p, 2840).

3.5 Caution using PCK

Due to the nature of instructional strategies involved it could be difficult to classify experiment or laboratory investigation as a single teacher orientation (Friedrichsen et al., 2011).

Friedrichsen et al. (2011, p. 358) examined the science teaching orientation component of Magnusson et al.'s (1999) PCK model for science teaching along with other published studies, such as Kind (2015) and Cansiz and Cansiz (2016), which centred on science teachers' orientations and beliefs about science. These studies found some methodological issues such as the use of "orientation in different and or unclear ways"; unclear or absent relationship between orientations and other model of components"; "assigning teachers to one of nine categories of orientations and ignoring the overarching orientation component"(Friedrichsen et al.,2011.p,373) Thus for the purpose of clarity Friedrichsen et al. (2011) defined science teaching orientations as a set of beliefs with goals and purposes of science teaching, views of science and beliefs about science teaching and learning. These are the reasons why I have decided to incorporate Friedrichsen et al.'s (2011) science teaching orientations to supplement the remaining four components of Magnusson et al. (1999). Incorporating Friedrichsen et al.'s STOs avoids ignoring the overarching orientations component by only assigning teachers to one of Magnusson et al.'s nine categories of orientation.

3.6 Research conducted using PCK as a framework

This section examines some of the published studies conducted using PCK as a theoretical framework, particularly on science education. The review of these studies helped in shaping the methods used and the choice of participants in order to investigate teachers' orientations. I therefore deem it appropriate to use interviews and lessons observation to critically examine these teachers' PCK. Qualified teachers were selected as participants because they are likely to have richer PCK than unqualified teachers (Demirdöğen, 2016).

Boesdorfer and Lorsbach (2014) conducted a case-study in the United States of America on an experienced High School chemistry teacher. The research aimed to understand the teacher's practice by exploring their orientation towards science teaching. The data collected was through interview, observation and class documents. The findings concluded that the appropriate way to understand teachers' practice is to explore teachers' orientations toward science teaching. The study also outlines the professional development that teachers' orientations towards science teaching can provide.

A study conducted in Sweden by Nilsson and Vikström (2015) examined how six teachers changed or did not change their PCK, which they call professional knowledge of teaching, after inquiring into their own teaching within three learning studies. The study collected its data through interviews and video-recorded lessons from six teachers before and after the research. The findings indicated a change in teachers' ways of handling the content.

Kind (2015) also conducted research in United Kingdom secondary schools outlining science teacher orientation as a potential component of pedagogical content knowledge. The study used content–specific vignettes and a questionnaire for data collection, involving a sample of 237 teachers. The data indicated didactic, academic rigor, conceptual change, activity driven and inquiry orientation as intuitive teacher stances.

Studies conducted using PCK include Demirdöğen (2016), which was a case study and focused on the complexities of pre-service science teachers' science teaching orientations, viewed as an interrelated set of beliefs; interacting with other components of pedagogical content knowledge (PCK). The study involved eight pre-service science teachers and used both open and semi-structured interviews, questionnaires to explore teachers' Nature of Science and was deductively analysed using constant comparative analysis. The purpose of the study was to throw light on how orientation as an interrelated set of beliefs interacts with other PCK components using Friedrichsen et al.'s (2011). The participants used in the study were pre-service teachers. Pre-service teachers, according to Demirdöğen (2016), have relatively underdeveloped PCK while the in-service teachers might develop richer PCK. The findings revealed that "one's purpose for science teaching determines the PCK component(s) with which it interacts"; "a teacher's beliefs about the nature of science do not directly interact with his/ her PCK unless those beliefs relate directly to the purposes of teaching science" and "beliefs about science teaching and learning mostly interact with knowledge of instructional strategies" (Demirdöğen. 2016, p.495).

In conclusion this section highlights various methods used by researchers studying teachers' classroom practices. It is significant to note that the most common methods used in research about teachers' classroom practice is observation and interview. This leads to qualitative research being employed, hence the number of participants in most cases is small. Therefore, it was vital to review the research carried out on teachers' orientations to be able to inform the research methodology and methods that the study undertakes.

3.7 Chapter Summary

The chapter explains and justifies the theoretical framework of the study. The main framework is Magnusson et al.'s (1999) model of PCK in which all five components are considered and used for the data analysis. The first component called the science teaching orientations (STOs) are divided into two main categories, namely teacher centre orientations and student centred orientations. These sit well with SCL practices and are therefore used as part of the model to analyse SCL practices by the science teachers in this study. Thus the model addresses research question one, which looks into students' views of their science lessons; and research question two, which focuses on teachers' perceptions and how those influence their classroom practices. The remaining four components of the model address research question three, which examines teachers' orientation and how they impact on their classroom practice. These components are knowledge of assessment, knowledge of curriculum, knowledge of students' understanding of science and knowledge of instructional strategies by the teacher. The study also puts into account Friedrichsen et al.'s (2011) model of STOs to analyse research question three in order to give a more detailed examination of teachers' practices in the classroom. This is done because Friedrichsen et al.'s (2011) STOs include the goal and purpose of teaching science, the nature of science, and the teaching and learning of science, which are omitted from Magnusson et al.'s (1999) model, and so give a more comprehensive reflection of teachers' orientations.

Both models are combined together in figure 2 and discussed in detail to clarify the concept behind each component. The chapter also discussed research undertaken by other scholars using the model to examine teachers' practice in the classroom.

This helps to determine the type of methods employed in the study and the participants involved.

Chapter 4: Research Methodology and Methods

4.1. Introduction

This chapter explains and justifies the research design. The first section reiterates the aims of the study, articulates the research questions, and explains the methodological approaches and the philosophical stance underpinning the study. This is followed by a detailed discussion of the sampling process used in this study. The next section explains and justifies the methods employed during data collection. This is followed by a detailed discussion of triangulation and an evaluation of the limitations of methods used. The next section in the chapter highlights the pilot study and the revisions to the research design it initiated, for example making amendments to some of the interview questions. This is followed by the conceptualisation of Magnusson et al.'s (1999) model of Pedagogic Content Knowledge (PCK), supplemented by Friedrichsen et al.'s (2011) Science Teaching Orientations (STOs), as the theoretical framework used for the data analysis. This is followed by an explanation of the type of analysis undertaken in this study. The next section discusses the method of data analysis used and gives a detailed explanation of reflexivity and positionality. The final section in this chapter gives a detailed account of ethical concerns and how they were addressed in the research. A brief summary of key points concludes the chapter. A small- scale qualitative research is employed with the use of multiple methods involving lesson observation, interviews with science teachers and focus group with students. The chapter now explains and justifies my research designed in detail.

Aims and Research Questions

The first aim of the research explores into students' views of their science lessons. It was crucial to include students in the study so that they are given the opportunity to talk about their lessons so as to have an in-depth understanding of what prevails in the classroom since conducting one lesson observation for each participating science teacher would not be sufficient to give a definitive picture of their practices in the classroom. For this reason, a focus group was used as a method of having their views heard. The second aim of the research investigates science teachers' perceptions of Student Centred Learning (SCL) and how those have influenced their classroom practices at Upper Basic Level in the Gambia. The third aim examines how teachers' pedagogical orientations influence their classroom practices. The term 'perception' here refers to teachers' feelings, attitudes, and beliefs about the efficacy of SCL approaches, and the term 'orientations' relates to how teachers conceptualise science teaching. In order to explore teachers' perceptions, it was necessary to ask them to verbalise their opinions through interviews. Observations of their classroom practices were needed to understand if and how their perceptions and orientations influence their practice in the classroom.

To meet these aims, the following research questions about science teaching in the Gambia were devised:

1. To what extent do Gambian Upper Basic School students' perceptions of their science classes relate to student centred learning pedagogies?
2. In what ways do science teachers' own perceptions of student centred learning influence their classroom practices?

3. In what ways do science teachers' own pedagogical orientations influence their classroom practices?

The next section discusses the rationale for using an interpretivist paradigm in this study.

4.2 Interpretive paradigm

Henn, Weinstein and Foard (2006) define 'paradigm' as a collection of assumptions about the way phenomena are studied by a researcher. Creswell (2012) and Punch, (2014) say research paradigms are concepts that enhance understanding of how worldly phenomena are observed. This study uses interpretive paradigm because of the area being researched which is educational and is about students' views of their lessons, teachers' perceptions, orientations and their classroom practices. As an interpretive researcher my ontological belief is that the social world is constructed by people. This being the case is deemed appropriate and suitable for the study. The interpretive paradigm holds that truth and meaning are constructed through people's interactions with the world. Creswell (2007) pointed out that as an interpretive researcher 'reality' can be constructed from the interpretation of participants' responses. This study seeks to construct meaning about teachers' perceptions and teaching habits to gain a better understanding of how they interrelate. It does not set out to establish hard facts or verify a particular theory. This means qualitative data is best for interpretive research paradigm (Manson, 2002). This is because my epistemological believe as an interpretivist is that the relationship between me and my participants should be interactive. For this research, detailed perceptions and orientations of teachers and students within six schools were gathered for deep, qualitative scrutiny, rather than a larger sample to attempt the mathematical representativeness of a quantitative approach, as this research is interested in teachers' perceptions. In order to consider orientations and practices, qualitative data about teachers' justifications for their teaching practices was needed, which was gathered via interviews. Lesson observations were also needed to check for correlation between teachers' verbal explanations and their actual teaching habits. As an interpretive researcher this allowed me to accommodate different participants' viewpoints; I understood that the way to obtain responses as an interpretivist is not rigid. Filming the observed lessons meant this data set was as naturalistic and authentic as possible (Burton and Bartlett, 2005). The teacher interviews and student focus groups provided rich qualitative data for nuanced analysis of how teachers perceived their classroom practices, and how students received them (Newby, 2010; Bryman, 2016 & Muijs, 2004). This helped me to explain the categories emerging from the participants through an inductive approach.

The research is more concerned with high validity than with wide generalisation of the findings. Therefore, I decided intentionally to limit the number of participants, so that there would be time to get to know them, their classrooms and settings, which allowed a close rapport to develop with the participants, helping to generate deep, rich data for the research. A small sample is not large enough to represent the whole population, so findings may not be widely generalised (Kumar, 2011). Nevertheless, findings of the research contribute knowledge that is important and relevant to the Ministry of Basic and Secondary Education, (MoBSE), The Gambia; and to colleagues at the Science and Technology Education Directorate (STED), a directorate of the MoBSE who has sole responsibility for the enhancement of teaching and learning of science and mathematics in Gambian schools. The findings also contribute to the existing body of knowledge about science teaching, which holds interest for science teachers and academics inside and outside the Gambia. Furthermore, the examination of SCL at the heart of the research is relevant to education theory and practice more widely.

The next section gives a detailed discussion on qualitative approach undertaken in this study.

4.2.1 Qualitative Approach

As an interpretivist I choose qualitative approach to draw meanings from the participants' views and perceptions. This was done through having direct contact with participants; in the form of lesson observation, interviews and focus groups. In this study, the major concerns pertained more to depth and intensity of the findings, which makes the data more valid. Qualitative approach is used because the data collected is richer and more detailed compared to data obtained from quantitative approach which is more mathematical in nature (Punch, 2009). This is because I am not concerned with establishing any facts and quantity but rather focusing on multiple issues in my inquiry to explore diversity such as views of students on their science lessons, perceptions of teachers on SCL and orientations of teachers. I use qualitative approach because the findings are descriptive and narrative and interpretive in nature (Braun & Clarke, 2006). This means the use of words as data and not numbers. Quantitative research is objective and posits that reality exists independently of the researcher (Gray, 2009) which is contrary to my research. Large numbers of participants are normally involved and for this reason the relationship between the participants and the researcher is distant. Quantitative research also involves verifying theories and hypothesis through experimentation (Kumar, 2011).

In conclusion, a qualitative study is adopted because of the small number of participants involved in the study in order to have a better understanding of students' views of their lessons, their teachers' perceptions, orientations and practices. The use of interpretivist paradigm in this study leads to the use of qualitative approach.

4.2.2 Research strategy

The research strategy used in this study is a small - scale qualitative research which is another approach to interpretivism. This is because the aim of my study is to gain an in-depth understanding of teachers' classroom practices by involving few students, teachers and schools. Denscombe (2014) and Creswell (2007) argue that strategies used are not right or wrong, and neither are they good or bad, but it is the way in which strategies are used that validates their suitability. This study involved a detailed consideration of teachers' classroom practices in two different types of schools (adequately resourced and inadequately resourced schools). Refer to section 4.2.3 on sampling for a detailed account of schools involved in this study. The fact that this study involved more than one sample made it possible to observe different scenarios in the classrooms. It was also important to understand the rationale behind the teachers' practices, and this according to Newby (2010) is better done with small-scale qualitative research case study approach.

The Gambia has six educational regions. The small- scale qualitative research involved six Upper Basic Schools located in two of Gambia's urban regions, namely Greater Banjul and Kombo regions. These two regions and these schools were selected because they are relatively better resourced than schools in regions three, four, five and six, located in the provinces. The number of schools located in regions one and two are greater than the rest of the other regions. This is because of the higher populations within region one and two which result in a larger student population in schools. From my knowledge within schools, most of the experienced teachers would prefer to teach within these two regions because of its urban nature. Therefore, the use of small- scale research was significant because it ensured access to a greater number of science teachers.

The research therefore represents two categories of schools in the Gambia, and the findings obtained give me a better understanding of the science teachers' classroom practices at UBS level.

The next section focuses on the sampling and gives a detailed discussion on how and why the schools, teachers and students were selected.

4.2.3 Sampling

Sampling refers to the selection of cases from a wider pool of potential cases (Matthews and Ross, 2010). It is pointed out by Punch (2009) that selecting a sample size can be problematic as there is no clear-cut solution in getting an accurate or correct sample, because it is contingent on the intention and purposefulness of the study, as well as the population being studied.

The type of sampling chosen in this study was a non-probability and used purposive samples as its method of sampling linked to a qualitative approach. The method of sampling used small sample sizes, the findings of which was not intended to be generalised. Gray (2009) points out that purposive sampling focuses on the exploration and interpretation of the experience and perceptions of individuals, and used small in-depth studies that include qualitative approaches, such as case studies, grounded theory, ethnographical and some cross-sectional studies.

Purposive sampling was therefore deemed an appropriate sampling method in this study since it selected a small group of teachers in order to gain an in-depth understanding of their perceptions of SCL and their orientations in the teaching of science. Using purposive sampling allowed exploration into the research questions since participating schools and teachers in this study were chosen with purpose.

I chose a total of four schools, with adequately equipped chemistry, physics and biology labs. Schools A, C, E and F had fairly well-equipped science labs. Schools B and D each had a science lab with few or no apparatus and reagents. The total number of students in School C was 300 while School A, B, D, E and F each had a total number of over 2000 students. The total number of teachers from each school ranged from 26 teachers to 98 teachers depending of the size of the school. Furniture type and students' performance in science varied from one school to the other.

The rationale behind selecting such criteria in schools was to be able to compare and contrast the teachers' classroom practices across these categories. This, according to Creswell (2007) and Gray (2009), will give the opportunity to provide an in-depth study of the different classroom practices that the teachers are engaged in. It was important to ascertain information about the resourcefulness of the teachers, what teachers were able to do in the absence of basic science materials in comparison to their colleagues in other schools that were adequately resourced; in other words, how well the teachers were able to improvise.

Introductory visits were made to each of the six selected schools. Meetings were held with the school heads and their respective head of science departments to discuss the study and to request and review a range of science teachers' profiles. This was done to identify and determine the sample of teachers needed for participation in the study based on their experiences and length of service in the teaching field. This, according to Flick (2018), is regarded as a bias sample and purposeful. Twelve science teachers (three from School A, two teachers each from School B, C, D and E and one teacher from School F) were selected. I felt that the most experienced and longest serving teachers in the field would be in a better position to give responses that were likely to answer the research questions than unqualified or untrained teachers who have had no exposure to any form of teaching pedagogy. Thus, the sample of teachers selected was based on their qualification and experience, directly linked to the research topic.

Therefore, the research focuses on science and the participating teachers were qualified science teachers with at least two years' teaching experience. This was in order to gather rich information about classroom practices (Matthews & Ross, 2010). All the teachers had obtained a minimum of Higher Teachers' Certificate (HTC) as a professional qualification to teach at UBS level in the Gambian Education system.

A total number of four students was also selected from each of the participating teachers' classrooms to give detailed information about their science lessons. This was to gain an understanding of the cases in their natural setting, recognising their complexity and context while aiming to preserve and understand the wholeness and unity of the case (Punch, 2009). I chose these students because a single lesson observation conducted in each of the twelve classrooms was not convincing enough to give a clear and true picture of the teachers' practices. I consulted the students being taught by these teachers in order to gain their views so that I could obtain a deeper understanding of their teachers' classroom practices.

The students were aged between 12 and 15 years and were a mixture of both boys and girls. A random purposive sampling was used to select students from each participating school. The purpose of random purposeful sampling as pointed out by Marshall and Rossman (1999, p.78) is to increase the credibility of the sample due to the large number of potential students in the classrooms who were available to participate in the study. The student participants were selected by taking the attendance register of the class and calling every n^{th} student based on their willingness to participate. For example, in a class of 80 students, I divided the total number of 80 students by four, since I needed a focus group of only four students from a class. This gave a result of 20. I then used the class attendance register and called every 20^{th} name of the student on the list to participate. The same method of selection was applied to the rest of the classrooms that were involved in each of the schools. A total of four students representing a focus group were chosen from each of the twelve classrooms in all the six schools. This gave a total number of forty-eight students selected for the focus group. All the students agreed to participate except in Schools E and F where two and three students declined respectively when they were selected, but this was overcome by calling the consecutive student on the attendance register to participate.

Numbers/participants summary:

Total number of schools:	6
Total number of teachers:	12
Total number of students:	48
Total number of lesson observations:	12
Total number of interviews with teachers (12):	12

Duration of each lesson observation:	30-70 minutes
Duration of lesson observation, discussion:	10 minutes
Duration of each in-depth interview:	45 minutes
Duration of each focus group:	20 minutes

Duration of entire data collection exercises: 18 working days – 3 days for each school.

The next section explains and justifies the methods used for the data collection and describes how each was conducted.

4.2.4 Methods

This study comprised lesson observations, interviews and focus groups in order to answer the research questions that were raised. Twelve lesson observations were undertaken using non-participant observations. This made it possible to see the way teachers teach and how they engage their students during science lessons. This was used to answer RQ1, RQ2 and RQ3. As an observer, I sat in a corner in each classroom and video-recorded all that was happening, simultaneously jotting notes as the lessons progressed. This was followed by a discussion with the teachers to understand the rationale behind some of the things that had taken place during the lesson. The lesson observations were followed by interviews with the teachers and thereafter a focus group with students. Twelve focus groups of four students each were held to investigate their views of their science lessons (RQ1). For the interviews, one-to-one semi-structured interviews were conducted with twelve teachers to explore their perceptions of SCL (RQ2) and orientations to teaching science (RQ3). The subsequent sections elaborate, in the order in which the data was collected.

4.2.4.1 Observation

Since the study involved teachers' classroom practices, it was prudent to conduct lesson observations in order to have an idea of what prevails in the classrooms so as to find out if what teachers claim they are practising in science classrooms is what actually happens in reality (Muijs, 2004). Such observations, according to Flick (2011), entail observing interactions and actions during a classroom lesson where I was very attentive.

A total of twelve lessons were observed from six Upper Basic Schools (UBS) in the Gambia located within two regions. Each observed lesson lasted for a period of 30 to 70 minutes. This data collection exercise lasted for a duration of 18 working days between April and May 2017. The lesson observation was non-participatory with no disturbance of class proceedings. This unobtrusive approach maintained the natural setting of the classroom and thus enhanced the validity of the findings (Denzin & Lincoln, 2000).

During the lesson observation, the focus was on teachers' roles as a facilitator and resource person; students' interaction with teacher, with students and with materials; students' engagement and participation in class, students' needs and abilities and some of the teaching and learning techniques that aroused their interest during lessons.

I devised an observation check list (see Appendix 1) based on Magnusson et al.'s (1999) model of PCK, to record key classroom activities, such as i) teacher knowledge of instructional strategy, ii) teacher knowledge of curriculum, iii) teacher knowledge of student understanding of science, and iv) teacher knowledge of assessment in science. All these are linked to the elements of SCL. For example, teacher knowledge of instructional strategy involves making variety of activities and asking students questions to promote their participation and collaboration during the lesson.

Teacher knowledge of curriculum involves linking students' prior knowledge to new knowledge, making sure that the topics taught are interconnected and also the activities set are there to achieve the learning objectives.

Teacher knowledge of understanding of science involves addressing students' needs by providing them with adequate materials required during the lessons. Students' misconceptions are also addressed and support given to those students with difficulties during the lesson. The teacher also gives a recap of the previous lesson.

Teacher knowledge of assessment involves asking numerous questions to students that are not only knowledge based or recall. Teacher also gives students enough time to think before they make their responses and equally asks them to restate their answers where necessary.

The video coverage was useful in enabling the teachers to review how they taught their lessons with me, offering them the chance to explain the reasons why they did certain things, thus increasing the validity of the data (Gray, 2014). The viewing of the recording was done during the lesson observation discussions before the semi-structured interviews with teachers. Teachers were shown parts of the films to ascertain and understand the rationale behind the events in the classroom. These responses were included in the lesson observation notes. It is pointed out by Punch (2009) that if participants are given the opportunity to view their video-recorded lessons they would be able to give an account of their activities and also pick up on certain unexpected events which may be important. Such events included for example large group sizes during practical work/ experiment, where few students were seen lying on the table and not participating in the activities and discussions going on in their group. The video recordings did help to obtain a rich data from the lesson observations. These recorded images according to Creswell (2007) are powerful and incomparable with information that is orally given. Videos were later downloaded and stored safely. For ethical reasons adhering to the general data protection regulatory (GDPR) of the University, the films taken will be destroyed once the study is completed.

The lesson observations therefore enabled the exploration of teachers' practices in the classroom, which were triangulated with the interview data and focus group.

The next section focuses on interviews and the way the data were obtained.

4.2.4.2 Interviews

The purpose of the interview "is to understand the meaning of central themes of the subjects' lived world" (Kvale, 2007, p. 11). A similar comment made by Koshy (2005, p. 92) is that the purpose of using an interview is to gather responses, which are richer and more informative than questionnaires. Interviews in this study were used to explore teachers' perceptions, pedagogical orientations and classroom practices. It is pointed out by Punch (2009) that interview is an appropriate way of exploring people's perceptions and real-life situations. Conducting participant interviews, in particular in educational research, has become one of the preferred methods for data collection (Robinson & McCartan, 2016), but it should not be regarded as an everyday conversation and should not be merely subjective or objective. Concurring with Robson (2011) interviews need real skills to adopt and flexibility to find out what is being studied. This study does not aim at quantification, but rather seeks qualitative knowledge as expressed in normal language. The preference of interview has the advantage of being descriptive and participants are encouraged to precisely describe their feelings, experiences and actions (Kvale, 2007).

The use of interview in this study enabled the participants to seek further clarification in order to gain a better understanding of what was being asked before responding to such questions (Creswell, 2007).

A total of twelve (12) teachers selected from six schools took part in the one-to-one interviews which lasted for 45 minutes on average. The interviews with the teachers were conducted in quiet locations to avoid distraction. These venues included science laboratories, participating teachers' offices and under a tree within the school campus.

In order to allow the participants to talk freely and express their views, semi structured interviews were used in this research. This according to Creswell (2012), increases the validity of the study. Semi structured interviews aim to understand themes of the lived daily world from the participants' point of view (Creswell, 1994). Using semi-structured interviews allowed the participants in the study to convey in their own words their perspective of the topic studied (Robson, 2011). Semi structured interviews also made it possible to probe into participants' views and opinions, and where appropriate the participants were given the opportunity to expand on their answers (Kvale & Brinkmann, 2015). This helped to raise new questions that were not initially constructed in order to have detailed information of the issues under investigation (Creswell, 2009).

In addition to these, adequate time was given to participants to respond, so as to obtain in-depth information from the responses gathered, thus strengthening the validity of the collected data (Punch & Oancea, 2014).

An interview schedule was prepared, including a list of questions that were used (see Appendix 2). The same questions were asked in the same order for each participant, so as to compare and contrast the information obtained from the interviews and from one case to the other in different settings, thus increasing the validity of the study (Gray, 2014).

To increase the reliability of data in this study, ambiguity in the wording of the interview questions was avoided (Gregory & Mueller, 2010). All interviews followed the same protocol and this made it possible to avoid my being biased. The protocol was to ask the science teachers the same questions exactly as they were written in the same order and with a neutral tone of voice. At some point during the interview I have to repeat some questions if requested. I make sure that I was not irritated with the responses that were given to me by my participants during the interview. This, according to Punch and Oancea (2014), minimises what Gray (2014) called the 'interviewer effect'. However, it was difficult to ask the same questions using exactly the same tone of voice with each and every participant in the same way (Burns, 2000). Furthermore, the responses obtained from the participants were audio recorded without any alteration.

The teachers responded openly to all questions and appeared to answer questions with honesty. This is because some of the factors that impede their use of SCL in the classrooms were pointed clearly. This include large class size and lack of basic science materials. For instance, some of the teachers explained how they used their imagination to improvise science apparatus lacking in their classrooms and then showed me the improvised materials as confirmation. This contributed to my conclusion that their responses were honest and genuine and that they were not saying what they thought I wanted to hear. The teachers were able to put across what was affecting them without any fear as they all spoke freely, like a colleague without being harassed or intimidated. The interviews at some point reach a saturation point where I observed that most of the responses from the teachers were similar. This showed the reliability of the data obtained (Clough & Nutbrown, 2012).

Moreover, transcribing interviews verbatim was time consuming, as was analysing the data. Interviews were kept to a maximum of one hour to avoid participant fatigue, thus increasing the validity of the data (Robson, 2011).

The interviews with teachers were followed by focus groups with students and the next section focuses on this and how it was conducted.

4.2.4.3 Focus group

Focus groups were used to gather information on students' views on their day-to-day science lessons. Obtaining students' voices to illuminate different perspectives Henn, Weinstein, and Foard (2009) on their science lessons was significant in this study and focus groups were appropriate in this study. They were important because these students had been attending their science lessons throughout the academic year and were in a better position to explain their lessons than anybody. Taking into account the students' ages, it was better to talk to them in groups rather than interviewing them one–to–one in order to minimise shyness and encourage group discussion. The use of the focus groups enabled this study to easily draw on a larger number of participants than using one-to-one interviews (Gibbs, 2012). Students were not asked to discuss SCL due their level of understanding in this subject, but analysing the transcript I could deduce whether what they said about their lessons was related to the student centred methods that their science teachers claimed to be practising in the classroom. During the focus groups my role was that of a moderator, where I asked questions (see appendix 3), listened and made sure that every student was given the opportunity to share their views during discussions. This helped to stimulate students to put across their views and perceptions (George, 2012).

A total of twelve focus groups consisting of four students each were held in all six schools, thus making a total of 48 participating students. Each focus group lasted for 15 to 20 minutes and all the discussions were audio recorded. The focus group discussions were held in their classrooms or in some cases under a tree within the school campus, or in a science lab to avoid too much noise and distractions. This was to make sure that students felt relaxed and confident enough to express themselves freely during the discussions (Krueger & Casey, 2009). I was able to gather a rich data from the focus groups since the data was similar to the data obtained from the teachers, particularly some of the challenges that were affecting their learning of science. The student participation was high but varied from one group to another. To encourage some of the quiet students to speak, I posed them questions with respect to their science lessons.

It is important to note that the three methods used to collect data from this study lead to triangulation in order to increase the validity of the data. This is going to be discussed next.

4.3 Triangulation

Triangulation can either be ‘within methods’, where you compare within a data set such as comparing interviews with interviews, or ‘between methods’, where you compare interviews and observation (Creswell, 2012). The methods used were qualitative in nature; observations, focus groups, and interviews, defined as multi-methods or a triangulation approach. The type of triangulation used in this study therefore is between methods in order to connect the diverse data and to strengthen validity (Creswell, 2012; Robinson & McCartan, 2016; Yin, 2016). Accordingly, Yin (2016) and Creswell (2012) support that such a collection of converging evidence from varied sources increases the validity of the data.

The lesson observations conducted were followed by a discussion where I went through the observations filmed with the teachers so that they could explain and comment on their teaching. This led us straight to the one to one interviews for the purpose of robustness. Student focus groups to find out how they felt about their science lessons in general were conducted to offer an opportunity to compare their views with the type of teaching methods that teachers claimed to use in the classroom. In this way, the results across different settings, groups or events were compared explicitly to increase the validity of the data (Yin, 2012). The findings of the three data sets were corroborated and helped to convince me that the findings were valid. Interviews were recorded using an audio recorder, as Gray (2009) pointed out that by meticulously going through the recording and interpreting the data helps to increase the validity of the data.

4.4 The Study Limitations

The research takes a small-scale qualitative approach. This style of research design is sometimes criticised for the limited generalisability of its findings. This is because the samples involved in this study were small and do not represent the total number of schools and science teachers in the Gambia. Secondly, I was interested in gaining an in-depth understanding of science teachers' classroom practices. The methods used in this study were lesson observation, interviews and focus groups, and each of these has its own limitations. This is because of the costs involved in collecting such data and gaining access to schools to conduct these exercises.

Furthermore, starting with observation as a method, it is not easy to record what was going on during the lesson observations whilst at the same time writing notes. A limitation of observation is that a large volume of data was gathered within a short period of time, which was challenging during analysis of my data (Burton and Bartlett, 2005). A lot of time was needed to analyse the data. This is why Creswell (2012) and Muijs (2004) noted that observation is time consuming and intense. Likewise, participants could have changed their behaviour during observation due to my presence as a non-participant observer. To mitigate this, I had to use a digital video camera which I mounted on a stand behind the classroom where I sat at a corner with my observation schedule and notebook jotting exactly what I was seeing in the classroom instead of sitting in front of the class or walking around the class during the lesson. In this way I avoided any form of distraction during the coverage as the camera was mounted behind them throughout the lesson.

However, there are issues related to the validity and reliability based on the research methods undertaken by the study. With observation data the degree of consistency may be hard to obtain, as what was viewed and interpreted would have been different from another observer. A further limitation is that I would need to observe more than two lessons per school to be sure that the lessons were natural and that I had captured all the relevant teaching habits- similar to saturation points for interviews.

Data obtained from interviews may be deceptive if the participants' responses are made to please the researcher. To avoid this, teachers were encouraged to express themselves freely and not to say what I want to hear. This was done by setting interview questions that were not leading to such responses, and by developing a good rapport with participants so that they felt comfortable in voicing their honest opinions. There is a probability that participants' responses might be influenced by the interviewer, and that these can be compounded by tape-recording which could be intimidating to some participants (Creswell, 2012). Therefore, I remained neutral in the interviews throughout and did not give my views or acknowledge any of the responses obtained. In this study, all participants preferred to be audio-recorded, making the interviewing process less daunting. Conducting interviews consumes time and generates a lot of data which inevitably limits the number of participants involved in the study (Gray, 2009). Equally to avoid any form of distraction during the interviews, I used audio record to record the conversations and failed to write any notes during this time of the interviews. In this way the interviews ran smoothly and were held either under a tree, in a classroom or in their personal offices without any form of distraction.

In focus groups participants can sometimes over-report or under-report and be self-censored, but equally, it may be difficult to detect deceit or probe issues, and confidentiality may be problematic (McLafferty, 2004; Bloor et al., 2001; Gibbs, 2012). However, these potential problems were appropriately addressed by encouraging the students to frankly state their views about their science lessons without any fear hence their responses will not be shared with any of their teachers or head master. In this way the responses given were not restricted by wanting to give the answers that their teacher or myself wanted to hear. Another argument is that the views or opinions obtained from the group or individuals may be difficult to separate (Matthews & Ross, 2010; Neuman, 2011). In this regard the topic was only centred on the students' views of their daily science lessons. Students involved in the focus group could have made up their responses particularly if they are given a topic that they lack knowledge in. The focus group could have also given a trivial result especially when the groups were too big, say 10-12 students (Krueger and Casey, 2009). With the focus groups, I encouraged students to put across their views by giving each of them equal opportunity during the discussions. I made sure that the groups were kept to a total number of four students to avoid obtaining trivial results. The topic given to the focus group was not beyond their knowledge in order to avoid students making up their responses. The topic was students' views of their science lessons and the focus groups were able to easily respond to how they felt about their science lessons, therefore it was not something new to them. During the data analysis I used both inductive and deductive approach to analyse the data so that the findings arising from data and those interrogated by the models can all be captured.

In order to address these faults and limitations of each of the methods, and to overcome my bias, I decided to triangulate the three methods. The combined theoretical framework could not interrogate on the factors affecting science teachers' SCL practices. There was not much data gathered, students' roles during their science lessons and teachers' views of science (nature of science). Teachers' nature of science would be better researched using questionnaires for further research. Alternatively, for further research, a survey could be used as a research strategy to include a larger number of teachers and schools in the Gambia with the aim of generalisation of the findings.

The next section gives an overview of the experience gained from the pilot study conducted before the final data collection was done.

4.5 An overview and the experienced gained from the pilot study

The purpose of the pilot study was to test and evaluate the research questions to see the extent to which the questions could be answered. This was in keeping with Robson (2011) and Dawson (2009) who maintained that conducting pilot studies should involve making sure that inconsistencies are recognised and that care is taken to offset any difficulties.

The pilot study was conducted between October and November 2016 in the Gambia and involved a total of three schools centred within one region in the country. Two qualified science teachers and five students from each selected school took part in the study. The schools selected were all Upper Basic Schools (UBS) since the study focuses wholly at this level of the education system in the Gambia. In order to have a variety of responses from teachers, it was decided to include public, grant-aided and private schools. At this stage six schools could have been selected as intended for the final data collection but the primary aim was focused on evaluating the research questions, so the pilot was limited to three schools. The pilot study began with interviews of science teachers, followed by lesson observations and a discussion around the lesson observed and focus group with students.

4.5.1 Methods used in the pilot study

At the pilot stage, video-recording was introduced and used to stimulate general discussions on the lessons taught by the teachers after observation. 45 minute interviews with each teacher were carried out, 30 to 70 minute lesson observations followed by 10 minute discussions, and 15 to 20 minutes for focus groups. All interviews and lesson observations were recorded. The pilot study also provided a guide as to the number of days that had to be spent in each school to collect the final data. Thus, each school was allocated three days for the data gathering exercise.

4.5.2 Interview questions used in the pilot study

Interview questions were developed and used during the pilot study. However, questions were revised and reduced following the pilot. This is because some of the questions were leading and did not give enough room for the participants to give a detailed response. Thus my research design improved considerably before the collection of final data in the field. Below are some of the questions amended?

- ***What state is the availability of teaching learning resources in your school?*** This was amended to: ***Tell me how you will teach a science topic that involves practical activity/experiment?***
- **What do you understand as SCL? Do you use SCL in your classroom? Describe this to me**. It was good to have the question in this form to help gather more detailed information.
- ***What obstacles do you face during science lessons that you think hinder your progress in learning?*** This question was changed to: **What makes learning science difficult for you?**

To sum up, the pilot study helped in the final data collection to improve the sampling strategies undertaken. It gave me a clue as to the period of time I was going to spend in the field and the amount of data that I expected to obtain, and it also enabled me to review my interview schedule. The next section focuses on the data analysis and the type of data analysis undertaken in this study.

4.6 Data analysis

The study adopted a combination of Magnusson, Krajcik, and Borko's (1999) model of Pedagogical Content Knowledge (PCK) in teaching science and Friedrichsen, Van Driel and Abell's (2011) science teaching orientations as the theoretical framework for the data analysis. A detailed discussion of this model is in the theoretical framework, chapter three.

This section discusses the link between the theoretical framework and the methods used in collecting the data in order to answer the main research questions. It examines the type of data analysis undertaken and outlines some of the themes and codes obtained from the data.

Magnusson et al.'s (1999) model of PCK has five key components which are appropriate to the study. These components are i) science teachers' views and beliefs/orientations on teaching science (STO); ii) knowledge of assessment in science; iii) knowledge of instructional strategies; iv) knowledge of students' understanding of science, and v) knowledge of science curriculum. In order to examine science teachers' classroom practice and their links to SCL, I used the first component, Magnusson et al.'s (1999) model of STOs, which comprised nine orientations. These nine orientations are further classified as teacher centred orientations and student centred orientations. A detailed explanation of this model is given under the theoretical framework, chapter three.

From the nine proposed orientations, two are closely associated to teacher centred methods, while the remaining are linked to student centred approaches. It is suitable at this point to discuss these two main classes of orientations used to analyse the data obtained from the three methods.

4.6.1 Teacher-Centred Orientations

Magnusson et al. (1999, p. 100) states that a teacher with a didactic orientation has the goal to transmit the facts of science and that such instruction is mainly characterised as the teacher presents information, generally through talk and chalk and questions posed to students to test and see if they can recall the scientific facts (Magnusson et al., 1999, p. 100). In the analysis of the lesson observations and interview data gathered, the description that indicates the teacher as telling, showing, explaining, teacher presenting content knowledge and focusing on student recall, is considered in this study as didactic orientation and thus is linked to teacher centred method. A lesson that lacks activity and rigidly follows a syllabus with a focus on content and vocabulary is regarded as a knowledge based lesson and is thus considered to be teacher centred method (Magnusson et al., 1999).

Furthermore, a teacher's practice or orientation is considered as teacher centred if the description fits that of an academic rigor orientation where the goal of the teacher is to "represent a particular body of knowledge", instructions of which are characterised as "students are challenged with difficult problems and activities" (Magnusson et al., 1999, p. 100).

4.6.2 Student- Centred Orientations

Student-centred orientation comprises process, activity-driven, discovery, conceptual change, project based science, inquiry and guided inquiry. Any of these seven orientations practised by teachers were considered as student centred learning (Magnusson et al., 1999). The defining characteristics of each of these student centred orientations is now discussed.

Process orientation aims to develop students' processing skills. Science processes include observing, classifying, measuring and predicting. These may be observable in practical or activity based lessons in a student centred classroom (Magnusson et al., 1999). For example, students may observe an increase in temperature on a thermometer during boiling water, classify objects as solid liquid and gas. They may use a measuring cylinder and measure a specific volume of liquid and predict what will happen if water is added to salt. Such information may be gathered during lesson observations in this study.

Activity-driven orientation is characterised when students are engaged in practical work / experiment. Here students have hands-on experiences by being active with materials (Magnusson et al., 1999). Hands-on activities could be observed in a student centred classroom, for example when a teacher provides enough resources or materials for students and sets them to conduct an experiment in a science lesson.

Discovery orientation provides the opportunities for students to discover science concepts on their own. Allowing students to discover their own concept will enable them to remember what they have learnt more easily rather than telling them (Magnusson et al., 1999). This will involve the teacher posing conceptual questions and allowing students to investigate and respond to the questions (Magnusson et al., 1999). Thus learning opportunities offered to students by their teachers are considered as student centred practices.

Conceptual change orientation is defined as the goal to “facilitate the development of scientific knowledge by confronting students with contexts to explain, that challenge their naïve conceptions” (Magnusson et al., 1999, p.100). This involves asking for students’ views and helping them to establish valid claims (Magnusson et al., 1999). This is considered student centred learning.

Project–based science is characterised when students are involved in “investigating solutions to authentic problems” (Magnusson et al., 1999, p. 100). Any project based work would mean a student centred approach.

Inquiry orientation was defined as the goal to “represent science as an inquiry” where the nature of instruction requires students to investigate problems and assess knowledge (Magnusson et al., 1999, p. 100). The discovery and inquiry orientation both involve students’ investigation.

The seventh is guided inquiry, which encourages students to participate in “investigating, scaffolding, learning to achieve students’ independence; inventing and testing explanations, ability to use scientific materials” (Magnusson et al., 1999, p. 101). Teacher orientation that involve students to investigate the process of learning science is considered as student centred learning.

In my data analysis the seven STOs discussed above were used as criteria to identify participating teachers’ use of student centred learning. I looked out for these criteria in the interview, focus groups and lesson observation data. Thus, teachers categorised under teacher centred orientation were ascribed to one orientation - didactic or academic rigor orientations, while teachers under student centred orientation attributed to at least two orientations. This is because with SCL a teacher could use multiple methods within a topic. For example, if a teacher assigned students an experiment to conduct in class, such practice could be regarded as activity–driven and at the same time an inquiry or discovery- based orientations.

However, the analysis of data related to RQ3, on teacher orientations and how they impact on their practice in the classroom, was different to the RQ1 and RQ2. In order to better understand teachers' Pedagogic Content Knowledge (PCK), Friedrichsen et al.'s (2011) modified science teaching orientations (STOs) was adopted, which explains that science teaching orientation is a "set of beliefs with the following dimensions: goals and purposes of science teaching, views of science and beliefs about science teaching and learning" (p. 358-359). I felt it was inappropriate to assign any of the nine STOs by Magnusson et al.'s (1999) model to a teacher if all the remaining four components are to be considered. For this reason, Friedrichsen et al.'s (2011) STOs were drawn on to supplement Magnusson et al.'s (1999) criteria which were insufficient. Thus it was appropriate to use interviews to gather data on teachers' views and beliefs based on the Friedrichsen et al. (2011) dimensions and use observation method on the remaining four components by Magnusson et al. (1999). These observable parts of the data are comprised of knowledge of assessment in science; knowledge of instructional strategies; knowledge of students' understanding of science and knowledge of the science curriculum. These were the remaining components that form part of my observation criteria and are discussed below:

4.6.3 Knowledge of assessment in science

Teacher knowledge of assessment in science involved how the students are assessed during class time, for example asking numerous questions, getting students to restate their responses, questions asked not being based on knowledge recall and allowing students adequate time to think and reflect before responding to the questions posed to them (Magnusson et al., 1999).

4.6.4 Teacher knowledge of instructional strategies

This involved teachers providing appropriate and relevant activities and teaching learning resources, mastery of the subject by giving appropriate and relevant examples, encouraging students to ask questions, promoting student participation and collaboration (Magnusson et al., 1999).

4.6.5 Teacher knowledge of students understanding of science

This involved addressing students' misconceptions, helping students with difficulties, meeting the needs of students by providing adequate teaching learning resources and giving a brief revision of the previous lesson (Magnusson et al., 1999).

4.6.6 Teacher knowledge of curriculum

This involved linking prior knowledge to new knowledge, and making sure the topics taught are interconnected. Teachers demonstrating this were considered to possess knowledge of curriculum (Magnusson et al., 1999). The next section discusses the type of data analysis used in this study.

4.7 Type of data analysis

The approach to data analysis used in this study was deductive and inductive hence some of the themes arise from the theoretical framework while the rest arise from the data. The method of analysis used in this study is a thematic analysis (Braun & Clarke, 2006). Thematic analysis is the method for identifying, analysing and reporting patterns or themes within data: for example, finding repeated patterns of meaning from observation, interviews and focus groups, in other words, “searching across a data set” (Braun & Clarke, 2006, p. 86). Similarly, Grbich (2007) in Matthews and Ross (2010, p. 373) defined thematic analysis as ‘a process of segmentation, categorisation and relinking aspects of the data prior to final interpretation’. Thus, looking for patterns, differences and similarities of participants’ views and relating their views to the literature (King & Horrocks, 2010).

For the first stage of the analysis I transcribed the interviews and focus group data. During this transcription I became very familiar with the data, especially by revisiting the audio recordings against the transcripts for accuracy. The interview for each participant and focus group were transcribed (See appendix 4 and 5). These transcriptions were used to be able to compare and contrast the data across participants to see the similarities and differences of their views.

The second stage of the data analysis involved what Braun and Clarke (2006) refer to as initial coding. According to Bazeley (2009), coding enables the researcher to find evidence required and a way of indexing the data obtained. Coding the data to me was much easier than transcribing. Data was coded based on the Magnusson et al.’s (1999) model of PCK, Friedrichsen et al.’s (2011) STOs as the theoretical framework of this study and in some cases, points repeatedly mentioned by participants from the data but were not included in the model used. The table below shows how the data gathered was viewed.

Table 7: Analytical tool

Theoretical framework	Themes and sub - Themes	Themes and sub-Themes	Themes and Sub-Themes
Magnusson et al.(1999) Model of PCK	Teacher Centred Orientations 1.Didactic 2. Academic Rigor	Student Centred Orientations Process Activity-driven Discovery Conceptual change Project – based Inquiry Guided inquiry	The four PCK components Teacher knowledge of assessment Teacher knowledge of instructional strategies Teacher knowledge of students understanding of science Teacher knowledge of curriculum
Friedrichsen et al.(2011)STOs	Goals and purposes of science teaching Rationale for teaching science	Views of science Beliefs about science Values about science	Beliefs about science teaching and learning Role of the Teachers Role of students How students learn science How science can be taught to make it interesting ,enjoyable and comprehensible
Themes arising from the data(Additional themes)	Challenges/ constraints of SCL practices Resource constraints Inadequate training Large class size Prioritising the SSS level Lack of time	Teachers belief about SCL SCL is the best approach SCL develops students thinking ability	Science teachers understanding of SCL The role of teacher as a facilitator, guide, coaches, group work, conduct of

	Examination oriented syllabus Student view science as difficult	Students support and learn from each other	experiment, taking account of students' pre-requisite skills and knowledge and skills, individual differences, students participation and involvement, access to teaching and learning resources

Coding was done manually using Microsoft Word by highlighting and colour-coding patterns identified within the data. The data interrogated using Magnusson et al.'s model (1999) was colour coded in blue, that of Friedrichsen et al. (2011) was coded in green and additional themes arising from the data was coded in red. A two column table matching the initial codes to the data from the transcript was created. Below is an example of what extract from the focus group data, (see appendices 6,7 and 8) for a complete extract of the focus group, interview and lesson observation data.

Table 8: Two column table indicating data extract and coded for

Data Extract	**Coded for**
Student from T1: I have seen that science is a very good subject. Science in the school helps us a lot. Science in our school here helps us in many things about to be hygienic. It helps us to know the things in our body. Science is an important subject. It tells us parts of our body and their functions, like the heart, lungs, kidneys and our elementary canals. It tells us so much a lot of things about ourselves and day to day activities.	**Students' views about science:** **1. Knowing parts and function of the body.** **2.Helps to improve on our hygiene**
Student from T1: The circulatory system,	**Students favourite topics:** **1.Circulatory system**

Student from T1: Adaptation, adaptation	**2.Adaptation**
Student from T1: It was taught by showing us the diagram on the heart and part of the heart and their functions. Yeah, he even used some of as examples. He tells us and explains to us how the blood is circulated. **Student from T1:** Adaptation is just talking about these things the life of organisms. He taught us about toad, fish, agama lizard, he told us the difference between toad and frog. And also he told us about the toad, fish, this thing like toad is amphibian, he show us the diagram, label it for us and he told us the differences like toad live longer, aan the frog live longer in water than this things aah. **Student from T1:** Aah, he once asks us to know the 20 elements of the periodic table so that we know them individually like the elements and their symbols, their atomic numbers, metals and non-metals.	**Didactic** **1.Teacher shows** **2. The teacher tells** **3.The teacher explains** **4. The teacher ask us to know**
Student from T1: Diagrams, explanation and experiments, textbooks and pamphlets (repeatedly three times).**Student from T1:** Explanations, when there is no teacher sometime when I take a pamphlets I read it and do not understand but due to the teacher explanation of the teachers, I understand better. **Student from T1:** My best way to learn is to explain. **Student from T1:** To know what I am doing, to say like the teacher when we a treating this topic the teacher brings diagram to show me that this is what we are doing that also help me to know what I am doing. By observation, research. In the internet, parents, brothers. **Babou:** Where else can you do the research? **Student from T1:** In the science lab, you can go to your teachers, ok ask your teachers. Sometime teachers explain and you do not understand but when it is group work like this when our fellow students are also explaining you have better understanding.	**Best way to learn science:** **1. Explanation** **2. Reading pamphlets** **3. Use of diagram** **4. Through observation** **5.Research** **6. Through home support.** **7. Experiment**
Student from T1: Experiments and how to go about it; the labelling of the diagrams; **Student from T1:** Some parts have this big word that people cannot pronounce and cannot capture it. Pronunciation of the scientific terms.	**Challenges/Difficulties in learning science:** **1. Experiment and procedures** **2. Inability to pronounce scientific terms**

Sometimes in groups and sometime independently not always. **Student from T1:** We bring different ideas and take the best.	**Activity driven, process an conceptual change:** **1. Exchanging ideas** **2. Students understand better when they explain to each other**

The third stage involved sorting codes into themes and collating relevant codes extracted from the data within the identified themes. At this stage it was necessary to look into the relationship between the themes that emerged, sub-themes and codes, which were tabulated and used as extracted data. A column was created to include the evidence to substantiate the themes, sub-themes and codes according to each research question. This approach was in alignment with Braun and Clarke (2006, p. 87) as explained below in table 9 (see appendices 9, 10 and 11 for the analysis of RQ1, RQ2 and RQ3).

Table 9: Four column table indicating themes, sub-themes, codes and evidences

Themes	Sub-themes	Codes	Evidence
Teacher centred orientation	**Didactic**	**1.Teacher shows** **2. The teacher tells** **3.The teacher explains**	**Student from T1:** It was taught by showing us the diagram on the heart and part of the heart and their functions. Yeah, he even used some of as examples. He tells us and explains to us how the blood is circulated.

This enabled me to identify the codes that were common across the data and I could quickly count the number of participants stating the similar phenomena. I used A3 paper to write the themes, sub-themes and codes including the list of participants stating similar codes. This was done based on each individual research question. I checked and reviewed the themes to make sure that the themes worked in relation to the coded extracts and the entire data set. Thus I generated a thematic map of the analysis. A reduced size of the copy of this final part of the analysis can be found in appendices, 12, 13 and 14.

4.8 Reflexivity and Positionality

This section gives a detailed discussion on my background, attitudes and beliefs that may have had an impact on my research. This is done to minimise subjectivity so that the study is a qualitative research and data collected were through interviews and lesson observations. Reflexivity involves being explicit about and aware of one's role as a researcher, and could be described as being thoughtful and conscious of one's self-awareness (Finlay, 2002). Accordingly, Finlay points out, being self-aware can increase the trustworthiness and integrity of the study, based on honesty of the relationship between me and my participants. In view of this, the position of the researcher, especially with regard to what is being researched and the claims made, must continuously be explored. Consequently, analysing the subjective and inter-subjective elements are key to influencing the research (Finlay, 2002). This is because reflexivity is having an internal dialogue about an ongoing internal conversation about the experience, while at the same time living in the moment. Reflexivity pervades every part of what we do in research, challenging and testing researchers' abilities to be more aware of the culture and politics of those being studied (Lawrence-Wilkes, & Ashmore, 2014).

I have been a science teacher since 1997 and head of science and mathematics since 1998. I was head teacher between 2000 and 2002 in an UBS in Gambia. I left the school to pursue an undergraduate degree in Chemistry between 2002 and 2006 at the University of the Gambia (UTG). I did this course to develop myself better as a teacher and to be able to teach the subject at Secondary School level. However, upon completion I was offered an Education Officer (EO) job at the Ministry of Education in 2006 and I rose to the rank of Senior Education Officer (SEO) in 2009. My job at the Ministry entails the enhancement of teaching and learning of science and mathematics in Gambian schools. I also give technical support and advice to the director of science and mathematics education at the same directorate within the Ministry. As a result of these I was fortunate enough to access international training and workshops in Kenya, Malaysia and Zambia where I learnt new techniques in improving the teaching and learning of science. These experiences gained were shared with teachers in the form of Ministry funded workshops I organised upon return to Gambia. The workshops I facilitated involved exposing teachers to Activity Student Experiment Improvisation-Plan Do See and Improve (ASEI-PDSI), a SCL approach which encourages teachers to improvise basic science materials in the absence of conventional apparatus in order to make teaching and learning more interesting and meaningful to the students. The aim was for teachers to adopt and implement in their classroom practices. For these reasons I was motivated to conduct this research into teachers' classroom practices. This brief biography explains my positionality and relationship with the research, of which I need awareness to ensure that I am as objective as possible in my research design and data analysis.

My transition from being a practitioner to being a researcher began way back in 2014/2015 academic year when I did my Master's degree in education and wrote my thesis on ASEI-PDSI practices in Gambian Upper Basic Schools. This was because I was interested to know if the approach was adopted and implemented by science teachers or not, and I sought to advise what strategies needs to be employed by the ministry to make it functional. This motivated me further to dig further into science teachers' perceptions, orientations and classroom practices in my PhD study.

My PhD in education is a long journey and started way back in 2015. During this journey I attended several PGR courses to develop my skills and knowledge in research. I read extensively different textbooks and articles that related to my field of study. This enabled me to have a good knowledge of my field. I attended and presented papers in conferences within the University and outside the University. Among the conferences I presented papers at the Standing Conference on University Teaching and Research in the Education of Adults (SCURTEA) and British Educational Research Association (BERA) conferences. Attending such conferences enabled me to meet other researchers and develop a network of well-educated and experienced personnel from all over the world. Their feedback and comments during these presentations were very valuable.

During the study, however, I was aware of my sleeping or dormant role as a Senior Education Officer (SEO) in the Ministry, which could have had an effect on participants' responses. This is because I was managing the two identities of SEO and a researcher. However, having been away from the Gambia for three years, visits to schools was as a researcher and not in the position of an SEO. Therefore, in terms of positionality, as the researcher, it was crucial to remain aware of this potential bias, because I want the research to be a success and to have positive impacts/benefits in the Gambian educational system. I was aware that my previous role may have influenced the participating teachers' responses. This is because some of the teachers knew who I was and my position at the MoBSE. Some of the teachers were also part of the workshops that I facilitated while I was in my previous role. For this reason, they may want to give me responses that I wanted to hear. In order to avoid this, I therefore constructed the research design to mitigate, as far as possible, subjective bias arising from positionality; i.e. multi-methods – triangulation – validity; and deductive analysis drawing specifically from the combination of Magnusson et. al. (1999) model of PCK and Friedrichsen at al. (2011) STOs.

4.8.1 Ethical consideration

Research ethics refer to the moral principles guiding the research from the beginning to the end (Matthews & Ross, 2010, p. 71). Similarly, Neuman (2011), defined ethics as what is or is not appropriate to be done during the conduct of a study, as well as knowing what moral research procedure entails. It is emphasised by the British Educational Research Association (BERA) that researchers need to take into account ethical issues of respect and dignity for participants during a study (BERA, 2018). In this regard, the study I undertook here strictly adhered to the ethical guidelines highlighted by BERA. For ethical reasons I also adhered to the general data protection regulatory (GDPR) of the University, and I will make sure that the films taken during the lesson observation are destroyed once the study is completed.

Notwithstanding, some have argued that regardless of how effective and well behaved the researcher is, there is some possibility that the researcher may be unintentionally unethical (Punch, 2009). It was necessary as an interpretivist researcher from the beginning of the data collection exercise to seek and obtain permission from the head teacher in every participating school. This was relevant to uphold the ethical principles and values in order to maintain the integrity of my research. Identified schools were visited initially to meet school authorities and request access to the schools. A research consent form (see appendix 15) was given to the Principals as gate keepers, to open the doors of their schools for the conduct of the research. Schools were contacted through my role as a PhD student from Huddersfield University and not someone from the Ministry of Basic and Secondary Education (MoBSE). The more important point is that my interaction with the schools in this instance was as a researcher, not as a Ministry employee. This was due to the fact that I have been away from the Gambia since 2015 as a student and have not worked for the Ministry for such a long time. Furthermore, the teachers' responses were much better as they did not see me as a person coming from the ministry to scrutinise them. Before the field data collection, visits were made to see the teachers involved and to talk with them about my research and to reassure them and build their confidence. It was crucial to make this visit not only to make participants understand that the research undertaken would lead to successful completion of my study but also to assure them of their wellbeing throughout the research. I did this by reassuring teachers and students of their anonymity throughout the research. For anonymity, all participants and schools were given pseudonyms to ensure they were unidentifiable in this study. For example, the names of the schools were coded as school A, B, C, D, E and F; the names of the teachers were coded as T1, T2…. T12 and students from T1's class as ST1, ST2… ST12.

A participant information sheet indicating the purpose of the research, participants' right to withdraw from the study and confidentiality were made available to each participant (see Appendix 16). Participating teachers had time to read through the information sheet before deciding whether or not to participate, which was respecting the decisions and values of the participants (Flick, 2014). Additionally, participants were given the opportunity to seek clarification of the purpose of the study from me before agreeing to take part. Participants therefore were aware of what the research was about before they got involved in the study, which Metthews and Ross (2011) referred to as overt method, an open method of inquiry in which participants were ware of being studied. Having read the written information about the study to gain a full understanding of what it involved, an informed consent form was given to each of the science teachers to sign, agreeing to take part in the research without being forced or conditioned in any way by signing the informed consent form (see appendix 17). Giving participants an informed consent form is beneficial and can build participants' confidence to be able to discuss issues related to the research topic frankly and openly (Robson & McCartan, 2016).

As the research was conducted in schools, parents' consent was not sought for the reason that school heads authorised permission and gave access in their respective schools. Therefore, obtaining permission from the school head was sufficient in the context of the Gambian Education System for participating students to undertake the focus group. There was no harm caused to participants since the study did not seek for information that may have subjected the participants to anxiety or harassment, and none of the participants were embarrassed, ridiculed or belittled during the conduct of the study (Robson & McCartan, 2016).

Participating teachers and students were ensured of their rights and were informed that they could withdraw at any point during the data collection process if they wished. There was no point during the data collection exercise where participants left the class or opted out. At the commencement of each lesson, I was given the opportunity to introduce myself. Both teachers and students were informed from the onset of the use of the digital video camera in the lessons and the audio recording of one-to-one interviews and focus group. Their consents were sought to undertake the research and all agreed without any objection or being forced. At the beginning of the interviews, I explained the purpose of the interview to the participants and assured them of their names being anonymised in order to make them feel comfortable and relaxed. I informed them that their actual names would never be mentioned in my thesis and also would not be given to any Ministry of Basic and Secondary Education (MoBSE) personnel and that whatever they mentioned during the interviews would be kept confidential and I would be the only person to have access to such information. I made sure that no one was present during the interviews so as to avoid distraction, and also so that the participants were not discouraged from expressing their views freely. It can be argued that as well as a moral requirement, good ethical practice in research can also enhance validity of the study (Cooper & Schindler, 2014).

4.9 Chapter Summary

This chapter discussed the used of an interpretivist research approach to examine teachers' perceptions of SCL and their orientations to unpack their classroom practices. It also justifies the rationale for the use of the approach since as an interpretivist researcher I am concerned with the quality of the data drawn from a small sample to be able to deduce meaning from the participants' own live experiences. A small- scale qualitative research is employed with the use of multiple methods involving lesson observation, interviews with science teachers and focus groups with students. The manner in which each of these methods were conducted have been highlighted in this chapter. The three methods of data collection were triangulated, which enhances the validity of the data. The chapter also highlights the limitation of the study such as the limited number of participants involved, however the findings from the study was not aimed at generalisation rather I was interested to have a detail understanding of science teachers' perceptions and orientations in relation to SCL. The chapter also discussed the pilot study that was undertaken before the final data collection exercise was conducted. The pilot study was essential in the sense that the experiences gained from it enabled me as a researcher to select the samples chosen differently and to make some amendments to the questions.

The chapter gave a brief detailed description of the data analysis and made a link between the methods used and the theoretical framework. This chapter also gave a detailed account of my reflexivity and my positionality as a researcher. The chapter considered the ethical procedures that were undertaken during the conduct of the research. I made sure that permissions were obtained from the head teachers first by giving them a research consent form to sign. This was followed by giving each of the participating science teachers a participant information sheet and an informed consent form to sign after I explained what the research was all about. It was clearly highlighted from this chapter that participants' integrity, respect and confidentiality were maintained throughout in this study.

The next three chapter focuses on the data presentation and discussion of the findings. The first chapter, chapter 5, addresses RQ1: To what extent do Gambian Upper Basic School students' perceptions of their science lessons relate to students centred learning pedagogies? Chapter 6- RQ2: In what ways do science teachers' own perceptions of SCL influence their classroom practice? Chapter 7 -RQ3: In what ways do science teachers' pedagogical orientations influence their classroom practices?

Chapter 5: Data presentation and discussion

5.1 Introduction

This chapter is the data presentation and discussion for RQ 1: To what extent do Gambian Upper Basic School students' perceptions of their science lessons relate to student centred learning pedagogies? The students involved in the focus groups were from grades 7, 8 and 9, aged between 12 and 15 years old and a mixture of both boys and girls. A total of 48 students participated in 12 focus groups.

The data presentation and discussion is in three phases in this chapter. The first phase presents and discusses data interrogated using Magnusson et al.'s (1999) STOs, the second phase using Friedrichsen et al.'s (2011) STOs and the final phase considers relevant data missed by Magnusson's and Friedrichsen's models. The data presented in the first phase of this chapter consist of two themes; teacher centred orientations and student centred orientations, followed by a detailed discussion. The second phase consist of two themes; students' views of science and beliefs about science teaching and learning presents. The findings on each of the theme are presented and discussed. The third phase is the data not picked by the two models and this consists of one theme; difficulties and challenges in learning science. The data obtained on this theme are presented and discussed. The final section gives a detailed summary of how the data has answered to RQ1.

5.1.1 Participants' background information

During the lesson observation four students were selected from each of the classes taught by the twelve teachers. None of the 48 students were named in this study for confidentiality reasons: anonymous names given to each of the focus group are ST1 meaning students from teacher one's class, ST2, ST3, ST4, ST5, ST6, ST7, ST8, ST9, ST10, ST11, ST12 respectively.

5.2 Phase 1: Magnusson et al. (1999) model

This section presents and discusses data from the focus group that was analysed through the lenses of Magnusson et al.'s (1999) model of STOs. The findings revealed teachers' use of both teacher centred and SCL approaches. This was pointed out by eight focus groups out of the twelve indicating their science lessons as teacher showing, telling and explaining, which is didactic. Where the teacher engages students into practical work/ experiment, group work, relating topic taught to students' daily life and providing teaching aids to students, the lessons are student centred and involve activity driven, project based, conceptual change, process, inquiry, guided and discovery orientations.

5.2.1 Theme 1: Teacher Centred Orientation

Sub-Theme: Didactic

Code 1: Teacher shows, tells and explains (ST1, ST2, ST4, ST5, T7, ST6, ST10 and ST11)

The focus group data indicated that eight focus groups out of the twelve commented that their teachers taught them science by showing, telling and explaining during lessons. Below are comments made by students:

Student from T1: *It was taught by showing us the diagram of the heart and part of the heart and their functions. Yeah, he even used some of us as examples. He tells us and explains to us how the blood is circulated.*

Student from T1: *Adaptation is just talking about these things the life of organisms. He taught us about toad, fish, agama lizard, he told us the difference between toad and frog. And also he told us about the toad, fish, this thing like toad is amphibian, he shows us the diagram, label it for us and he told us the differences like toad live longer, aah the frog live longer in water than this things aah.*

Student from T1: *Aah, he once asks us to know the 20 elements of the periodic table so that we know them individually like the elements and their symbols, their atomic numbers, metals and non-metals.*

Student from T2: *He taught us how it happens, at which age do you see in your body changes and stuff like that. Like the menstruation flow she talked about how did it come about and how long did it last.*

Student from T4*: He told us that energy is the ability to do work.*

Student from T5*: For me how she teaches, if she is teaching she wants everybody to understand, and the way she talks, that is the reason why I like her. Her teaching is very, very nice.* ***Student from T5****: She makes us to understand well. When she is teaching she used to do it easy, easy, and easier.*

Student fromT6*: He takes his time, explains it, students will understand and he will ask questions in return and if we don't understand anything we will ask him and he will make it clear in our mind.*

Student from T10*: Like when he comes to class he writes notes. He will explain some of the things. After writing those notes he will have to explain after explaining he will ask questions do you understand, if all the class understand then we have to ask each other questions. If no questions he will ask us questions to know the understanding, we have.*

Student from T11*: He tells us the definitions, difference of plants and animals.*

5.2.2 Theme 2: Student Centred Orientation

Sub- Theme: Activity driven, conceptual change, process, inquiry and discovery orientations

Code 1: Practical work / Experiment (ST3, ST7, ST8, and ST9)

The focus group data showed that students from four focus groups out of the twelve commented that their lessons involve practical work / experiment. Below are the remarks obtained from these students:

Student from T3: *We did it in the classroom with the teacher and even individually I did it at home to see whether in the atmosphere water vapour is present. We take ice cube and put it in the beaker and observe after 2 to 3 minutes to see any particle outside to see that it is condensed. Theoretically, we have learned that water vapour can be condensed in order to have liquid by doing such practical you realise that those facts are true.*

Student from T8: *Since the beginning of the term we are cooperating with her. First thing she is kind to us yeah, she always came to class early as possible as she introduced the lesson to us we cooperate with her. Sometimes she does give us experiment, homework, yeah*.

Code 2: Group work (ST1, ST2, ST3, ST4, ST5, ST8, ST9, ST10 and ST12)

The focus group data showed that students from nine focus groups out of the twelve commented that their lessons involve group work. Below are the remarks obtained from these students:

Student from T5*: If she gives you group work she comes round to see if you are doing it correctly. By telling us to come for Saturday classes. I think that is the only thing.* ***Student from T5****: Yes, we work both in groups and independently in class. Like if he gives us class test we work independently but if she gives us group work we come together and work in groups.* ***Student from T5****: We enjoy group work because we exchange our ideas but with individual work you are the only one to think what to do.*

Student from T8: *For our science teacher she is very kind too and gives us class work and group work to do it in the class or at home.* ***Student from T8***: *When she gives us group work we work in groups when she gives us assignment we do it independently.* ***Student from T8***: *We bring our opinions, discuss and compare.* ***Student from T8***: *Yes, we are helped by her sometimes she does gives us some group work. She will form two to three groups like that when you tell her madam come here I do not understand this she will come and explain that.*

Student T9: *We work sometimes independently and sometimes in groups.* ***Student T9:*** *When we are doing practical we work in groups. If we are given homework we do it individually.* ***Student from T9***: *We like working in groups because we share our ideas as the saying goes two heads is better than one. We the students we can learn from each other better than the way the teacher is teaching us. For example, if the teacher teaches us and I don't understand if a student comes and explain I understand it more. In fact, when I understand from the teacher and my colleague student comes and explain I will understand more from him than the teacher.*

Code 3: Providing teaching aids (ST8)

The focus group data showed that students from T8's classroom commented that the teacher provides teaching aids. This is what was stated:

Student from T8: *Since she started introducing the topic she wrote it on a card board and paste it as a teaching aid so she starts introducing and asking us questions and answering so as we go on we try to understand much better.*

Code 4: Relating topic to student's daily life (ST6)

From the focus group a student from T6 stated that the teacher relates topics taught to their daily lives. Below is a comment made by the student?

Student from T6: Not only explanations, sometimes if we don't understand it he twists explanation in another form just like in our daily activities of our life so that we can understand. He knows that we are used to those things so if he explains it we used to understand.

5.2.2.1 Discussion

The discussion focuses on the relevant findings of phase 1. The findings revealed students' perceptions of their lessons as teacher centred. The first paragraph discusses teacher centred orientation, the second paragraph discusses student centred orientation and the third paragraph interprets the data to respond to RQ1.

When interrogated using Magnusson et al.'s (1999) model of STOs the focus group data showed that science teachers' practice in the classrooms runs through the continuum of teacher centred to student centred learning. Eight out of twelve focus groups stated their teachers' practice involved the teacher showing, telling, talking, explaining and asking them questions only after explanation. Such a practice, according to Magnusson et al.'s (1999) STOs relates to didactic orientation, a traditional teacher centred method used by teachers T1, T2, T4, T5, T6, T7, T10 and T11. This occurred in both adequately and inadequately resourced schools. However, teacher centred method seems to be more teacher focused than student focused. The teacher seems to be in control of the activities going in the class. From what has been said by the students, it means the students were less active and had no other choice but to pay attention to what the teacher is telling or showing them. They are passive listeners and receivers of knowledge from the teacher (Gibbs, 1981).

Analysing the data gathered from the focus groups using Magnusson et al.'s (1999) STOs indicated a link between students' views of their science lessons and teachers' use of student centred learning practices in their classrooms. This is because students claimed that their science lessons involved experiment, group work, linking lessons taught to their daily life, and teachers providing them with teaching and learning resources during the lessons. These practices concur with student centred related practices. According to Magnusson et al.'s (1999) model of STOs, such practices are student centred as they involve activity driven, process driven, conceptual change, discovery and inquiry based orientations. Use of experiment in science lessons is key and links to student centred related practices, so Magnusson et al.'s (1999) student centred orientation, including activity driven, inquiry and discovery orientations, involved practical work/ experiment.

Another student centred practice that focus groups reported and that was the most common across all schools was group work. This, according to the students, enables them to discuss, share and exchange their ideas and thus learn from each other more than from the teacher. This concurs with Magnusson et al.'s (1999) student centred orientations such as activity driven, inquiry, process and conceptual change. Another vital aspect of the focus group data is the teaching learning resources which the teacher provides in class. This is recognised by the student as useful, since it helps them to understand what they learn much better. The provision and use of teaching and learning resources during lessons is vital. This makes lessons practical and fosters student understanding of the subject matter. Students' interaction with physical objects concurs with Magnusson et al.'s (1999) student centred orientation particularly when the lessons are activity driven and process orientated. The final key feature of the use of student centred learning is the teacher relating topics taught to students' daily life. This helps students to link what they have learned to practical life situations, and is in line with SCL principles by Brandes and Ginnis (1994) and Magnusson et al. (1999) STOs. The students' awareness of the application of knowledge and skills gained from the lesson learned could be used later in life as they pursue their various careers.

It can be deduced that UBS teachers to some degree use more didactic approach than student centre learning strategies in their classroom practices. This is because practical work which is key to science lessons and regarded as a student centred learning practice is less frequent in class compared didactic method of teaching. The number of focus groups who indicated their teachers' use of didactic approach by showing and telling was twice the number of the focus group whose teachers offer them practical work. The only element of SCL practices that was more frequent than the didactic method of teaching was group work. The data indicated group work as the most prominent practice by teachers, hence this was mentioned by nine focus groups out of the twelve. This difference in frequency was only one which was less significant. This is because during the lesson observation it was observed that group work was not very effective due to the large size of the groups. For example, in School A, a whole class size of 50 was divided into two groups to conduct an experiment to test for the presence of starch in a leaf. Few students were seen doing the activities while the rest were less active either lying on the desk or watching what was going on in the group. Out of the twelve focus groups only one of the groups mentioned the teacher providing them with teaching aids and relating the topic taught to their daily life. Teachers' practice in Gambian UBS science classrooms from the student's perspective could therefore be regarded as more didactic than student centred based on their students account of their lessons. The next section is the second phase on Friedrichsen et al.'s (2011) model of STOs and it presents and discusses students' views of science and their beliefs about the teaching and learning of science.

5.3 Phase 2: Friedrichsen et al. (2011) model of STOs

This section analyses the data using Friedrichsen et al.'s (2011) STOs and focuses the data presentation and discussion on the two themes. It is important to note that the goal and purpose for teaching science is deliberately ignored under this phase as it has nothing to do with students because they are not the teachers. The themes presented are students' views of science and their beliefs about science teaching and learning. Theme 3 is the students' view of science as difficult, important, interesting and good subject, and theme 4 is the students' beliefs about science teaching and learning involving explanation, asking questions, participation and discussion, doing practical work and group work.

5.3.1 Theme 3: Views of Science

Sub- Theme: Beliefs and values about science

Code 1: Science is difficult (ST2, ST3 and ST6)

The focus group data indicated that students from three out of the twelve focus groups commented that science is difficult. Students commented as follows:

Student's from T2: *Yes, because there are larger numbers of students offering arts because it's a simple field to do and science there is not much doctors in the Gambia, not much qualified doctors because everybody feels like it's a very complicated field, it's very difficult to tackle with. So, that's why I myself I want to oppose it.*

Student from T3: *Most of the time also the physics and chemistry part are very tough, the calculations.*

Student from T6: *Science is one of the core subjects here and every student sometimes feels that science is a difficult subject but with that I don't think so. Science is not a difficult subject, is just a matter of reading and understanding.*
Student from T6: *Science is easy and we have some students who said that*

science is difficult but it is not that, it is based on your studies and how you focus in class or how you participate in class.

Code 2: Science is important, interesting and a good subject (ST1, ST2, ST3, ST4, ST5, ST7, ST8, ST9 and ST12)

The focus group data showed that nine out of the twelve focus groups of four students commented that science is important, interesting and a good subject. Below are some of the statements made during the focus group:

Student from T1*: I have seen that science is a very good subject. Science in the school helps us a lot. Science in our school here helps us in many things about to be hygienic. It helps us to know the things in our body. Science is an important subject. It tells us parts of our body and their functions, like the heart, lungs, kidneys and our alimentary canals. It tells us so much a lot of things about ourselves and day to day activities.*

Student from T2: *Science is a very important subject because it helps us to know many things like it help us know the health issues of ourselves, we know so many diseases and their causes and that is a very important thing and we know how to take care of ourselves and all is because of science and it helps us to invent new materials like these cars and they are all important, so I think science is very good subject that is needed in the school, yes.*

Student from T5*: Is a nice subject. Without science you cannot have good life. Without science you cannot have good jobs.* ***Student from T5:*** *It makes human beings to know their body well.*

Student T9*: Science is a very, very important subject in our everyday life. Through science we can be able to have scientist, doctors and all other things.*

Student from T9*: But now science has developed a lot you can be here and get up anytime and go somewhere else. Vehicle are available, aeroplanes, things are working. Now you can know the amount of medicine to take in and foods to eat a lot of things science have done in this world.*

Student from T9*: They are very, very right without science you cannot have these aeroplanes, cars because they are all made by scientist. You have these medicine vaccines they were made by scientists. Without the help of science, we will not be able to have scientist who will help us. Even this telephones, electricity we are* *benefiting from today were made by scientist who sacrifice their lives for the generation.*

***Student from T10**: Science is very interesting, my best subject is science and I pass it always so I like it. **Student from T10**: It is very important; I like science because with science you study many things in our lives. Science is very interesting and very important. **Student from T10**: Science tells us about body, our daily lives, and about our environment around us. Science is really good. **Student from T10**: Without science you cannot be a doctor. You have to learn science before you become a doctor.*

5.3.1.1 Discussion

Student from T6's class does not have the view that science is a difficult subject, but acknowledges the views of other students regarding science as difficult. The student from T2's class acknowledges science as difficult for his colleagues which results in many of them specialising in the field of arts instead of science. Students from T3's class equally described the calculations involved in physics as tough. This corroborated with what teachers said during the one to one interview about their students that science is difficult. This finding concurs with the view made by students that physics is mathematical in nature, difficult, boring and irrelevant (Williams et al., 2003, cited in Owen et al., 2008, p. 114).

Students perceived science as significant since according to them science enables them to know the parts and functions of the body, helps them to improve their hygiene, helps them to know about their health and could earn them a good living. These beliefs and values about science correspond to the common views stated by participants using Friedrichsen et al.'s (2011) STOs. Students' positive views about science as a subject also correspond to other findings made by Jenkins and Nelson (2005) in which students perceived science as useful and beneficial. Thus the findings from this study were in accordance with the findings made by Jenkins and

Nelson (2005) where students indicated the relevance, significance and interest they have for science and also regard their science lessons as useful for their daily life and how to take care of their health.

It can be concluded that students' view of science is both negative and positive. It is negative when they regard science as difficult. This may result in individual students having a lack of interest in the subject and fear of failure of the subject. The positive side of the students' view of science is the recognition of the significance and values they attach to science. Students believe that one can only become a medical doctor if you specialise in science in order to support the sick. The next section presents the data on students' beliefs about science teaching and learning.

5.3.2 Theme 4: Beliefs about science teaching and learning

Sub- theme: Best ways students learn

Code 1: Doing practical / experiment (ST1, ST2, ST3, ST8, ST9, ST11 and ST12)

The focus group data showed that students from seven focus groups out of the twelve stated that they learn science best by doing practical / experiment. Below are examples of statements that the students made during the focus group.

Student from T2: *The most important thing we want now is any topic that they teach let them bring along materials, like this experiment so that we can see what is actually happening instead of. Let them improve on that. Yeah, instead of teaching theoretically, just verbally like that explaining.* ***Student from T2:*** *The practical aspect, like when there is, they always conduct practical like when it comes to experiment you get more interested in the subject, the practical will help us to see exactly what he is talking about, it helps to be interested.* ***Student from T3****: I think it is the experiment. How he teaches and the teachers' motivation. How effective the class will be.*

Student from T9: *I enjoy all the aspect of science in fact the most part I enjoy is the practical part. We do experiment, this experiment if you do them once they will be part of your life. In the future generation for example in the exams when they bring questions your mind will be able to remember it. The apparatus you use the step you take so that is why I said that I enjoy the practical part a lot.* ***Student from T9:*** *Yeah, as xxx said things that can help you to learn science very quickly and understand is the practical because once you see you remember. As the proverb says things that they tell you is not factual, but what you see yourself is factual.* ***Student from T9:*** *Me also I believe in proofs with these materials if you hear or see them in books they might be right, but if you yourself see it and you are doing it that is the best thing for me and I enjoy them a lot.* ***Student from T9:*** *Things that make us to learn a lot is these materials and the equipment.*

Student from T12: *When you lack science materials. When the teacher explains whilst the materials are not there, it will be difficult to understand but if you have the materials, you can easily understand.*

Code 2: Group work (ST1, ST4 and ST11)

The focus group data showed that students from three focus groups out of the twelve commented that they learn science best when they work in groups. Below is the statement made by some of the students from the focus groups.

Student from T1: *In the science lab, you can go to your teachers, ok ask your teachers. Sometime teachers explain and you do not understand but when it is group work like this when our fellow students are also explaining you have better understanding.*

Student from T11: *It is supposed to be practical so that you can see the instrument he is talking about and know what it means. He discusses with us in the class properly and we understand the lesson. You study hard. Through explanation, group work and discussion during practical.*

Code 3: Participation and discussion (ST4 and ST12)

The focus group data indicated that two focus groups out of the twelve mentioned that they learn best through participation and discussion. Below are comments made by some of the students from the focus group.

Students from T4*: Concentration. When the teacher is explaining you concentrate and listen to what he is saying. Participating in class lessons through discussions, and also asking questions if you don't understand.*

Student from T12: *You participate in science when the teacher is explaining, or if you see something in science and you don't understand, you can ask a teacher to explain so that you can understand it.*

Code 4: Asking Questions (ST3, ST4, ST5 and ST12)

The focus group data showed that students from four focus groups out of the twelve said that they learn science best by asking questions. This is what was gathered from the students:

Student from T3*: There are various ways in which I learn science. As a scientist, one of the qualities of a scientist is that you have to be curious. I tried to be curious like if someone said something I tried to question and ask about what you have said to know more about that particular thing. Mr xxx is someone who can explain a lot. He helps me to learn science and as I said I ask a lot and my father is a literate in science so most of the time I go to him and ask him if I have doubts in many things. Last but not the list I myself I have to read my books too, reading your books also make you to understand more*.

Student from T5: By studying it, by asking questions, by reading it, by learning.

Code 5: Explanation (ST1, ST2, ST3, ST4, ST8, ST11 and ST12)

The focus group data also indicated students from seven focus groups out of the twelve commented that they learn science better through explanation. Below are the statements obtained from students:

Student from T2: *Is when teacher is explaining and at the same time bringing materials to show us exactly what he is explaining, like what we did here, this practical and sometimes when you don't understand what he explains, you can go on asking people how to make an experiment for you or you can go to the internet and research then you see the images then.*

Student from T3*: I learn best through the teacher explanation, when he explains it perfectly through to my own understanding and level. I understand it better than* *reading the books. Through his explanation I understand more than going through the notes.*

Student from T12: *If you don't know something and you ask someone about it about science, you ask the teacher himself about it so that he explain properly.*

5.3.2.1 Discussion

The students' opinion was sought to find out how they learn science best. In order words their best learning strategy. From the data the best and most common way students learn science was through the conduct of experiment/ practical work. This was mentioned by seven out of the twelve focus groups, group work mentioned by three focus groups out of twelve, class participation and discussions mentioned by two focus groups, asking questions by a total of four focus groups and explanations complimented by teaching aids mentioned by seven out of the twelve focus groups. These findings relate to teachers' beliefs about science teaching and learning. Hence they believe that students learn science well through group work, asking and answering questions, conduct of practical and other learning strategies that will be presented and discussed in detail under chapter seven. The students' view is that practical work enables them to remember what they learn. This finding is similar to the views stated by the teachers during the interviews. This finding concurs with the findings made by Toplis (2012) in which students mentioned that practical work enabled them to retain what they have learnt in science compared to other learning approaches. A similar finding was also recorded by Murphy and Beggs (2003, p.113) in which students stated that experiment helps them to remember new things and enables them to understand in more detail compared to notes copying. This finding shows how crucial students found experiment / practical work in their science lessons. These remarks were made by students from both category of schools.

Another finding from the focus group data that students believe makes them learn best in science is group work. It is through group work that students are able to exchange their ideas, share their knowledge and support one another. Students believe that group work promotes discussion and they are able to learn from each other more than from the teacher. These findings correspond with Darby's (2005) findings in which students indicated that they are able to interact with their peers and are able to share their ideas or knowledge during class discussion. Involving students in group work and encouraging them to participate in discussion will increase their level of engagement in class. Group work is pinpointed by Brandes and Ginnis (1994, p. 33) as a key element of SCL environment where students sit in circular groups and are able to speak freely, express their opinions and share their feelings. This also correlates with the interview data about the beliefs the teachers hold of how science can be well learned by students.

The view about asking questions as a preferred way to learn science implies that freedom of expression in student centred classrooms is paramount. Students in an SCL environment are free to ask and answer questions in the classroom without any fear. This concurs with Brandes and Ginnis' (1994) SCL principles.

The final common findings across seven focus groups was learning science through explanation. However, the type of explanation as pointed out by students in this study suggested teachers use physical materials/teaching aids to help their understanding. It is through clear explanation from the teacher that students' misconceptions and errors are rectified. This is in line with Magnusson et al.'s (1999) student centred orientation as mere explanation to students only will be didactic. It can be concluded that the best ways students learn science are through student centred learning practices and principles. Hence SCL strategies involve what the students believe are their preferred way of learning science which is doing practical work, group work, participation and discussion, asking questions and explanation using concrete objects. The next section gives a data presentation of the difficulties and challenges in learning science, and this is followed by a detailed discussion of the findings.

5.4 Phase 3: Data not picked by the two models

This section presents and discusses the data from the focus groups that were not picked by Magnusson et al. (1999) and Friedrichsen et al. (2011) mode of STOs. The data shows the difficulties and challenges students encounter in the learning of science. These were the findings: lack of basic science apparatus, lack of practical work, prioritising the senior secondary level students, students' inability to pronounce scientific terms, numerous diagrams to remember in science the mathematical nature of science. These challenges were also similar to what their teachers mentioned about the difficulties they have in practising SCL during the interviews.

5.4.1 Theme 5: Difficulties and challenges in learning science

Code 1: Lack of basic science apparatus (ST2, ST3, ST7, ST8, ST9 and ST12)

The focus group interview showed that students from six focus groups out of the twelve stated the lack of basic science apparatus as an obstacle to learning of science. Below are few statements obtained from the data:

Student from T2: *Yea, like the way he teaches it is like its perfect but when it comes to practical parts like we are not that much, like we are not having that much of those materials to use for, we use for experiment so we don't see much of the practical side when it comes to like physics some of the chemicals we never saw them.*

Student from T3*: I think we have good teachers but the only problem is we don't have enough facilities. Like in grade seven giving us the apparatus for us to do the experiment was the only thing lacking but apart from that everything has been fantastic. We have experience teachers and that is all.*

Student from T3*: Science lessons are good and is really effective, as he said like this experiment we did should have been done long ago since in grade 7. Going to class having our lessons is very good we don't have any problem with that****.***

Student from T3*: The only thing we are lacking is the apparatus and the experiment we are supposed to do since we were in grade 7 and 8 but thanks be to God and I believe that everything is fine with us.*

Student from T3*: Yes, our science teachers are very good teachers when they are teaching us we always understand but only thing is the apparatus since we were in grade 7 and 8 we don't use to conduct experiment only teaching but their teaching is always fantastic.*

Student from T8*: Yeah, like this scientific instrument some of them we do hear about their names but we do not see it physically.* ***Student from T8****: Like the Bunsen burner me, I have never seen it.*

Code 2: Lack of Practical work / Experiment (ST2, ST3, ST7, ST9 and ST10)

The focus group data showed that students from five focus groups out of the twelve commented that they lack practical work / experiment in their science lessons. Below are statements obtained from the focus group:

Student from T2*: Let's say once in a year, once…. very rare. Very rare.*

Student from T3: *Only a few I can remember one or two since grade 7.* ***Student from T3****: For the past grades we have not it is only this grade 9 that we have started doing some.*

Students from T10*: This is the first time we have done practical in grade 8. In grade 7 we had three practical.*

Student from T9: *For example, if you don't have materials in class, you cannot have your practical so it will be very, very difficult for you to understand things.*

Code 3: Prioritising the Senior Secondary level (ST2)

The focus group data indicated that students from one focus group out of the twelve stated that the teachers prioritise the senior secondary school over the upper basic school when it comes to the conduct of practical work.

Student from T2: *For the Upper Basic School, we are not allowed to use the Chemistry labs and other labs because it's for Senior level they are the ones who have physics practical exam.*

Code 4: Inability to pronounce scientific terms (ST1 and ST8)

The focus group data showed that two focus groups out of the twelve commented that they are challenged with learning science due to their inability to pronounce scientific terms. Below are the comments obtained from students:

Student from T1: *Some parts have this big word that people cannot pronounce and cannot capture it. Pronunciation of the scientific terms.*

Student from T8*: This thing the biological words.* ***Student from T8****: This Oxford dictionary sometimes when madam pronounces a word if you check them you cannot find them. Like the words are difficult to pronounce.*

Code 5: Numerous diagrams to remember in science (ST10 and ST11)

The focus group data indicated that two focus groups out of the twelve stated that their difficulties in learning science are to do with the numerous diagrams to remember in science. Below are some of the comments made by the students:

Student from T11: *Science my problem is labelling the parts; the diagrams are many.*

Students from T10*: Remembering of the parts and functions of the numerous diagrams in science.*

Code 6: The mathematical part of science (ST3)

The focus group data showed that one out of the twelve focus groups of students stated that the mathematical part of science makes it difficult for them to learn science. Below are the statements made by the student:

Student from T3*: Most of the time also the physics and chemistry part are very tough, the calculations.*

Student from T3*: Well I can see that I am not very good in mathematics and that is why I want to do commerce. Apart from that I would have love to specialise in science.*

5.4.1.1 Discussions

The findings from focus group data revealed key and common issues that they felt hampered their lessons in the teaching and learning of science. These common features included the lack of simple basic science apparatus, lack of practical work / experiment, inability to pronounce scientific terms, numerous diagrams for students to remember in science, prioritising the senior secondary level, and the mathematical nature of some parts of the science syllabus.

The lack of basic science materials in schools seems to result in theoretical teaching mainly talk and chalk method as students described their lessons. Similar comments were also made by students from schools with less resources and those operating without an equipped science laboratory. This finding was in correspondence with the qualitative data findings by Barmby et al. (2008, p. 1088), which revealed the lack of practical in science lessons as perceived by students. This seems to suggest that science is learnt more in the form of theory than practical work, hence the students from T8's classroom attesting that they have never come in contact with some of the apparatus like a Bunsen burner. This student comes from an inadequately resourced school. Furthermore, practical work/ experiment is hardly conducted by teachers in schools whose laboratories were well equipped either. This is evident from the comments made by ST2, ST3, ST7 and ST10. When I asked the students how many times they held an experimental lesson, students responded in the negative that they hardly conduct practical work. This suggested that teachers from equipped science laboratories do not seem to be engaged with their students in practical work which does not suggest much difference from their counterparts in schools that are faced with inadequate basic science materials. The adequately resourced schools each had three labs: biology, physics and chemistry labs.

In this study all the six schools involved were similar in nature and have both Upper Basic School (UBS) and Senior Secondary School (SSS) running concurrently in one school. At the UBS level, the final exam that candidates sit to known as the Gambia Basic Education Certificate Examination (GABECE) does not involve final year candidates conducting experiment in science. The science papers are theoretical and most of the questions require recall of knowledge. However, this is not the case at the SSS level exam known as West African Senior School Certificate Examination (WASSCE). This exam requires the conduct of practical and for this reason some of the schools give priorities to SSS level candidates conducting experiments in order to adequately prepare their candidates. Therefore students are leaving the UBS level without much engagement in practical work due to the limited resources that the schools are faced with. A student in School A mentioned about the school giving more attention and priority to SSS level students because of the final year student involvement in the conduct of international practical exams. This corroborated with what the class teacher mentioned during the one to one interviews as being a result of the inadequate resources confronting the schools.

This comment was not common to all the six schools, since one of the schools was not offering pure science to students at SSS level, but unique to the rest of the school except school C. This is because school C is well equipped with an overall average of 25 students per class. However, it can be argued that students could do better at UBS level if they were exposed to practical, hence according to Osborne and Collins (2000) practical work would enable students to more easily retain what they have learnt and become autonomous learners. Additionally, taking into account Magnusson et al.'s (1999) student centred orientation involving practical work and the absence of such in science lessons would mean teachers' use of didactic traditional teacher centred in their lessons instead of student centred. This finding concurs with Toplis (2012) who pointed out that the lack of basic science apparatus, inadequate models and limited laboratory experience could hinder the conduct of experiment during science lessons. Hence schools with laboratories were still managing with the little resources they have due to the large number of students.

Another finding students deem a challenge to the learning of science is the pronunciation of scientific words or terms. The students felt that certain terms used in biology are difficult to pronounce and such terms cannot be found in a dictionary for them to quickly gather the meanings, thus making the learning of science difficult.

Another challenge that the students are confronted with in the learning of science is the numerous diagrams they are expected to learn and label parts on and note their functions. It can be argued that science involves numerous diagrams and knowing their parts and functions is required by the students. During exams diagrams are drawn in which students are asked to name the parts and state their functions. Students were also quick to note physics as mathematical, and because they find mathematics difficult, students enjoy Biology more than the Physics and Chemistry parts of the syllabus. This was indicated in the data when students were asked to mention the topics they found interesting and enjoyable to learn. When asked to describe the topics they found interesting and enjoyable in their science lessons, students mentioned Biology topics more compared to Physics and Chemistry. This suggests that the Biology part of science was more popular with students than Physics and Chemistry which students described as mathematical in nature. Students' view is that biology topics are related to their bodies which they tend to develop more interest in. The following topics were the most common that students find interesting and enjoyable to learn: circulatory system, adaptation, changes of state of matter, energy, reproductive system, force, animal, human body, unicellular and multi-cellular organism, plant and animal cell.

5.5 Summary

In conclusion, this chapter presents and discusses RQ1 findings from the focus groups data to examine the extent to which Upper Basic School students' perceptions of their science classes relate to SCL pedagogies. The findings suggested the use of teacher centred method by teachers. This is true of schools that are both well resourced and under resourced. The findings revealed that science lessons were didactic, involving the teacher telling, showing, talking and explaining to students without any level of student engagement. The focus group mentioned this view more frequently than the elements of SCL practices used by teachers except group work which was not very effective due to their large size in nature.

Students' view of science was both positive and negative. The findings indicate that students view science as difficult but at the same time recognise its importance and see science as interesting and a good subject. The findings also revealed practical work as the best way in which student learn science. However, this was lacking in their science lessons but they believe that practical work enables them to remember what they have learned. Group work was seen as a preferred way of learning science where they share their ideas and experiences during discussion and conduct of practical work, thus increasing their level of participation in the lesson. The freedom of students to ask questions and seek explanation was regarded among their preferred learning strategies. These methods of learning as identified by students correspond with SCL principles. The final part of the findings indicated the difficulties that students have in learning science which corroborates well with the findings from the interview data with teachers. This includes lack of basic science materials, conduct of few or no practical, prioritising SSS students due to the international exams that they sit, inability to pronounce scientific terms, numerous diagrams to remember and the mathematical nature of science. These factors particularly the lack of materials resulted in use of teacher centred method by eight out of the twelve teachers who participated in this study. The evaluation of RQ1 is found in chapter 8.

Chapter 6: Data Presentation and Discussion

6.1 Introduction

This chapter is the data presentation and discussion for RQ2: In what ways do science teachers' own perceptions of student centred learning influence their classroom practices? Theme 1a presents and discusses data provided by each individual teacher based on their interpretation and understanding of SCL. This is to find out their level of understanding of SCL. This is followed by Theme 1b which presents and discusses the data about teachers' beliefs of SCL. The next, Theme 2, presents and discusses the data about teachers' understandings of teacher centred method. This was to see if teachers are able to compare and contrast the two methods without any conflict. Theme 3, is on student centred orientation and this section examines teachers' classroom practice to see if this was related to their perception of SCL. Finally, Theme 4 further examines the key factors that impede their classroom practices which lead to some of the teachers' use of teacher centred practices to some extent. Firstly, I will present the background information of the teachers which will be followed by the data presentation and discussion.

6.2 Participants' background information

A total of twelve science teachers were drawn from six Upper Basic School within region one- Greater Banjul area and region two- Kombo area in the Gambia. All the teachers selected obtained a qualified teacher status with Higher Teachers' Certificate (HTC). In the Gambia teachers with such professional qualifications teach at Upper Basic School level of the education system. The participants comprise ten male teachers and two female teachers altogether. Out of these twelve teachers, two male teachers obtained a bachelor's degree in one of the physical sciences. The teachers have accrued different numbers of years of teaching experience ranging from two years to fourteen years. All of them also had some form of professional development training either in the form of school based workshop, training organised by other international organisations, training offered to teachers abroad, or training organised by the Ministry of Basic and Secondary Education (MoBSE). For the purpose of confidentiality, pseudonyms were given to participants and the schools they teach in by assigning a code to each of the twelve participating teachers and the six schools they came from. Thus, the names of the twelve participating teachers were coded as T1 -meaning Teacher one, T2, T3, T4, T5, T6, T7, T8, T9, T10, T11 and T12 respectively. The schools where each of the participating teachers were selected were given the codes School A, School B, School C, School D, School E and School F. T1, T2 and T3 were drawn from School A; T4 and T5 from School B; T6 and T7 from School C; T8 and T9 from School D; T10 and T11 from School E, and T12 from School F.

6.3 Theme 1a: Teachers' perception of Student Centred Learning

Sub-Theme: Science teachers' understanding of Student Centred Learning

This section is descriptive as it presents the data obtained from each teacher and gives a detailed discussion of each teacher's understanding and interpretation of SCL. Student centred learning (SCL) is understood and interpreted differently by many scholars from the literature. This varied interpretation and understanding also reflects the Gambian science teachers' stance on SCL. The data obtained from the interviews conducted with twelve teachers in the Gambia revealed varied interpretations and a fair idea of what is considered as SCL by teachers. When teachers were asked about their understanding of SCL in an interview, the following responses were gathered:

T1*: Ok first of all, the teacher needs to give the student group work, whether two students sitting together discussing, or 5 or 10, depending on how the teacher wants to do it, but at least, a number of students must come together, sit up and discuss what you need them to discuss. Like the topic at hand, after discussion, one or two must present the activity they have done which enables them to at least bring the different ideas they have to showcase the main points which means the topic at hand, at least. After that presentation, the teacher explains or summarises for better understanding of the students.*

SCL seems to be understood by T1 as involving group work, group discussions and presentations, and the teacher giving an explanation and summary of what is done to foster understanding. Group work, discussions and presentations are elements of SCL as these involve and encourage student participation, which are necessary for learning (Brandes and Ginnis, 1994). These are also in correspondence with Magnusson et al.'s (1999) student centred orientations which can be activity driven and inquiry based orientations. However, the explanation and summary giving as part of T1's understanding of SCL seems to differ from SCL principles and corresponds to the didactic orientation which involves explaining and telling as pointed out by Magnusson et al.'s (1999) model. This finding was also similar to the data obtained from a focus group of four students from his class. Another interpretation of SCL by T2 reads:

T2: *When we talk about student centred learning, it means the student should participate, interact and get involved in the learning process. As a teacher you are there to guide, you are not there to impose, so you have to tap from their minds and then guide to the right and appropriate information of what you want them to know.*

T2's understanding of SCL seems to suggest that students are participatory, interactive and involved in the process of learning. He also stated the role of the teacher as a guide to students, which is one of the fundamental principles of SCL. T2's understanding of SCL seems to be consistent with SCL principles where involvement and participation are necessary for learning, and teacher becomes a guide (Brandes and Ginnis, 1994). This also concurs with Magnusson et al.’s (1999) student centred orientations and could involve inquiry based, discovery based and activity - driven orientations since the role of the teacher is to guide and therefore this relates to the constructivist approach of learning.

T3: *My understanding is that you give more room to the students to interact with materials, see the materials, or learning materials or try to eeh, give their own conclusions. Or in short you know is like learning by interacting with materials and coming with their own ideas about how they perceive things with regard to that particular area. Yes, it doesn’t mean that the teacher has to come to class and do all what not in the class without involving the students but you allow the students to learn or do certain things to be able to achieve something on their own with the guidance of the teacher.*

T3 seems to understand SCL as interactive and involving students while the teacher guides. This interpretation of SCL by T3 seems to concur with Magnusson et al. (1999), student centred orientations, which could be activity driven and inquiry orientations, and also in line with the constructivism as the philosophical theory underpinning SCL which pointed out teacher’s role as a guide and student interaction as key to SCL approach (Bates, 2016). Comparing and contrasting the last two interpretations of SCL, it seems that both T2 and T3 have a common understanding of SCL as involving and interactive for students with teacher as a guide. However, T4 understood SCL differently and this was what he mentioned when asked about his understanding of SCL:

T4: *According to my understanding not every student centred learning involves practical but every practical should be student centred or must be student centred just like this one here. Student centred learning as the name implies teaching students but it will be ammm teaching students but giving chance to students themselves to express themselves more, to conduct, you conduct the lesson. You the teacher you will not be like the teacher giving direct information. You will only be guiding the students like if you want to do practical. For me that is student centred students themselves doing the work, doing more work, doing more of the talking than* *the teacher, that is my understanding…. students learning on their own with the help of few points from the teacher.*

T4 seems to suggest that practical work is student centred and that students are allowed to express themselves during lessons and the teacher becomes a guide to students. T4's understanding of SCL, citing the teacher's role as a guide and the democratic nature of student centred, are fundamental principles of SCL which is in accordance with Singh (2011). Practical work is fundamental and key in science lessons and taking into account Magnusson et al.'s (1999) student centred orientations, practical work could mean the use of two or more of the orientations which could be activity driven, inquiry and discovery based. However, his understanding of SCL as teaching students seems confusing, as particularly if it means transmitting knowledge, then that may imply didactic or teacher centred and not SCL approach. Therefore, one can draw a conclusion from T4's understanding of SCL that it could mean instructional and at the same time with facilitation. However, T5 seems to have a very narrow view about SCL during the interview. Below is a statement obtained from T5:

***T5**: For me student centred method is whereby students do the work on their own. The job is being done by the student more than the teacher.*

T5's interpretation of SCL seems very unclear since work given to students either teacher centred or student centred will be done by students. It does not seem to relate to any of the SCL principles by Brandes and Ginnis (1994) or Singh (2011) and does not link to any of the student centred orientations of Magnusson et al. (1999). This indicates the limited understanding of SCL by T5. Another interpretation of SCL by T6 states:

***T6**: Student centred learning is a kind of a learning which is very conducive for students where students are not seated rigidly at one place throughout the entire* *class but students take control of the class, they take charge of the class, have access to resources, have that atmosphere of discussing together where the teacher come and guide them too but it is not a situation where everything all explanation from A to Z is being masterminded by the teacher, no. Much room is given to students for students to work together as a group harmoniously.*

T6's understanding of SCL seems to involve a flexible seating arrangement in class where the students have access to resources and take charge or are in control of their class. The students have the freedom to discuss in class with teacher acting as a guide. It also seems to suggest less teacher talk and more student talk and working in groups. T6's definition of SCL seems to be in correspondence with Brandes and Ginnis's (1994) SCL principles and ideas and also with Schuh (2004), student centred practices, there is more or equal student talk and questions than the teacher. This corresponds to Magnusson et al. (1999), student centred orientations, and could include activity driven orientation, conceptual changed orientation and inquiry. T6 seems to have a similar interpretation of SCL as T7's. Below is a comment obtained from T7:

T7*: I think for that area we will just allow the students to do most of the activities on their own rather than teacher doing the whole process. So if it is a lesson whereby it is child centred the students need to get involved, they need to do the work, you're just there to guide or to support them yaa and I believe for science lessons the best lesson should be a lesson which is a child centred lesson, give them the materials tell them how to do it and leave them to do it on their own.*

From T7's comments SCL could mean learner centred. T7's understanding of SCL seems to suggest that students are involved and do most of the activities on their own while the teacher becomes a resource person where he provides students with materials and guides or supports them. This interpretation of SCL seems to be in correspondence with Singh's (2011) SCL principles and Magnusson et al.'s (1999) student centred orientations. T8 seems to take a different view about SCL. This is what was stated:

***T8**: What I understand by student centred learning is that the teacher should always seek the consent of the students on whatever topic one is teaching, like if I go to class, I should not do all the talking. I should listen to their understanding of the topic and from there we explain together and come to conclusion. That is what I understand from the term student centred learning.*

It is not clear to me as to what T8 meant by seeking consent from the students. Does it suggest asking for endorsement from students as to what to teach? Is it suggesting giving students the option to choose a topic to be taught? However, in the extreme SCL approaches the teacher does not have to teach, but allows students to choose topics that they want to learn. T8's understanding of SCL that the teacher should talk less in class seems to be part of the student centred classroom environment as pointed by Schuh (2004). Below is T9's understanding of SCL:

***T9**: … student centred learning, normally in any lesson that I normally start with I have to review any previous lesson that I treated with them and try to connect it to the recent one that we are currently treating. In that we do brainstorming session. When we brainstorm we sometimes even enquire from the students their prior understanding on some of the things we do in class. Then we do the activities, some small scale experiment and we improvise materials. Sometimes I do explain and demonstrations in most case as well. Those are some of the teaching methods I do in the school here. Most of the students are involved that is why I say I used the student centred approach.*

T9 understood that SCL features involve reviewing lessons taught and linking it to the current lesson, brainstorming, finding out students' prior understanding, conducting activities, experiments and improvisation of materials, demonstration and explanation. T9's interpretation of SCL seems to include both key elements of student centred classroom environment and a resource person - a key principle which is in correspondence with Singh (2011) as teacher is suggested to improvise materials for students. At the same time these characteristic features of SCL are in agreement with Magnusson et al.'s (1999) student centred orientations. This is because the teacher demonstrated the use of activities and experiments and these are seen as an activity driven, inquiry, and discovery based orientations. Below is what T10's understood about SCL:

***T10**: Well according to my understanding in child centred learning the teacher only serves as a guide and you can probably give the children the instructions or the guidelines as to how things are supposed to be done and the children will carry out the activities on their own while the teacher observed. Where they are about to deviate from in terms of instructions if instructions are given, if the children are about to deviate you can put them back on track that no this is not the way to go or take this other way as it should be done and then you allow them to carry out the activities. **T10**: The term student centred learning is a learning process in which the child takes the lead in being involved in the activity rather than the teacher taking the lead in the conduct of the activity in a class. That is my understanding of the term student centred learning*

T10 seems to suggest the teacher's role as a guide, which is in correspondence with constructivist model of learning. Both T7 and T10 seem to suggest that SCL could mean child centred learning. T10's understanding is that the teacher should give instructions for the student to conduct activities on their own.

***T11**: Now when you talk about student centred learning according to my own ideology. If you look at percentage you should be in class, introduce the topic, allow the students to do the work on their own. For example, if I decided to look at flotation which talks about liquid and substance that floats in water. So you can introduce the topic and let them do the talking. You the teacher should not do everything; do the talking, writing and other activities. Involving the students themselves, you should just help them to simplify things so that they can understand them.*

T11 seems to suggest that SCL involves less talking and writing by the teacher and the students conducting activities. This seems to be in correspondence with the student centred classroom environment pointed out by Schuh (2004). The conduct of activities could mean having one or more orientation as pointed by Magnusson et al. (1999). Finally, this is what T12 mentioned when he was asked about his understanding of SCL:

***T12**: Well what I understand is that where students will participate. They will not be spoon-fed… They have to take part and participate in the discussions or whatsoever* *in class because some of those kids, they know something which the teachers themselves don't even know. So when you involve them, that's the time you realise that. You learn from them also.*

This particular teacher's understanding of SCL is that students should not be told but rather should take part and get involved in discussions which is in correspondence with Zain et el. (2012), Singh's (2011) definitions of SCL and Brandes' and Ginnis' (1994) SCL principle on students' involvement and participations. These interpretations are also in line with activity-driven, inquiry based and discovery based orientations, which according to Magnusson et al (1999) are classified student centred orientations.

6.3. 1a Discussion

The various interpretations and understandings of SCL by these teachers seem to indicate both convergent and divergent perceptions of SCL. However, to some degree, some of these teachers do have some understanding of SCL principles and practices which were in correspondence with the literature and the student centred orientations by Magnusson et al. (1999). The definitions and interpretations of SCL obtained from the science teachers involve students working together in groups, this was mentioned by three teachers (T1, T4 and T6); the teacher's role as a guide and support. This is mentioned by eight teachers (T1, T2, T3, T4, T6, T7, T10 and T11). While six teachers (T2, T3, T7, T9 T10 and T12) understood SCL as encouraging student participation, interaction and involvement in the lesson, two of the teachers (T2 and T4) mentioned that students should express themselves freely. T4 perceived practical work as SCL. T7 views that activities should be conducted by the students while T8 and T11 opined that teachers should do less talking and writing. Considering their differences in their interpretations, some teachers felt that students should be facilitated while others perceived that they should be instructed during practical work. In conclusion the interpretations given by teachers concur with the student centred learning definition adopted in this study in the context of the Gambia. Out of the twelve only T5 did not have a clear understanding or interpretation of SCL. The next section presents the data obtained from the one to one interviews and gives a detailed discussion of the teachers' beliefs of student centred learning.

6.3 Theme 1b: Teacher's Perception of SCL

Sub- Theme: Teacher's beliefs about student centred learning

Code 1: Student centred learning is the best approach (T3, T7, T8, T10 and T11)

The interview data showed that five teachers out of the twelve commented that student centred learning is the best approach. Below is the remark made by the teachers:

T3: *The child centred approach is the best because students learn by themselves. Sometimes they come with ideas which even you don't know.*

T7*: I believe that the child centred method is the best because students they learn through what they see and what they do on their own.*

T10: *Child centred method is the best, it actually helps children very well. Is like a child is discovering for himself, what you are discovering for yourself is normally maintained in your memory for a very long time rather than somebody discover something and tells you that this and this is what happened. Is better you conduct the activity and discover for yourself. So actually that is what we are employing in our class, we are deploying child centred learning.*

T11: *They understand better with the student centred than the teacher centred.*

Code 2: Student centred learning develops students' thinking ability (T12)

The interview showed that one teacher out of twelve perceived that SCL develops students' thinking abilities and skills. Below is the statement made by T12.

T12: *They will not be spoon-fed where they participate. To develop their ability of thinking and so whereby the teacher will not be giving them… they will not be spoon-fed.*

Code 3: Students are able to support and learn from each other (T2)

The interview data showed that one teacher out of the twelve commented that students are able to support and learn from each other. Below is the comment made by T2.

T2: *That's why I said that the student centred approach is most appropriate because when they learn from each other and help each other it is more effective.* ***T2****: Yes, that is real, they do both. They ask their fellow colleagues to make things simpler for them and also they pose questions generally to the teacher during lesson deliberations.*

6.3.1b Discussion

This section discusses the findings on teachers' beliefs about SCL. Teachers believe that student centred learning is the best approach; it develops the thinking ability of the students and students are able to support and learn from each other.

In this study, the teachers were able to recognise the significance of SCL practices and did mention SCL as the best approach. Thus it is the teachers' belief that students understand better using SCL approach than other methods such as teacher centred. These comments are concomitant with the study conducted by Yilmaz (2008). T3 seems to emphasise the students' pre-requisite knowledge and skills that the students brought into class being considered in a student centred lesson while T11 believes that SCL fosters students' levels of understanding, and T7 and T10 believe that SCL is the best because it is more practical to students and learning by doing helps students to retain for longer what they learn, which resonates with Magnusson et al.'s (1999) student centred orientations.

The finding from this study that SCL develops students' thinking ability is in correspondence with Kim, 2005; Li, 2012 as cited in Metto and Makewa, 2014, p.24, who believe that SCL enables teachers to use different kinds of methods thereby increasing students' interest, motivation and involvement; supporting learners to think critically, take up the responsibility of their learning and retain what they have learnt.

T2's perception about SCL is in line with Brandes' & Ginnis' (1994, p. 15) SCL principle which emphasised the involvement of learners working in groups. This also concurs with Magnusson et al.'s (1999) student centred orientation such as activity driven, inquiry and discovery based orientations which encourages students' participation and involvement in the lessons, thus increasing student-student interaction to be able to exchange or share their ideas.

It can be concluded in this study that SCL is beneficial to the learners. Hence students are able to learn from each other and retain what they learn much easier through learning by doing.

6.4 Theme 2: Teacher's Perception of Teacher Centred Method

Sub – theme: Teachers understanding of TCM

Code 1: Teacher tells, talks and explains (T4, T7 and T10)

The interview data showed that three teachers out of twelve commented that in teacher centred method; the teacher tells, talks and explains. Below are the statements made by the teachers:

T4: *Teacher centred as you know is where the teacher will do more of the work, more of talking, more of giving to the students directly from him.* ***T4****: How do students participate in teacher centred learning apart from writing and listening and may be given chance later on to ask questions and answer questions finish.*

T7*: Yaa, it is quite different because a lesson whereby you just come to the class explain everything on your own.*

Code 2: Teacher does all the activities (T1, T2, T5 and T6)

The interview data indicated that four out of twelve teachers mentioned that in teacher centred method, the teacher does all the activities in class. Below are the statements obtained from the teachers:

T2: *With the teacher centred approach it means all the brainstorming, interaction, all the lesson presentation and demonstration is strictly done by the teacher. So you can see it's like when it comes to the teacher centred approach, it is all based on the teacher, the whole is delivered by the teacher not the students.*

T6: *Yeah teacher centred approach is a situation in class is like all the work is done by the teacher. The teacher spends a lot of time giving instructions. Students are rigidly seated at one place. They do not have freedom to work together, perhaps materials are not enough also enough for the topic or materials are not just given like that and then everything is dominated by the teacher and the teacher will always be counting for understanding not necessarily the application that the students can do*.

Code 3: Students are passive listeners (T1, T4 and T10)

The interview data indicated that three out of twelve teachers mentioned that in teacher centred method, students are passive listeners. Below are the statements obtained from the teachers:

***T1**: Teacher centred approach is far worse than child centred learning**. T1**: Because teacher centred approach you will realise that there is less activity you want to do with students or even no activity you want to do with students. The teacher does it all, he introduces the topic, explains the topic, he explains his diagram or presents his diagrams, at the end of the day he concludes his lesson while students are just there listening.*

***T10:** …teacher centred where the teacher stands and just talks to the children tell them everything for them to just memorise or try to copy, that is not actually not a good way of teaching.*

***T10:** But on the other side where you have teacher centred it's like the children are not actively involved, they are passive recipients of the information that the teacher is giving. The children will just sit possibly quietly and listen to the teacher as he elaborates and if it involves an activity the children will still be standing watching the teacher carrying out the activity while the children don't have a personal contact with the material.*

6.4.1 Discussion

This section focuses on science teachers' understanding of teacher centred method in order to be able to distinguish between student centred learning and teacher centred method. Teachers' perception of teacher centred method was interpreted as the opposite to SCL. T4's, T7's and T10's interpretations of teacher centred as teacher telling, talking and explaining concurs with Magnusson et al.'s (1999) didactic orientation, which is classified as teacher centred method, while T1, T2, T5 and T6 perceived teacher centred method as the teacher conducting all the activities and associating TCM as instructional, teacher controlled, regimental class, lack of group work and inadequate teaching and learning materials which corresponds to Magnusson et al.'s (1999) didactic orientation. T1, T4 and T10 interpret teacher centred method as not engaging students' participation and involvement in the lesson. Students are described as passive listeners and receivers of information who memorise what is taught by the teacher. The teacher is also described as the one who transmits information. This is in accordance with Schuh (2004) whose study focuses on a learning environment that may be considered as teacher or learner centred based on the activity in the classroom. These teacher centred instructions involve more teacher talk and questions. Students are usually regarded as passive listeners with no group work or discussion. Teachers' perceptions towards teacher centred method is negative compared to SCL, hence teacher centred method is described as a worse method of teaching students as alluded to by T1.

6.5 Theme 3: Student centred orientation

Sub -Theme: Activity driven and process

Code1: Use of local materials and diagrams

The interview data showed that T1 commented on the use of local materials and diagrams as part of his classroom practices. Below are T1's comments:

T1: There are some topics in the science, locally you can get materials so it depends with the topic that you have, so if the topic enables you to get materials within the surrounding then you might be able to get the materials. That is why I did say, you realise that in most of our classes we use diagrams because you teaching the science you realise that you will not have the materials.

Sub-Theme: Activity driven, project based and conceptual change

Code 1: Project work, teacher as a guide and student involvement and participation

The interview data indicated that T2 commented that his classroom practice involves project work, he stated that he guides his students and encourages them to participate and be involved in the lesson. Below is his statement:

T2: So I always make sure that they are involved, making the lesson learner centred not teacher centred. When it is teacher centred, it means all the suggestions, answers and manifestations come from the teacher but if they are involved in the lesson administration, it makes them belong, it makes them partake and it makes them interested in the lesson. The teacher is just there to guide and put them through but not to subject them to the lesson. T2: I gave each and every group a different topic and they go out to research and bring all the stuff and then we had a presentation. To me that was a project which they went to research about, write notes, get teaching aids and all what they require to do and then they came to class we sit together and then group by group did their presentation on different topics.

Sub-Theme: conceptual change and discovery orientation

Code 1: Students' response to questions, teacher guides and group work and discussions

Within the interview data T3 stated that his classroom practices involve students' responses to questions, guiding students, group work and discussions. Below is his statement:

T3: *What we do we ask students questions and then they respond, yes. At most case we ask them to discuss within themselves, try to find some kind of responses when they acquire those responses we give them the floor to express themselves. So when they express themselves I guide them on their mistakes or errors. Okay, that is how we normally teach them in the class based on child centred approach. And also more importantly we normally keep them or allow them to seat in groups. So if you go to the class you find out that the table are packed in such a way that the students seat in groups that makes it easy for us to teach them, yes based on child centred approach*.

Sub- Theme: Didactic, activity driven and conceptual change orientations

Code1: Theoretical teaching, explanation, and notes giving

Code 2: Use of materials, asking questions and discussions

The interview data revealed T4 makes use of theoretical teaching, explanation and note giving and at same time uses materials, asks questions and involves students in discussions. Below is the statement made by T4:

T4: *Since my science lesson is not much based on practical, is much based on theory I teach science using materials I have mentioned before. That is my mobile phone, that is internet, other textbooks, the pamphlets, which is of course guided by the curriculum or the syllabus to a particular grade. So preparing scheme of work and lesson plan, do that, then go into the class and teach them those objectives I have in mind which are also directly connected to the syllabus and to the curriculum. This is how I teach science in the school here. Discussions, asking questions, giving notes, explanations finish. This is the normal way of me teaching science.*

Sub-Theme: Activity driven and conceptual change

Code 1: Discussions and rectifying students' errors

The interview data indicated that T5's classroom practice involves discussions and rectifying students' errors. Below is the comment made by T5:

T5: *For me what I do is this, I will write information, I will write it on my instruction sheet do this and they follow the steps. They are the one to discuss on their own and know what to do. That is they are the one cracking their understanding and agreeing on one thing. Unless they failed or miss the point you rectify them. Which means you rectify their work, that is student centred learning*.

Sub-Theme: Process, activity driven and project based orientation

Code 1: Students involved and engaged in activities, students working together and conduct of project work

The interview data showed that T6’s classroom practice involves students working together, being involved and engaging in activities and conducting project work.

T6: *I make sure they involve and engage in the activities. Interact with the activities; they have a taste with the activities by touching it, feeling it, and working together as peers. T6: In our science lab we have solar kits where we have different electric gadgets like a bell, like a stand fan, like small radio. So normally we do the theoretical part in class were they are exposed to parallel and the like then know that this the voltage, this the ammeter, this is the resistor. These are the cells so after doing the theoretical part of it in the classroom they come to the lab take the materials outside and they develop their own solar system and they feel very happy when they see the results out of it that is done here many times.*

Sub- Theme: Activity driven, process and conceptual change

Code1: Provision of materials and guiding students

The interview data showed that T7’s classroom practices involve the provision of materials and guiding students. Below is the statement made by T7:

T7: *Normally I go over the topic and see the materials that are needed, I provide them from there, I see which methods I should use to teach this particular topic to them.* ***T7***: *Yaa because most of the things are done by them am just there to guide.*

Sub- Theme: Activity-driven, process and inquiry orientations

Code 1: Provide teaching aids, group work, students to observe and draw conclusion.

The interview data showed that T8’s practice in the classroom involves providing teaching aids, students conducting group work and practical work where they observe and draw conclusions. Below is the statement made by T8:

T8: *Yes, like this group working, sometimes not all the topics but in most of the topics I put them in groups. Like for example these plants, flowering and non-flowering plants, I will bring some specimens sometimes if we are to treat the topic tomorrow I will ask them to bring this and that plants in the next class. So if they* *come with the plants the monocot and the dicot I will group them, then give them the specimens to study and then after that I will ask them to give their observation. So from that we will look at it together and then discuss and come to conclusion.* ***T8****: Yes, there are many topics like the topic we were treating the last time is burning and rusting and there is this experiment which I even asked them to do it at home.*

Sub-Theme: Activity- Driven, conceptual change and project work

Code 1: Discussions, use of teaching aids and project work

The interview data showed that T9's classroom practice involved discussions, use of teaching aids and project work.

T9*: Normally we do a brainstorming session and when I brainstorm them, we have a discussion on some of the responses. I will further explain and if I explain I will demonstrate. I also show them some audio visual aid. I have some of these videos that I downloaded from GAMTEL. So most of the topics that we find difficult to do practical on after teaching them, I also show them the videos. I use my personal laptop which I mount on a table right in front of the class and the students will be watching.* ***T9****: I use teaching aids, van guards, sometimes I draw on van guards, sometimes I have wall charts that I use were as we don't have that I normally use van guard. T9: One of the projects was to prepare Neem cream.*

Sub-Theme: Process and activity driven

Code 1: The lesson involves activity, students conduct practical and teacher guides.

The interview data showed that T10's classroom practice as commented involves activity, students conducting practical work and his role is to guide. Below are the comments made by T10:

T10: *For child centred normally students are allowed to take the lead while the teacher guides. So because of that lessons always involve activity and you know children they like activities, they are always very excited, happy, you will see them smiling. You will realise that the euphoria in the classroom is very positive actually when you are conducting practical classes so the children like interacting with materials.* ***T10****: Normally we do so but to be honest that one has to deal with the senior school. We normally involve the senior school more on project work. Normally* *project takes longer time; it can be weeks, months and whatever. So we normally involve the senior students and not the junior students.*

Sub-Themes: Process, Activity driven and conceptual change orientations

Code 1: Teacher guides, allow students to interact and do things on their own

The interview data showed that T11's classroom practice involves guidance and student interaction and doing things on their own.

T11*: Yes, I do, most of the time; I go to class, introduce the topic and leave them to do the work. I be a guide and let them interact among themselves. When you talk about child centred, they should be at the centre. They should be allowed to do things by themselves and you the teacher just guide them.*

Sub-Theme: Activity driven, process and conceptual change

Code 1: Students working in groups, discussions and presentations

The interview data showed that T12's classroom practice involves group work, discussion and presentations. Below is the comment made by T12:

T12: *Alright, normally what I would do is I would go to the class, ask them to divide themselves into groups of five-five people and then I will give them topics, each group specific topics then I will give them time to discuss on the topics. Sometimes if it's a double period, I'll give them the whole period for them to discuss as a group then after that discussion, each group will come and present to the rest, the topic that is given to them and I'll just be there listening to them*.

6.5.1 Discussion

This section discusses the data presented in the above section to examine teachers' classroom practices. The data revealed six key practices that the science teachers said they did: the role of the teacher as a guide, stated by five teachers out of the twelve; discussion, mentioned by four teachers out of the twelve; encouraging students' participation and involvement, mentioned by three teachers out of the twelve; group work was mentioned by four teachers out of the twelve; the use of teaching /learning materials was commented by six teachers out of the twelve; and project work was mentioned by five teachers out of the twelve. These practices mentioned by the teachers conform with SCL principles by Brandes and Ginnis (1994) and also concur with Magnusson et al.'s (1999) student centred orientation. However, T4 comments on theoretical teaching, note giving and explanation which suggests his use of didactic method of teaching according to Magnusson et al.'s (1999) teacher centred orientation.

Below is the discussion about each individual teacher's practice:

T1's practice involves obtaining materials locally from the environment and the use of diagrams. Such practices, according to Magnusson et al. (1999) involve activity driven and process.

T2's practice involves project work, he acts as a guide and encourages students' participation and involvement during the lesson. This concurs with student centred practices in line with Magnusson et al.'s (1999) student centred orientations. T2's classroom practice seems to be student centred hence student involvement and participation are encouraged. The teacher does this through his guidance. This concurs with SCL principles as pointed out by Brandes and Ginnis (1994). Such practices according to Magnusson et al. (1999) are activity driven, project work in the form of research and conceptual change orientation which are student centred.

T3's classroom practices from the data interview involve group work, discussions, students answering questions. This finding concurs with Magnusson et al.'s (1999) student centred orientation which is conceptual change and discovery orientation. This is because T3's practice involves posing questions to students and getting them to explain by responding to the questions. Group work and teacher guidance are regarded as key to SCL practices.

T4's ways of practice are didactic; he said his lessons are theoretical based and this is confirmed in the notes he gives together with explanation. T4 also said he uses activity-driven and conceptual change orientation, which concurs with Magnusson et al.'s (1999) student centred orientation as it involves the use of materials, discussion and asking questions.

What T5 does in class is student centred since he encourages discussion where students can explain concepts to each other. This concurs with conceptual change orientation and correcting students' errors, thus indicating teacher knowledge of student understanding of science in line with Magnusson et al.'s (1999) model of PCK.

T6's classroom practices involved students' engagement in activities, working together and conducting project work which is in consistent with Magnusson et al.'s (1999) student centred orientation such as process, activity based and project based orientation. T7's way of practice involves provision of materials, use of appropriate method to teach specific topics and specifies the role of the teacher as a guide. These are in correspondence with Magnusson et al.'s (1999) student centred orientation and could be aligned with process, activity and conceptual change orientations.

T8's mode of practice concurs with process, inquiry and activity-driven orientations which according to Magnusson et al. (1999) are student centred, hence it involves students working in groups, provision of teaching aids, allowing students to make observation and encouraging them to conduct practical at home level.

T9's practice in the classroom involves brainstorming, discussions, demonstration, project work and use of teaching materials. This concurs with activity driven, conceptual change and project based orientation from Magnusson et al.'s (1999) model of science teaching orientation, which is classified as student centred. T9 seems to use different learning styles such as discussions, demonstration, use of teaching aids and videos which, according to Di Napoli (2004 as cited in Zain et al. (2012, p. 325), enables students through presentations and discussions in which a clear picture of the concept being explained can be visualised.

T10's classroom practice involves project work which is often lacking at UBS level, his lessons are activity based and the students conduct practical with his guidance. This concurs with Magnusson et al.'s (1999) student centred orientations and involves process and activity driven.

T11's classroom practice from the interview data is student centred and from Magnusson et al.'s (1999) science teaching orientation would involve activity-driven, conceptual change, process orientation. This is because his practice encourages student interaction in the classroom and students doing things on their own with his guidance.

T12's actions in class are student centred and involve students working in groups, discussions, and presentation of their work. This concurs with activity driven, process and conceptual change from Magnusson et al.'s (1999) science teaching orientations.

The teachers' practices are in line with Schuh (2004) who suggest that SCL requires a variety of instructional materials, more student participation and that students can work individually or in small groups. Teaching and learning materials are made available to students where they work in groups during lessons. From the teachers' comments, their practices to some degree have more SCL elements than teacher centred methods. The most common of these are group work and discussions, use of teaching and learning resources, project work, encouraging student participation and involvement and guiding the students, which is in agreement with Magnusson et al.'s (1999) student centred orientations.

6.6 Theme 4: Challenges / Constraints in the implementation of SCL practices

This section presents the data on the challenges /constraints in the practice of SCL by teachers. The data presented is from the one to one interviews and lesson observations. This is followed by a detailed discussion of the findings.

Code 1: Lack of materials (T1, T2, T3, T5, T7, T8, T9, T10 and T12)

The interview data showed that nine teachers out of twelve commented on the lack of materials as a challenge in their classroom practices. Below are the teachers' comments during the one to one interviews and lesson observations:

T2*: I want the Gambian system like the upper basic system to be equipped with like conventional scientific apparatus because it is really becoming difficult for science teachers nowadays for them to have the conventional science apparatus. I think one of the issues of not making these materials to schools is because they are expensive and some of them are not within the country, you have to export them and bring them here and there.*

T10*: In the meantime, is difficult financing those resource materials, teaching and learning is normally a problem with us.* ***T10****: Additional information, well, well, well, the only thing I want to say to be honest at times materials are lacking from the side of the school.*

T7: *…. because at now there is no Hoffman's voltmeter here we don't have the material so I decide to improvise because we don't have the materials.*

T11*: We have to practicalise our lessons but we don't have equipment. So is more of theoretical but we are trying to transform it to get into the practical aspect.*

T12*: Now here science teaching in most Gambian schools is abstract because in most Gambian schools because most of the schools are ill equipped when it comes to science labs so this is why most of the time you learn things you don't even know, if they are presented before you, you don't even know them.*

T8*: Like I said before, my main problem is the scientific apparatus. If we can have plenty of them they will help a lot. Apparatus are our main problem here.*

The following statements about lack of materials were also obtained from the lesson observation discussion I had with teachers.

T2: *The reason why I didn't group them is that we did not have enough scientific apparatus or materials. It is rather very difficult to have the real conventional materials, so that's why I did a thorough demonstration in front so that everyone can see and also involve students to do it whilst others will see, but it would have been more appropriate and proper to group them so each and every one would be given a task to do on their own*.

T9: *That is very right when we treated the theory in class, like the actual materials that we should have used at the time most of them were not available. I told them any way if we have materials we will get on with the practical materials. Like even here today most of these materials are improvised ones. That is why I feel like let me just put them through because they may not know why we are using improvised materials instead of the conventional materials*.

T10: *Initially what happened there were Bunsen burners in the lab, I think there were 3-4 in the lab that was long years ago. Eventually they decided to renovate the lab. During the renovation they decided to remove those facilities for the Bunsen burners with the hope that it was going to be replaced or improved but that replacement is long overdue. This is why we are conditioned to use gas bottles.* ***T10****: We don't have evaporating dishes. What we have are mortars and pestles.*

T3: *This is because we do not have enough compounds. That is why I decided to divide the class into two. If there were enough compounds available we would have divided the class into different groups and in smaller number and given them each the sample number required but the problem was there was not enough compound, that is why I divided the class into two groups. Basically materials are not enough. You could even see when I gave them test tubes, one group got 4 test tubes and the other one got 3 test tubes only. That is because of the fact that we do not have enough materials in the lab here, yeah*.

Code 2: Large class size (T1, T4 and T5)

The interview data showed that three out of the twelve teachers indicated large class size as a constraint to their classroom practices. Below are some of the comments made by teachers during the one to one interviews and lesson observations.

***T1**: Ahhaa, anyway, it is challenging to teach science especially in the Gambia. One, limited resources. Two, number of students per class. And three, what is demanded from you by the school. So looking at it is hectic, one I have to make sure that I provide material locally to make sure that the students are able to achieve exactly what they need to achieve.*

***T4**: The main factor is the large class size. Large class sizes do not allow us to have that enough time and to have that enough room to conduct a successful science practical.*

***T5**: When it comes to doing practical too is not very frequent because is not easy to do practical inside the class and taking them to the lab the number too, they cannot contain them in the lab so we do practical but not always, not always.*

Lesson observation data also indicating class size as a constraint

T4: When it comes to teaching and learning, one of the foremost factors that is affecting in terms of teaching and learning in this school is the large class size. It affects teachers' ability, it affects students' ability, it also affects when you come to assessment and evaluation which is very much key. You can't have a regular, adequate assessment and evaluation with such a large class multiplied by five other classes. That gives you an approximate of 350 students that is 350: 1. The dependency of one teacher is too large, so incredible.

***T5**: Yeah that is one of the problems we have because when you look at the number and the seating arrangement, is very difficult to organise group work because the class size is not easy to organise in groups likewise the tables, the seats were they are they cannot turn and then also they cannot sit in groups and do the group work. Like all of them sit down, others have to leave their seat and come and join other groups, that it is the only way we can do and we try with that method but is not easy*.

Code 3: Prioritising the SSS level over the Upper Basic level (T1 and T5)

The interview data showed that two out of twelve teachers indicated the priorities given to students at SSS level over their juniors at UBS level. Below are the comments made:

T1*: In terms of education we will, people will say that they are not separated, but to me they are separated. When we look at material bought, materials are bought for the senior secondary school students; classes, at the end of the day we who are having the junior school, we only have to use limited materials so that we would not exhaust the materials. So when we have experiment, we have to use a little of that to make sure that we do the experiment with the students because if we exhaust them at the end of the day, the senior secondary school will not have.*

T5*: Obviously, there are little materials in the lab because the lab is not situated for, like they are not considering these grade eight to be using the lab. So the lab is for the science students so they are fifteen to nineteen in number. So when you compare 15 to 19 in number with some classes that are 84, 69 and 67 to take all of them in the lab becomes a big problem ha-ha accessing the materials and then so, yeah is not easy.*

Prioritising the SSS level also arose during the lesson observation discussion I had with teachers. This was what T2 stated:

T2: *From my observation, I have come to realize that it is not all the students that are exposed to the physics, chemistry and biology labs. It is more of the senior school being exposed there than the junior school. That is why in fact there are some materials that are not available, some of the materials I needed were not available, so sometimes we link with sister schools to get some of the materials.*

Code 4: Lack of time (T3, T4, T5, T8 and T9)

The interview data indicated some of the reasons why teachers (T3, T4, T5, T8 and T9) perceived that SCL is time consuming when they were asked to give a detailed explanation of their practices in the classrooms:

T3: *Yes but it has a disadvantage because it doesn't save time.* ***T3****: Yes is time consuming because you have to allow the students to interact.*

T5*: I teach science here because most of the time as I said, I do group work but it is difficult and it consumes time and they go and join the other groups come here and there.*

T8*: I think if we have more of these materials that will really help. We come here time to time to look at their weaknesses, and if you look at it 70 minutes is not enough.*

Lack of time arise from lesson observation data during my discussion with T9.

T9*: I think is lack of proper time management. If time was there we would have done all of them though we do not have the conventional materials but we would have improvised. It would have been better if we have the real materials to do distillation, yeah if we have the conventional materials but without that as well we can equally improvise. The methods used really consumed our time if not we would have done it as well.*

Code 5: Examination orientated syllabus / curriculum (T1, T3, T4, T5 and T8)

The interview data showed that five out of the twelve teachers mentioned that their science syllabus is examination orientated. Below is the remark made by T3:

T3*: We use more of theory that is the fact because materials are not available and also we run to meet the time so that we can be done with the syllabus for their final exams, yes. The reason why we do that is, we normally run… like I said we try to cover the syllabus on time before their final exams. Because if you don't cover a lot and then they happen to have their exams if they do not perform the blame comes back to you from the administration. That is why at most cases we teach the student theoretically rather than giving them practical in the labs. We have three labs here but I think based on the timeframe here, the grade 9 students we don't normally engage them in activity in the school lab*.

Code 6: Inadequate training (T4 and T7)

The interview data showed that two teachers out of the twelve commented that they have had inadequate training to conduct practical work during their lessons. Below are the comments made by the two teachers during the one to one interview:

T4*: …. the second one is I have to be very honest is we the science teachers especially in the school we need more training on many of the practical. We can do some we only know by the book, how to do the other one we do not practicalised it so we need to do them ourselves first successfully before engaging the students. So that will improve our confidence.*

***T7**: …. and also for the chemistry aspect for me as a teacher there are some materials whereby am I was not exposed to them when I was going to school. **T7**: Yes, I specialise in science but I was from the provinces whereby materials are very limited.*

Code 7: Students view science as difficult (T1, T5, T6, T7, T8, T10 and T11)

The interview data showed that seven teachers out of twelve commented that students view science as difficult. Below are some of the remarks obtained:

T6: *Well I just want to challenge my colleagues, my counterparts who are teaching science anywhere let them try to bring fun in the teaching of science because many at times students see science as subject that is very, very difficult, a subject that cause trouble to many, many candidates.*

T8: *If you go to class without the life objects, especially in science and biology gives some of the students a lot of problems. They find it difficult to pronounce the biological words. Some of the words sound funny to them and like I said before they found it challenging to pronounce biological words.*

T11: *That for sure I can say no. Art and commercial classes are more than the science classes. Many of them fear science because of the mathematics involved. You need to see problems and solve and come to conclusion. For them mathematically, they are poor and all the topics in science deal with Mathematics. When you look at their grades in mathematics during the final exams they hardly have a credit. T11: The common problem is that they don't understand the language. Many of them don't speak English, they speak their own dialect. That's one of the challenges we are facing.*

6.6.1 Discussion

The most common factors that impede teachers' classroom practice in this study include: resource constraint, large class size, prioritising the SSS, time constraint, examination orientated syllabus, inadequate training and students' fear of science. The lack of resources, prioritising the SSS and time factors were common findings from both lesson observation and interview data. Resource constraint from the findings is considered to be both financial and material. The expensive nature of science materials seems to be one of the causes of the lack of materials in their schools. For this reason, it was viewed by T2 that the school administrations were unwilling to purchase the conventional scientific materials required for them to conduct particle lessons. Student centred learning requires materials, the absence of which may lead to talk and chalk methods (Peters, 2010). Basic science materials are key and useful for practical / experiments which enable students to learn independently and become autonomous learners, and also aid comprehension and memory.

The study reveals the lack of materials in schools as one of the factors hampering the teachers' practices in the classrooms. This factor is common across all the two categories of schools. The lack of equipment in schools was mentioned by nine out of twelve teachers and these were: T1, T2, T3, T5, T7, T8, T10, T11 and T12. This concurs with Yilmaz's (2008); Aswegen & Dreyer's (2004) findings which point out inadequate resources in schools as an obstacle to SCL practices. This shows the usefulness of having adequate conventional science materials in science topics that enable experiment. Hence the absence of these materials will continue to pose a lot of difficulties for teachers to practise student centred lessons in their classrooms. The Ministry of Basic and Secondary Education is yet to provide a standard science laboratory to all Upper Basic Schools. Currently the government gave a free education to students at this level and pays fees to the school in the form of a grant which is referred to as the school improvement grant (SIG) for the schools administration to be able to utilise the money for the smooth running of the school. However, this money still seems not to have been used by the school administrations to purchase the basic science materials that the students required for the smooth conduct of their practical lessons as indicated by T2.

Another factor that hinders student centred practices is the large class size. T4 coming from School B, an inadequately resourced school, noted that due to the large number of students in his class he finds it difficult to improvise materials locally in order to engage his students. Due to the large number of students per class in School B, the only available small science lab in the school could not accommodate the students during practical lesson. T4 and T5 all in School B had class size of 70 students which was far beyond the size of the lab. This was confirmed during the lesson observation. The small laboratory was empty and dusty with no chairs and the tables available were fixed and concrete. This in comparison to facilities available in T1's school (School A) was completely different. School A had all the core science labs (Biology, Physics and Chemistry) and these structures were standard and wide enough to accommodate the large class size. This study's finding of large class size being an obstacle to teachers' classroom practices is in correspondence with Mtika and Gates's (2010) findings who identified large class size as an impediment to SCL practices. Large class size could minimise teacher student interaction in class, because teacher student ratio is high, for example 1:70 respectively. The large class size also calls for more teaching and learning resources, particularly when the teacher is to engage students into practical/experimental activity. It will also mean more teacher workload, particularly in marking and giving students feedback during assessment. Finally, group work, which is a key element of SCL practices, could be hindered, hence large group sizes may result in just a few of the students conducting the entire activities set up for the groups, leaving the rest not participating and so limiting their learning if this happens. This also raises the issue of equality in learning - all students should get an equal chance.

Another key issue from the findings is the school giving more privilege to the senior/secondary students than the upper basic students. The issue of prioritising the Senior Secondary School (SSS) over the Upper Basic School (UBS) came up during the one to one interview with teachers and lesson observation, which also corroborates with data gathered from the focus group with students. As a result, the UBS students were left at a disadvantage. This prioritisation of students when critically examined in the context of this study is linked to the limited resources available in the schools and the large number of students at UBS level. Thus as a result teachers give more privilege to the SSS level in terms of conduct of practical than the UBS students. This finding is unique in the context of the Gambian education system. This is because the study focuses on the lower level of secondary education in the Gambia and at the end of the UBS-grade nine students sit the Gambia Basic Education Certificate Examination (GABECE). The examination questions here are more knowledge based than application based. Thus students do not conduct any practical and it is theoretical based assessment. However, at Senior Secondary School which is the higher level of the secondary education in Gambia, students sit West Africa Senior Secondary Certificate Examination (WASSCE) at the end of grade twelve. These students perform experiments as part of the exams in all the core science subjects: Physics, Chemistry and Biology. For this reason more privilege is accorded to students, since the practical work contributes to the final grade at the end of their secondary education.

The next finding from the study is the lack of time in the practice of SCL lessons in the Gambia. The lack of time arose from both interview and lesson observation data. Teachers perceived that conducting practical requires adequate time. In addition to that, student centred learning requires group work which is also time consuming.

Students take a bit of time to get organised into groups and more time is needed for the group discussion due to the large number of students per group. The lack of time was mentioned by only four teachers during the interview (T3, T4, T5 and T8) and five teachers during the lesson observation (T4, T8, T9, T11, and T12). Student centred practice such as group work requires time for student-student and student-materials interaction and this was in correspondence with Yilmaz (2008). The lack of time in the practice of SCL concurs with Seng's (2014); Mtika & Gates's (2010); Aswegen & Dreyer's (2004) study findings which indicated the lack of time as an impediment to student centred practices. This was echoed by T8 who felt that a seventy-minute science period was not enough taking into account the large student number per class. The average length of time in teaching science in the Gambia is 30-35 minutes per period/session. Subjects like science which are considered a core subject are given 5 periods a week. In order to cater for practical lessons, two periods are connected at a time in order to give the teacher enough room to conduct practical work or engage students in activity based lessons. However, time is lost in students becoming seated in groups to do work as a result of the large class sizes and furniture type in some of the classrooms.

The next factor that hinders teachers' practices is the examination orientated syllabus. The broad science curriculum and syllabus at Upper Basic School culminated with the lack of materials is perceived by T3 as an obstacle to the practice of student centred lessons in their classrooms. Due to the wide nature of the science syllabus and pressure from the school administration to complete the syllabus before the commencement of the Gambia Basic Education Certificate Examination (GABECE) as indicated by T3, teachers are usually given specific parts of the syllabus to cover at the beginning of every term. As a result of this they tend to rush the students to complete the task assigned to them on time. This finding concurs with that of Mtika & Gates (2010); Aswegen & Dreyer (2004) whose study singled out national curriculum as an impediment to the student centred learning practices.

The next and a very significant finding in this study is the lack of knowledge and skills to conduct practical work as cited by T4 and T7. Both teachers were qualified HTC holders. However, T4 from School B did not specialise in science during his Senior Secondary School education and only did general science which is a non-core subject area in science. He was then enrolled and recruited at Gambia College, the only teacher recruitment institute in the Gambia, to become a science teacher. During our interview he discloses that not much practical work was done at the time of his training and recommends that more training be given to him in the near future. On the other hand, T7 was a science specialist during his secondary education and had his training from the same college as T4. However, T7 discloses that he had less opportunity to conduct practical during his school days due to the limited science materials the school was faced with at that time. As a result their lessons were non practical based and there was little opportunity to interact with materials. Thus, the study's findings of inadequate training to equip teachers with practical knowledge is in accordance with Shaffer (2016) and Yilmaz (2008). Teacher training is key and the teachers' knowledge is expected to be above the level of the students. The responses obtained from T4 and T7 seem to flag teachers' lack of exposure to practical or experiment in science. This reflects back to their high school days and also their college recruitment days.

The final finding on the challenges and constraints in the practice of SCL is the perception by some of the teachers that students have a fear of science and that students have the notion that science is a difficult subject. Perhaps this negative view held by students of science as difficult makes them less interested in the subject area thus making it more challenging to teachers in their classroom practices. The notion that science is difficult also corroborates with the focus group data. T8 from inadequately resourced School D felt that this is as a result of the lack of materials during their science lessons and also the students' inability to pronounce scientific terms particularly in biology. Teacher T11 viewed that science subjects such as physics and chemistry are mathematical and those students weak in mathematics find it difficult to comprehend. The second point made by T11 was the difficulty for students in understanding the English language, as the English language is the medium of instruction in schools in the Gambia. The view that science is difficult concurs with Mtika and Gates's (2010) findings. Students' fear of science as a subject also corroborated with the focus group data which revealed the belief that science is mathematical, associated with difficult terms to pronounce and lots of diagrams to label and state their functions. Thus the fear of science is as a result of the fear of failure of the subject. For example, if students are weak in mathematics they will not opt to do science because they know that they are going to fail. This will result in a lack of interest in the subject of science.

6.7 Summary

This chapter is in response to RQ2 which examines how science teachers' perceptions of SCL influence their classroom practices. It is found in this study that Gambian teachers understood SCL as involving students in working in groups, teachers as guides or support, encouraging students' participation, interaction and involvement during lessons, students expressing themselves freely during lessons, practical work, activities being conducted by students and the teacher doing less talking and writing. The study also indicated key findings on teachers' beliefs of SCL. Teachers belief that student centred learning is the best approach because students are able to retain longer what they learn by doing than what they are being told by the teacher. SCL, teachers' beliefs, developing the students' thinking ability, and the use of SCL enable students to support and learn from each other better than the teacher.

The Gambian science teachers were also able to made a distinct comparison of SCL and teacher centred method. The findings revealed that teacher centred method involves the teacher talking, telling and explaining to students without the use of any teaching aid to support the explanations. The teacher does all the activities during the lessons, and students are regarded as receivers of information and passive listeners and are made to memorise what is learned.

The study findings also revealed that teachers' perception of SCL directly link to their classroom practices. These involve discussion, teacher facilitation, encouraging student participation and involvement, group work, use of teaching and learning materials and engaging students in practical activity.

The study findings also revealed the challenges and constraints affecting teachers' classroom practices. These include: lack of resources in schools, large class sizes, prioritising SSS, lack of time, examination orientated syllabus/curriculum, inadequate training and the student view that science is difficult. Teacher use of SCL was impeded by these factors, resulting in their use of teacher centred in most of their lessons. The evaluation of RQ2 is found in chapter 8.

Chapter Seven: Data Presentation and Discussion

7.1 Introduction

This chapter is the data presentation and discussion for RQ 3: In what ways do science teachers' pedagogical orientation influence their classroom practices? The study uses Friedrichsen et al.'s (2011) science teaching orientations (STOs) and the remaining four components of Magnusson et al.'s (1999) model of Pedagogical Content Knowledge (PCK) as an analytical tool to analyse teachers' orientations and how they have an influence on their classroom practices. In this chapter the data is presented based on the themes arising from Friedrichsen et al. (2011) STOs which are: beliefs about the goals and purposes of science teaching, views of science and the learning and teaching of science. The term orientation refers to the set of beliefs held by teachers with regards to: the purpose of teaching science (why do teachers teach science to students); views of science (beliefs and values about science); and the teaching and learning of science (this includes the beliefs about the role of the teacher, the role of the student, how students learn science and how science can be taught to make it interesting and understandable) (Friedrichsen et al., 2011).

This is followed by the data presentation based on Magnusson et al.'s (1999) four main components of PCK as themes: teachers' knowledge of assessment, teachers' knowledge of instructional strategy, teachers' knowledge of curriculum, and teachers' knowledge of students' understanding of science. The presentation of data in each of the themes is followed by a detailed discussion.

7.2 Theme 1: Beliefs about the goals and purpose of teaching of science:

7.2.1 Rationale for teaching science to students

The data gathered from the interviews indicated teachers' reasons for teaching science to their students. During one to one interviews, when asked their reasons for teaching science to their students, the following data was obtained:

Code 1: Teachers like/ enjoy science (T1, T2, T5, T6, T7, T8 and T10)

The interview data showed that seven teachers out of the twelve commented that they like science. For example:

T1: *Anyway choosing to teach science I like it, I love it I can say it is my hobby and to me it seems I am naturally built to like nature, that is why today I find myself teaching science.*

T5: *I choose to teach science because it was the subject I like when it comes to in terms of experiment I like doing it, talking about environment, made a lot of observation*.

T8: *I like science since when I went to school.*

T7: *Yaa, is also a particular area that I also enjoy and I enjoy teaching it yaa. So I like it, I majored science and English.*

T6: *I like science because science is actually something that you can really link to real life situation. By studying sciences, it means that you are studying yourself and nature in general. So I really, really like it. As I said earlier on I always find fun in science. I don't want to study a particular field that gives me stress, but science is something that I always get the fun out of whenever I teach it.*

Code 2: To impart knowledge (T1, T6, T10 and T12)

The interview data indicated that four teachers out of twelve stated that they impart knowledge. For example:

T1: *My goal is the students Mr. Joof, because my goal is that I have to impart knowledge in to the students.*

T6: *My goal to teach science is to ensure that capacities of students are built in different, different areas.*

T10: To help children build the knowledge as I said, have the spirit of investigation and also have confidence in themselves in a bit to encouraging them to choose science as a career.

***T12**: Well when I teach science, I teach science for it to have an impact on the student.*

Code 3: To inspire students (T4 and T8)

The interview data showed that two teachers out of the twelve commented that they teach science to inspire their students. For example:

***T4**: My number one goal when I teach science to my students is to inspire them.*

***T8:** My goal to teach science is to make sure that I teach and prepare students who are the future leaders. I want them to be inspired by me to study science.*

Code 4: To change student's life and perception (T3 and T7)

The interview data revealed that two out of twelve teachers remarked on changing students' lives and perceptions. This evidence is shown below:

***T3**: My goal when I teach science, my ultimate objective is to pass an idea to be able to change the life or change the life and perception of my students based on a particular area. Students have to see science as a real thing.*

***T7**: Ok, like one of my goals could be like at least let the student understands better. I want to remove the concept of it is a very difficult area yaa.*

Code 5: To achieve good results (T4 and T9)

The interview data showed that two teachers out of twelve commented that they teach to achieve good results. Below is the evidence:

***T4:** No we have never achieved our goals in terms of science but we have achieved our goals in terms of results because that is what the administration need. This people have aggregate 6, aggregate 7, this people have credit in science that is finished.*

T9*: When I teach science is two folds: One is to help student to improve in the area and two is to improve myself in the area. T9... make sure that they perform well in the external exams but in the process I also learn a lot.*

7.2.2 Activities designed to achieve the goals of teaching science

Code 1: Use of science materials (T1, T6 and T7)

The interview data showed that three teachers out of twelve commented on the use of science materials. This evidence is stated below:

T1*: Ok, the only thing I will say is that, in teaching science to achieve the goal, is necessary for the teachers and students to get the right materials, it helps to gain or achieve desired goals. In the absence of teaching materials, the teacher finds it difficult to impart the knowledge and students in turn to achieve these goals, and in fact the teacher will not even learn from the students neither will the students learn from the teacher.*

T6*: Primarily, I make sure that the goals or objectives that are set in teaching science are achievable that I can do with the support of the readily available resources and interaction with students as well. I do not enjoy teaching in the abstract.*

Code 2: Class discussion (T3, T6 and T9)

The interview data showed that three teachers out of twelve commented that class discussions enable them to achieve their goals:

T3*: One I sometimes kind of teach students based on my own eeeh let's say I kind of do most of the activity to be able to pass the information. Secondly I sometimes give the floor to student to be able to speak their mind and then discussions come in the class and there is argument here and there but in the end we agree on a particular thing based on my guidance.*

T9*: In implementation we have class discussion, we have explanation going with demonstrations, practical activity and even problem solving.*

Code 3: Group work (T7)

During the interview T7 commented about group work:

T7: *We do group work is one of the activities we do sometimes also we have exhibition*. T7: *also exploration we do go out a times to see certain things*.

Code 4: Practical work (T7, T9, T10, T11, and T12)

The interview data showed that five teachers out of twelve commented on the use of practical work in their science classrooms. Below is what the teachers stated:

***T11**: When you talk about science it has to be practical.*

***T12**: Right amm... by involving the students because once you involve them, they build interest. **T12**: Alright like when I go to the class, I come up with things that will make them interested by involving in practical.*

7.2.3 Discussion

The interview data showed five key reasons teachers give for teaching science: teachers like science, their goal is to impart knowledge, to inspire the students they teach, to change students' lives and perceptions and to achieve good results in their exams. These reasons for teaching science concur with Friedrichsen et al.'s (2011) STOs. From the above statements T5 chooses to teach science because he likes the subject which involves conducting experiment and talking about the environment. Similar comments were made by T1, T2, T6, T7, T8 and T10 that their like and love for science was the main reason why they teach science. T6 further regards science as fun. For T3 science is an interesting subject which helps students to understand innovation in science. T11's rationale for teaching science is said to be out of curiosity. For T10 his choosing of science was because he comprehends science more than other subjects due to the activities conducted during the lessons. In general, the most common reasons for these teachers teaching science is the love they have for the subject. This concurs with the findings made by Friedrichsen et al. (2011).

I further asked the teachers the kind of activities they set up to achieve their goals. T1, T6 and T7 mentioned to me that they achieved their goals through the use of science materials. None of the teachers from School B and D mentioned about the use of science materials because their schools were inadequately resourced. Hence all the three teachers were from adequately resourced schools, School A and School C respectively. Another form teacher achieved their goals through class discussions. This was common to both categories of school, hence stated by T3 from School A, T6 from School C and T9 from School D. Group work was mentioned by T7 as a way to achieve his goals for teaching science while five teachers mentioned using practical work. However out of these five teachers, only one of the teachers from inadequately resourced School D employed practical work as a way to achieve his goal. In conclusion the methods these teachers believe that they were employing to meet their goals and purpose of teaching science concurs with SCL strategies hence it involved use of materials, class discussions, group work and practical work, thus concurs with Magnusson et al.'s (1999) student centred orientations. This means that their beliefs seems to influence their practices in the classrooms. In reality, from the observation held, eleven teachers out of twelve had their lessons on practical work related topics. However, this contradicted students' account of their lessons which was mainly dominated by teacher centred method. The next section presents and discusses the data on teachers' view of science.

7.3 Theme 2: Teacher's view of science

7.3.1 Beliefs and values about science teaching and learning

Code 1: Science is difficult (T1, T6, T10, T11 and T12).

The interview data showed that five teachers out of twelve stated that science is difficult. Below are some statements:

T1*…we believe that especially I believe that science is far more difficult for students than mathematics.*

T6*: Well I just want to challenge my colleagues, my counter parts who are teaching science anywhere let them try to bring fun in the teaching of science because many at times students see science as subject that is very, very difficult, a subject that cause trouble to many, many candidates.*

T10: *As you are aware normally in our school system, children tend to fear science they think science is difficult because of that we the science teachers are also very careful.*

T12*: Now what I normally do, because what is happening like most students do not like science subjects. They don't like science subjects.*

These remarks are unlike what T2 stated:

T2: Students like it and are seeing what the benefits of science are doing in the world at large and they are also encountering it their daily lives. Of course yes, they are continuing with science and some of them want to take it as a career in the near future, some of them want to become doctors, architects and the like.

Code 2: Science is broad (T7 and T11)

The interview data revealed that two out of the twelve teachers commented that science is broad. Find below the statements:

T7*: Yes, like if you look at science it's a very broad area and the area that am teaching consists of three main components which is the Biology aspect, Physics aspect and the Chemistry aspect.*

***T11**: Well science itself is very broad. I say for science it is a little bit difficult. We face some obstacles especially in delivering our lessons according to our plan.*

Code 3: Science is life (T3)

T3 from the interview data commented that science is life.

***T3**: First of all, after doing science at Senior School, College level, I decided to stick with it due to the fact that science is life. Yes, because everything you do in life is equal to science. That is why science is very interesting and I stick my life to it so that I can be able to understand how the changes in the world are taking place, like innovation even in real life.*

7.3.2 Discussion

Teachers' beliefs about science being difficult during the interview concur with the views of their students during the focus group. The difficulties associated with science teaching and learning comprise of key factors such as the mathematical aspect of science which tends to put off students opting for science because they are weak in mathematics. Another key factor from this finding is the lack of basic science materials to induce students' interest into doing science. It was demonstrated in the previous chapter that students do very little, if any, practical work or experiments at the Upper Basic level of the Gambia education system as the study revealed. This was confirmed by both students and teachers within the 12 schools that the study was conducted. The notion that science is difficult may result from students' fear of failure of the subject and students' lack of interest in the subject. The number of teachers who believe that their students viewed science as difficult were a total of five out of the twelve. However only one of the teachers out of the twelve felt that their students like science. This concurs with the finding from the focus group in which almost all the students said their love of science was because of the importance of the subject, for example you cannot be a doctor without doing science. However, the difficulties of science still remain as the student finds it difficult to remember the numerous diagrams, their parts and functions and the difficulties in pronouncing scientific terms. This concurs with teachers' beliefs that science is broad and that science is life.

7.4 Theme 3: Belief about science teaching and learning of science

The belief about science teaching and learning consists of four subthemes: belief about the role of the teacher, belief about the role of the students, belief about how students learn best, and belief about how science can be taught and making it interesting to students. The data gathered from the interview is presented accordingly.

7.4.1 The role of the teacher

Code1: Teacher should be well prepared (T3)

The interview data showed that one out of twelve teachers mentioned that the teacher should be well prepared: Below is the evidence:

T3: *You prepare yourself meaning you do your lesson plans from there you also prepare based on your topic, based on the materials you want to teach in class. You prepare yourself very well go to class you deliver.*

Code 2: Teacher serves as a guide (T2, T3, T7, T10 and T11)

The interview data indicated that five out of twelve teachers commented that they serve as a guide. Below are the remarks made:

T3: *... we normally guide them even in class, even if we are discussing in class, the teacher comes there as a guide, you understand and then show them what to do*.

T7: *Yaa because most of the things are done by them am just there to guide.*

T10: *The teacher serves as a guide*.

Code 3: Teacher's role is to teach (T11)

The interview data showed that one out of the twelve teachers stated that his role was to teach the lesson. Below is the comment made:

T11: *The role of the teacher is to teach the lesson.*

7.4.2 The role of the student

The interview data showed that one out of twelve teachers remarked that the role of the student is to investigate. Below is the comment:

Code1: Students to investigate (T10)

T10: *So the students' role here is investigative.*

The interview data showed that one out of twelve teachers remarked that the role of the student is to investigate. Below is the comment:

Code 2: Students to pay attention to their work (T5)

T5*: So obviously they will pay attention when you give them work they will pay attention like what I did with them when you go and ask they will explain….*

7.4.3 How students learn science

Code 1: Provide student with materials (T1, T5, T8 and T11)

The interview data showed that four teachers out of twelve commented that students learn science best when they are provided with materials. Below are few remarks made:

***T1**: Ammm, if you want your students to really be engulfed with the subject you have to give them what they need. That is still the materials you are talking about, let them see the materials, let them touch, let them feel, and possible let them play with it if they are unbreakable.*

***T5**: You explain the topic to them then allow them the next lesson like what I did today you tell them we will be doing the practical today so that they can bring their materials because I used cup with them, spoons with them which you can use as beaker and spatulas but you have bring the materials to avoid the breakage, you see how the number is large they can easily break those materials. It is a tin of milk they open it so that we can have an evaporating dish. So we improvise the materials and they work with them.*

***T8**: When I went to the class, I took the materials to them. They were so happy and they told me that we are going to do everything on our own. You will not do any teaching. Yes, as you can see in class most of the parts were named by them and at the end of the day they were able to state the function of them.*

Code 2. Conduct of practical (T6, T9 and T11)

The interview data indicated that three teachers out of the twelve believed that students learn science through doing practical work. Below are some of the statement gathered:

***T9**: Doing it is like forming an indelible image in their mind, in their brain, and with that they will go a long way in getting that information. That is why we go more in for practical activities where what they do they can easily remember and they understand.*

***T11**: When you allow them to see after you did it once that the best way they can learn. If they feel it and touch it you can see how the students feel about it. They see it themselves and feel it. If they practicalising it then they learn better and can do it themselves. It makes them to learn faster.*

Code 3: Making lessons activity base (T6, T7, and T9)

The interview data revealed that three out of the twelve teachers stated that students learn science when lessons are activity based. Below are the remarks made:

T6: *To be very frank with you some of them when they are starting with me at the upper basic sector they come with a kind of very, very low interest in science but before they graduate from the Upper Basic all of them would always yearn to specialise in science in the Senior Secondary School. That is very real here, yes.* ***T6****: Virtually, one way is perhaps may be the methodology that I am taking and also I do motivate them by bringing fun in the teaching of science. They are not very much stressful or feel bored in class because they always have what we call hands on activity.*

T7*: They always learn it well, if they do most of the work on their own yaa for me that is what I believe. If they're involve they'll learn it better than you doing everything for them. Let it be just purely child centred lesson, always try to avoid the class being so boring.*

T9*: When we involve we may involve by only talking to them but if we allow them to do the activity on their own I think with that approach we are ensuring that they are getting what we want them to have.*

Code 4: Asking and answering questions (T2, T3, T4, T7 and T12)

The interview data indicated that five out of the twelve teachers commented that students learn science by asking and answering questions. Below are few statements:

T3*: That is normally done in various ways. Sometimes when you are introducing your topic you can ask questions related to the previous discussions and then ask students what they have learnt the previous day in order to help them at least remember some of the things that you have done in the past.*

T7*: Yes, it does happen, at times I will be teaching somebody will ask a question then instead of me somebody will prefer ok yes T7 ok let me also handle that particular question.*

T12: So what I would do is, I would give them a lot of assignments, and then at the end of the day, the assignments, I would have to mark and then and is part of the assessment termly assessment. So that would force them to read and then also every day, in the morning when I come to the class, I used to ask them each a question if I entered the class because today I didn't do but normal days that's what I would do.

Code 5: Rectifying student's error (T2)

The interview data showed that one out of the twelve teachers commented that rectifying the students' errors is a good way for students to learn. Below is the remark made by T2.

***T2**: … it is very important you introduce the topic, and brainstorm into the topic with them by allowing them to interact and then rectify their mistakes as you go along the interaction and then make facts and relate them to real life issues.*

Code 6: Group work (T3)

The interview data showed that one out of the twelve teachers commented that students learn science when they work in groups. Below is the remark made by T3.

***T3**: You give them class exercise and sometimes assignments will help to enable them remember what they have learnt before, you understand. Also like I said group activity or group work so they will be able to work on a particular area and be able to remember what they have done before.*

7.4.4 How science can be taught

Code 1: The use of experiment (T1-T12)

The interview data showed that the twelve teachers stated that science can be taught through practical work /experiment. Below are some of the remarks obtained:

***T2**: I personally believe that one cannot teach science in the absence of experiments and also in the absence of exposing them to the real nature of what you are teaching, so it is rather abstract when you just talk and talk without doing, they go together. When you conduct an experiment it cuts down time, makes to understand easily, makes them to interact with the materials, they get to love the subject more and participate rather than you talking throughout without any based practical lesson.*

***T3**: When you teach a science topic which involve practical work. First of all you must have the aim or objective. If you have your aim or objective, you try to gather some materials. Those materials sometimes are locally available or sometimes they are available in the school lab there. So you set your procedures, that is the step you are going to take to carry out that particular activity and then from there you have* *your observation of the activity, what students are doing and then from there you have your general conclusion. These are the ways we teach practical topics.*

***T9**: I group students, distribute materials. **T9**: Yes, I will make sure that they have a worksheet, each group have a secretary where they will be working in groups, whatever they do they will take note of. Like what I did today I will put the activity title and I will also put the materials involved, they will have to jot down the materials they will use and the procedures involve in the experiment.*

***T10**: A normal science lesson will have to involve some form of practical that is how I see a science lesson, because a science lesson needs to be activity wise, something that will involve activity.*

Code 2: Provision of teaching and learning materials (T1-T12)

The interview data indicated that twelve out of the twelve teachers stated that science can be taught by providing teaching and learning materials to students.

Below are a few comments from the teachers:

***T3**: I think with the teaching of science it can be enhanced more if we have the required teaching materials you will be able to teach science I think we are lucky to have labs but some schools they have no materials and teachers teach in the abstract.*

***T10**: If the lesson involves some teaching aids or learning materials they must be provided and normally this is what we do. We go to class with teaching materials alongside the lesson plan and then the lesson notes.T10:… teaching aids will be displayed accordingly in order to promote student understanding.*

Code 3: Linking topic taught to students' daily activities (T2 and T7)

The interview data indicated that two out of the twelve teachers mentioned that science can be taught by linking topics taught to the students' daily activities/lives.

For example:

***T2:** As I said, the learning activities which I embarked on to achieve my goal in teaching science is; I always make sure that any topic that I teach I relate it to real life issues and show them people that survive on those real life issues. I took my students to the hospital, I covered a topic on malnutrition that is deficiencies due to lack of vitamins and I took them to the hospital and they saw people lacking those vitamins and how they ended up and how are those things treated. They saw the* *difference that on the whole this is important, because they were taking it as something just to know but on the whole this is happening. When I took them to the hospital I took them to the surgeon, there was somebody who had a goitre and was being operated, they saw it and from there they knew that lack of iodine causes goitre and that iodine is found in our local foods. From there they realised that it was very good that I eat snails, oysters and other sources of iodine to avoid the iodine deficiency. You can see that subject was connected and you are helping them to have an insight of what happens around when it comes to your teaching, your teaching should not only be a teaching but it should be connected to real life issues. But if they don't see it in any way connected to the lives of people they will only learn theoretically and forget about it.*

Code 4: Taking in to account student prior knowledge and skills (T2, T6, T10, and T12)

The interview data showed that four out twelve commented that science can be taught by taking in to account students' prior knowledge and skills.

***T7**: Certain topics in Physics is related to mathematics and for the Chemistry aspect there is a particular area that has some mathematics like the solubility curve so I always make sure that before I discuss that with them they have already treated graphs with the maths teacher so that by the time we talk about it they already treated graph.*

***T10**: You can't just start teaching a topic blindly without knowing the level of understanding of the children as far as other particular topic is concerned. You can simply do that in the introduction; during the introduction you can actually find out the level of understanding of the children or the child's knowledge as far as the topic is concerned and eventually in the development you will know where to begin based on the feedback you get during the introduction.*

***T10**: At the end of the lesson you normally try to recapitulate or revisit the key points of the lesson either verbally or orally or through oral questions and answers from the children.*

Code 5: Use of appropriate methodology and teaching/learning resources (T10)

The interview data revealed that one out of the twelve teachers commented that science can be taught using appropriate methodology and teaching/learning resources. Below is the comment made:

***T10**: We always deploy methodology that will help the children understand and actually make them discard the fear of science. Actually the teaching of science cannot be successful and effective without the right methodology and the right equipment or what we called teaching and learning resources. In a sense teaching science we focus more on child centred as you may be aware a teacher is meant to be a guide to the students and the students are allow to carry on with the real activities. So in short the teaching of science as I said I focus more on children involvement let them participate actively in the lesson. Be it a practical lesson or a theoretical lesson we normally guide the children with questions during the lesson for them to discover for themselves whatever we might want them to learn or discover.*

7.4.5 Discussions

The most common finding from this study indicated the role of the teacher in a science classroom as guide. This has been mentioned by five teachers out of the twelve. This role concurs with SCL principles by Brandes and Ginnis (1994) in which teachers' role is to facilitate the process of learning. Teachers' role as a guide also concurs with student centred orientation as stated by Magnusson et al.'s (1999) model of STOs. In general, having examined the individual statements obtained from the teachers during the interviews, these were not limited to offering support to students but also involved preparing lessons, providing teaching aids, offering support to one another, encouraging students in science, making sure that students are involved and participating in science lessons which are in correspondence with Friedrichsen et al. (2011) STOs.

Teachers have the belief that student roles should be investigative, attentive and involving in the lessons. This concurs with Friedrichsen et al.'s (2011) science teaching orientations. The role of students as investigative could involve practical work/experiment such as discovery and inquiry, project based, guided inquiry. These methods encourage students to be investigative as pointed by Magnusson et al.'s (1999) STOs and are student centred.

From the teachers' comments it is their belief that students learn best when they are provided with the materials that they require. This was mentioned by T1, T5, T8 and T11. T6, T9 and T11 who believe that students learn science best when they conduct practical work. This concurs with Toplis' (2012) findings which pinpointed the sense of ownership for students and student participation in groups that practical work can offer. Students mentioned that practical work enabled them to retain what they have learnt in science compared to other learning approaches (Toplis, 2012). This view by students concurs with what the teachers mentioned during the interview. T6, T7, and T9 suggested that students learn science when the lesson is activity based. Activity based lessons could include practical work and group activities that the students could engage in without necessarily doing experiment. Another key finding is the students' freedom to ask and answer questions during science lessons. This was mentioned by five teachers. Freedom of expression in class is an element of student centred learning and concurs with Brandes' and Ginnis' (1994) SCL principles. The next finding in the study is rectifying students' errors as the lesson progresses. This concurs with teachers' knowledge of students' understanding of science as pointed out by Magnusson et al.'s (1999) model of PCK. Finally, four teachers in the study mentioned group work as the best way that students learn science. This is because it is through group work that students are able to discuss, support each other, share and exchange their ideas and experiences. This concurs with Brandes' and Ginnis' (1994) SCL principles. Therefore, teachers' belief of how students learn science well corresponds to Friedrichsen et al. (2011).

From the data gathered, the teachers' belief about how science can be taught and made interesting to learners involves the use of experiment, provision of teaching and learning materials, linking topics taught in science to the students' daily life, taking into account students' pre-requisite knowledge and skills, use of appropriate methodology and teaching learning resources. These features resonate well with SCL definition that the study undertakes and concurs with Magnusson et al.'s (1999) student centred orientations. The use of experiment and the provision of teaching learning materials were common across all teachers. This corresponds to how students learn science well through the conduct of practical. This shows the significance that teachers attached to conducting experiment and use of materials in their classroom practices. T2, T6, T10, and T12 believe that science can be taught by taking into account students' prior knowledge and skills. This concurs with Magnusson et al.'s (1999) teachers' knowledge of students' understanding of science and teachers' knowledge of instructional strategies. This indicates a relationship between beliefs about science teaching and learning of Friedrichsen et al.'s (2011) and Magnusson et al.'s (1999) components of PCK, particularly teachers' knowledge of students' understanding of science and knowledge of instructional strategies and curriculum.

7.5 Theme 4: Teacher Pedagogical Content Knowledge

7.5.1 Teacher knowledge of Curriculum

Code: Topics taught are interconnected (T3, T6 and T7)

The interview data showed that three out of the twelve teachers commented that they make sure that the topics they teach are connected. Below are the remarks made:

T3*: Yes, I do relate to the former topics taught to make sure that at least students know something from a particular topic before moving to another and also they have* *to be connected. Yes, that is very important and we do that always. You have to make sure that students have some idea previously before they are exposed to a particular lesson, yes we do that.*

***T7**: Like if am treating a particular topic whereby I feel it has a link with the other so I also make sure that before I teach this topic then it's necessary for me to teach this particular topic for better understanding. When am also drawing my syllabus we consider that where we sit together as department and discuss that this is what we are going to teach this term, so when we are doing that we used to be very conscious to make sure that the topics are in chronological order. For example: **T7**: They must know the electron number of each element because the electron number determines the valence of that particular element and you have to know the atomic number of each element then from there also the periodic table I will make sure that elements of each group it belongs to you know.*

7.5.1.1 Discussion

From the data gathered each of T3, T6 and T7 to some degree ensure that topics taught are linked to each other in their classroom practices. These teachers have displayed knowledge of the science curriculum/syllabus used at school. This concurs with Magnusson et al.'s (1999) model of PCK which pointed out the teachers' understanding of the topics within the science syllabus and how they are connected to each other, and their ability to link students' prior knowledge to new knowledge.

7.5.2 Teacher Knowledge of students understanding of science

Code1: Review of previous topic (T2, T3 and T6)

The interview data showed that three out of twelve teachers stated that they review previous topics learned. Below is the statement made:

T2: Beginning a new topic when the previous one was not digested makes the new topic difficult and boring for learners. By bringing a reflection of the previous topic before introducing a new one you are giving your students a gentle reminder that every topic is connected to the other.

T2: *Yes, that's why you can see even before I embarked into the practical I made a brainstorm of the lesson to see what their prior skills and knowledge is based on the lesson of the day.*

From the lesson observation data:

The lesson observation data showed that seven out of the twelve teachers gave a brief revision of the previous lesson (T1, T2, T3, T5, T8, T9 and T10).

Code 1: Meeting the needs of students by providing adequate teaching learning resources (T1, T6, T7, T9 and T10)

The lesson observation data showed that five teachers out of the twelve met the needs of students by providing adequate teaching learning resources.

7.5.2.1 Discussion

Teachers to some degree reflected on the students' pre-requite skills and knowledge before teaching a new topic. This was evident in almost all the 12 lessons that I observed. Teachers did this by making a brief recap of what was done in their previous lessons. Teachers were also observed helping students and addressing some of the wrong conceptions they brought to class. Observing teachers' practice and knowledge of students' understanding of science, T2 of School A did some brainstorming with students before introducing an activity to be conducted by students. This activity was to show that air contains oxygen. T3 made a recap of the previous lesson by going through the types of salts and uses with students before giving them an activity. T5 did something similar to T3 by recapping the previous lesson on unsaturated, saturated and supersaturated solution, crystallisation, and evaporation, solute and solvent before the practical was conducted by students. Similar strategies were also employed by T8, T9 and T10 during their practices.

Teachers from Schools A, C, and E were able to provide conventional resources to their students during lessons while teachers from Schools B and D, which were inadequately resourced, improvised with locally available materials which they provided for their classes. T1 from School A was able to provide conventional materials to students and these include: test tube, beakers, burners, test tube holders, test tube racks, ethanol, matches and fresh leaves. T2 provides materials such as beaker, candle, water, ice cubes and matches. T3 provided enough chemical substance and materials such as: test tubes, Copper (II) sulphate ($CuSO_4$), Hydrochloric acid (HCl), Nitric acid (HNO_3), Silver nitrate ($AgNO_3$), Barium Chloride ($BaCl_2$), Sodium Hydroxide (NaOH), red and blue litmus paper. Equally, T6, whose students investigated the causes of rusting, were given adequate materials for the activity. These included brand new nails, test tubes, water, oil, cotton, and stopper, test tube holders, work sheets and a diagram showing the experimental set-up. T7's lessons on separation of immiscible liquids for example, water and oil also came with a diagram of the practical set-up which was mounted on the board. He also provided the groups with enough oil, water, beakers and separating funnels for them to conduct the activities. Both T6 and T7 during the lesson observation discussion expressed how equipped their school was and the small size of their classes which was a quarter of the class size of A, B, D, E and F. T10 and T11 all from School E had their lessons on mixtures and solutions and were able to provide students with adequate materials to conduct their activities. T12 in School F had no problems with materials since they have Chemistry, Physics and Biology labs in the school. However, his lesson was on female reproductive system which he taught using an improvised chart.

In School B and D, being the less resourced schools, T8’s topic was on parts and function of the microscope, managing to share 5 microscopes out to groups with a total number of 12 students. T9, from the same school, also managed to engage his students to conduct a series of activities on separating different mixtures. The students conducted the experiment with few conventional beakers and improvised using non-conventional materials, making beakers and funnels out of plastic, candles as source of heat, and piece of cloth as a filter paper. The science lab in School B was identical to School D in terms of the facilities that were available. School D had a single lab smaller than an actual classroom size. The tables were constructed with cement and covered with tiles. These tables were fixed and were found at the sides of the lab and at the middle of the lab. There were no lab chairs for students to sit on during lessons. The chairs found were too small in size and short and the number of chairs was less than four. The chairs were not used by the students during the activity, so they instead stood on their feet throughout the double period (70 minutes). One running tap was seen at the corner of the lab and there was no Bunsen burner. During one of their experiments when the students needed a source of heat to evaporate their solution, they had to resort to using a candle which was unable to give the correct result.

T4, from school B, provided improvised materials to students to conduct an experiment from the list of activities provided by the teacher. These activities were later presented by the group leaders. Some of the materials were brought by the students which included rice particles, salt, sand, metallic objects, magnets, plastic bottles which they used to make beakers and funnel from. The science lesson was held in the only available science lab in the school. The lab had cement concrete tables without tiles, and no lab chairs for the students to sit on. The lab was too small to contain a class of more than seventy students. The lab was hardly used as it could be seen as too dusty and had one running tap and no Bunsen burner. Both T4 and T5 had to improvise a source of heat outside the classroom. These two teachers provided the students with a charcoal pot as a source of heat in the absence of Bunsen burner.

From this study it can be concluded that teachers from schools with inadequate materials seem to use more of their discretion to improvise materials than the teachers with fully equipped laboratories. This is confirmed from the lesson observation that I undertook in each of the 12 lessons. Thus, improvisation of basic science materials was done by teachers in Schools B and D which students use to conduct practical work and experiments, while Schools A, C, E and F depend on their conventional science materials readily available in the labs. Thus the finding from this study revealed two key Gambian science teachers' knowledge of students' understanding of science; one as giving a brief revision of the previous lesson and two, providing students with adequate teaching and learning resource which concurs with Magnusson et al.'s (1999) model of PCK and relates to Friedrichsen et al.'s (2011) belief about science teaching and learning.

7.5.3 Teacher knowledge of instructional strategies

Code 1: Providing appropriate and relevant activities and teaching learning resources (T1-T12)

The lesson observation data showed that twelve out of twelve teachers provide appropriate and relevant activities and teaching and learning resources.

Code 2: Making variety of activities (T2, T4, T5, T9 and T10)

The lesson observation data indicated that five teachers out of twelve offer a variety of activities.

Code 3: Encouraging students to ask questions (T1, T6, T8, T10 and T11)

The lesson observation data showed that five teachers out of the twelve encourage students to ask questions.

Code 4: Promoting student participation and collaboration (T1, T6 and T8)

The lesson observation data showed that three out of twelve teachers promote student participation and collaboration.

Code 5: Mastery of subject matter by giving appropriate and relevant examples (T1, T2, T8 and T11).

The lesson observation revealed that four teachers out of the twelve demonstrate a mastery of the subject matter by giving appropriate and relevant examples.

7.5.3.1 Discussion

The lessons observed were all experimental based topics except T12 whose lesson was on the female reproductive system. In most of the lessons that I observed, I realised that teachers made a quick review on the previous topics taught before engaging students into practical activity. Most teachers wrote an experimental procedure on the board and took students through it before setting up the practical activities for students. Such strategy avails students with the opportunity to ask questions for clarification before conducting the experiment.

T1 copied the procedure on the blackboard for students to follow. The teacher took the students through the procedure before allowing them to conduct the experiment.

Students were encouraged to ask for clarification. During the group activities, students were seen discussing among themselves, even though they were in two large groups of over 16 students in each group. There were group presentations after the activity in which they were able to compare and contrast their findings. This means that T1 used multiple strategies in his classroom practice. Thus T1’s knowledge of instructional strategy seems to link to his orientation towards teaching science being student centred. T10 and T11 in School E had similar teaching strategies to T1 in School A. Both teachers had their lesson on mixtures.

T2’s lesson was also practical and similar to T1’s lessons. T2 started with a review of the previous lesson in the form of whole class discussions on the percentages and composition of air with students. This was followed by practical activities conducted by the students. The experiment procedures were distributed to the groups to follow. The results were obtained and discussed, and summaries of these were written on the blackboard by members from each group. The second experiment was demonstrated by the teacher to show that air contains water vapour. A student was called to put an ice cube into a beaker. This was observed by students for a while before the beaker was carried by one of the students who moved round the lab to show it to the rest of the class. This was followed by a whole class discussion on the rationale behind the water formation outside the beaker. T2’s knowledge of instructional strategy seems to be related to the student centred method. His teaching strategy consists of different methods and involved students in a variety of activities. Thus, T2’s orientation could be considered discovery based and activity driven which shapes well his knowledge of instructional strategies.

A practical based lesson was also conducted in the lab with a facilitation from T3. He started the lesson with a review of the type of salts and their uses. This was in the form of whole class discussion. The teacher wrote procedures on the blackboard and further explained how the experiment was supposed to be conducted. Students were asked questions which they responded to. In two large groups they started the activity and discussed in their groups. At the end of the group activity, students were able to identify compounds given to them as acids, bases and salts with the help of the litmus papers they used. The teacher gave each group some time to present their experimental results and this was done by their group secretaries. This gave the groups the opportunity to compare their results which created a discussion on how they differ from each other. T3’s knowledge of instructional strategy relates to his orientations towards the teaching of science which were activity-driven and guided or discovery and inquiry, thus pointing to Magnusson et al.’s (1999) student centred learning.

T1, T2 and T3 in School A, from the observation checklist provided appropriate and relevant teaching learning resources and activities. T1 and T2 both showed a mastery of the subject matter, and T1 encouraged student participation and collaboration.

T6 and T7 in School C had their lessons on rusting and separating immiscible liquid (water and oil) respectively. These teachers demonstrated adequate subject content knowledge and encouraged student participation throughout the lesson. The teachers provided relevant and appropriate materials for students to be able to conduct their activities. Procedures and worksheets were provided and distributed to groups. A diagram of the experimental set-up was also drawn and pinned on the blackboard. The students presented and discussed their findings at the end of the activity to the entire class. T6 and T7 therefore used multiple strategies in their classroom practices which links to the use of student centred learning. Therefore, their orientations influence their classroom practices.

T4 and T5 were from School B with inadequate materials. The type of furniture in the school was not flexible enough for students to sit in groups and this hindered group discussion and activities. Both teachers managed to conduct practical lessons under such conditions by improvising basic scientific apparatus to engage the students and make their lessons interesting. T4 had his lesson in a lab with virtually no facilities. His topic was on separating mixtures and all the materials provided were improvised. T4 gave a variety of activities to students in their groups. He did not give students any procedure to conduct the activities given, but instead he challenged them to write how they carried out their activities and indicate their observation and results. T4 was also seen going round to each group and telling them what to do. At the end of the activity group leaders were called to present their findings. In a similar vein T5 did her lesson in a class and set activities to the groups. Instructions for each activity were handwritten on a piece of paper and distributed to the groups. Therefore, both T4's and T5's knowledge of instructional strategies involved providing a variety of activities and using multiple methods in their lessons, thus making their lesson SCL, which implies their orientations are linked to their classroom practices.

T8 and T9 are from School D which is similar to School B in terms of inadequacy of science materials. T8's lesson was on separation of mixtures which he conducted in the lab. There was no filter paper and Bunsen burner in the school lab. These were improvised by using a piece of cloth as a filter paper and candles as a source of heat and substitute for a Bunsen burner. However, due to the low amount of heat produced by the candle, a desirable result was not obtained when the students heated the salt solution after filtration. The school has only one conventional separating funnel and the teacher improvised enough for the groups to use a small plastic bottles and straws. The teacher explained every activity that he assigned to the students. There were no procedures or worksheets given to students. The students were divided into five groups and were seen discussing in their groups. At the end of every activity, for example, the separation of sulphur powder and magnets, the teacher questioned the students on the materials used, procedure, observation and conclusion. T8 also promoted students' participation and collaboration by asking students questions and obtaining responses from them. She made sure that each group had a microscope to interact with. Therefore, there were relevant teaching and learning materials used by both teachers apart from the candle used by students of T8 which was not appropriate for the task, due to the lack of other source of heat during the lesson. However, both had adequate content knowledge of the subject matter. Both teachers even though under very hard conditions, put great efforts into making their lessons student centred, taking into account their knowledge of instructional strategy which was student centred orientated and involved guided and discovery based learning using Activity Student Experiment Improvisation Plan Do See and Improvise (ASEI-PDSI) approach – a hallmark for student centred learning.

However, T12 had a lesson on the female reproductive system which was the only non-practical based lesson observed. The teacher attached a chart of the female reproductive system on the blackboard and explained to students without asking any questions. Students were passive listeners and were not given the opportunity to discuss in groups. After his explanation, the teacher asked students the function of the female sex organ. T12's classroom practices do not link to his orientation which is student centred, hence his lessons are didactic. When I questioned him during the lesson observation discussion about his method used in the lesson, he mentioned that the class was a low ability group and that was the only way he teaches them because he knows that they will not answer any questions if he does not explain to them first. According to him he teaches other groups differently.

It can be concluded that teacher knowledge of instructional strategy involves providing relevant activities and teaching and learning resources which they do during experiment, giving appropriate examples and diagrams in their lessons. This concurs with Magnusson et al.'s (1999) teacher knowledge of instructional strategies.

7.5.4 Teacher knowledge of assessment

Code 1: Asking numerous number of questions (T1, T2, T5, T6, T7, T8, T9, T10 and T11)

The lesson observation data showed that nine teachers out of twelve ask numerous questions of students during their classes.

Code 2: Questions asked not only based on knowledge or recall (T5 and T7)

The lesson observation data indicated that two teachers out of twelve ask questions that were not only based on knowledge or recall.

7.5.4.1 Discussion

The findings indicated teachers' practice involves asking numerous questions to assess their students' level of understanding. This was done by nine teachers out of the twelve during the lesson observation and the remaining three teachers referred to questioning students during the interview as a way that science is learnt well by students. In their classroom practice, T1 asked his students at the end of the experiment what they had learned. In response to these questions the students said that they were able to confirm the presence of starch in a leaf through observing a blue/black colour change in the leaf. T2 asked students to define air. When the students responded that air was a mixture of gases, he made a follow-up question and went on to ask what a mixture was. This question was answered by students as two or more substances physically combined together. Students were also able to recall the percentage composition of air when they were asked by the teacher. These questions asked by the teacher were recall of knowledge and did not test for any skills. The teacher asked key questions at the end of the experiments on presence of oxygen in air. He asked them to state the reason why the lighted candle went off after some times when the glass jar was used to cover the candle and why there was an increase of water level in the jar and a decrease in the beaker. The last experimental assessment was the reason behind the formation of water droplets on the exterior surface of the beaker. Such questions made students think critically since they were not recall or knowledge based questions. T3's students at the end of the experiment were able to classify the compounds given to them as acids, bases and salt with the help of the litmus. T5 also asked her students some knowledge questions like defining saturated, unsaturated and supersaturated solutions after taking them through a series of activities in making each of the solutions. At the end of his practical lesson, T6 asked students to name the test tube in which rusting will not occur. This prediction was made before the conduct of the experiment. This kind of question is more application of knowledge as whatever they learn from that lesson they will be able to apply in a real-life situation, for example such as preventing metals from corrosion. T7 gave each group a worksheet containing a diagram of the set-up of the experiment and a few questions based on the parts and function of the apparatus used (separating funnel, beaker). Students answered these questions on the worksheets given to them by the teacher. T8 asked her students to define a microscope and state the type of microscope. The types of microscope were classified as light and electrical microscope. She also asked the students the parts and function of the microscope. She gave them the material to interact with and link its uses to a clinical situation thus making it more applicable to students. T9's, T10's and T11's lessons were similar to T4's and did not show much difference apart from the materials used. T12 explained all he wanted the students to know about the female reproductive system and evaluated his students by asking them to state the parts and function of the female reproductive system which was more recall of knowledge as only those who can remember what he said were able to give correct answers to his questions. However, other forms of assessment apart from oral questioning by teachers included homework, classwork, tests and exams. Mostly tests and exams are graded and are considered as part of the students' progress to another level in their education journey.

Therefore, teacher knowledge of assessment as a component of Magnusson et al.'s (1999) PCK relates to their classroom practices.

7.6 Summary

The chapter revealed key findings on the relationship between science teaching orientations and teachers' classroom practices. In the context of the Gambia, the goals and purpose of science teaching according to teachers is that they like science and they want to impart knowledge, change students' lives and perceptions and to achieve good results. Teachers revealed that they achieve their goals by use of materials, class discussions, group work and practical work. The chapter also revealed teachers' views of science which highlighted the teachers' beliefs and values about science. The science teachers in the Gambia believe that science is difficult and broad. Another key theme in this chapter is the belief about science teaching and learning. On this theme a key role of the teacher in a science lesson is as a guide/ facilitator which concurs with the constructivist theory and SCL principles, while the role of the student in a science lesson is investigative. Teachers also believe that students learn science well when they are provided with materials, conduct experiment, make lessons activity based, when students ask and answer questions, when students' errors are rectified during the lessons and group work. This finding seems to overlap with how science can be taught to make it interesting and enjoyable to students. The data revealed the use of experiment, provision of teaching and learning materials, linking topics taught to students' daily life activities; taking students' prior knowledge into account and the use of appropriate methodology and teaching and learning resources. The chapter highlights teachers' PCK which resonates well with their orientations. The chapter revealed that teacher knowledge of the curriculum involves making sure that the topics taught are interconnected. Teachers' knowledge of students' understanding of science involved reviewing previous topics and providing adequate teaching and learning resources. The teachers demonstrated teacher knowledge of instructional strategies which include providing appropriate and relevant activities and teaching learning resources; offering a variety of activities; encouraging students to ask questions; promoting students' participation and collaboration and teachers showing mastery of the subject matter by giving appropriate and relevant examples. The teacher PCK also highlighted teachers' knowledge of assessment. Teachers showcased this in their classroom practice by asking numerous questions. The evaluation of RQ3 is found in the next chapter.

Chapter 8: Evaluation of RQ1, RQ2, RQ3 and model used

8.1 Introduction

This chapter presents an evaluation of the three research questions and the models used as an analytical tool for analysing the data obtained through lesson observation, interviews and focus groups. To address RQ1, data was collected through focus groups and lesson observation and analysed using a combination of both Magnusson et al.'s (1999) STOs and Friedrichsen et al.'s (2011) STOs, excluding the goal and purpose of teaching science. Data for RQ2 was obtained through interviews with science teachers and lesson observation using Magnusson et al.'s (1999) model of STOs as the analytical tool for its data analysis. RQ3 was also addressed by interviews and lesson observation data analysed using Magnusson et al.'s (1999) model of PCK, but also used Friedrichsen et al.'s (2011) model of STOs as an analytical tool for analysing the data. After discussing each research question, the chapter evaluates Magnusson et al.'s and Friedrichsen et al.'s models. It concludes by presenting and evaluating the model that I proposed for future research on SCL and teacher pedagogical orientations related study, which bridges the gap between Magnusson et al.'s and Friedrichsen et al.'s models.

8.2 Evaluation of RQ1

Addressing RQ1: The extent to which Gambian Upper Basic School students' perceptions of their science lessons relates to SCL pedagogies. In order to gather students' views of their science lessons, I deemed it necessary to examine critically their views of science and beliefs about science teaching and learning, deliberately ignoring the goals and purposes of teaching science as the students were not teachers. Magnusson et al.'s (1999) model of STOs and Friedrichsen et al.'s (2011) model of STOs were applied to analyse the data in order to answer research question one.

Challenges and difficulties students face in learning science arose from the data that were not addressed by the two models. These challenges include numerous diagrams to draw, label and state their functions in science, difficulties with understanding and pronouncing scientific terms, the mathematical nature of some science topics and the lack of basic science materials to conduct practical work. Science is seen as difficult and challenging because of the large number of diagrams involved which students are required to learn to be able to label their parts and state their functions. Some students find it hard to pronounce biological terms and science topics that are mathematical. This is because they are weak in Mathematics and felt that Physics and Chemistry topics that require some form of calculation are difficult to understand. According to the students they hardly conducted practical work due to lack of materials in their schools. In school A, students echoed that priority was given to the students at SSS level since the materials were not sufficient for both levels to do practical. Furthermore, candidates at senior secondary school do practical work as part of their final year examination in Physics, Chemistry and Biology, so there was a fear from the teachers that the apparatus and reagents at hand might become exhausted if they had to do practical with UBS students due to the large student population in their school.

The findings from the students' accounts of their lessons indicated that in general, teachers' classroom practices were predominantly teacher centred, even though they tried to make their lessons student centred. Lessons were mainly didactic, meaning that the teacher tells, shows, talks and explains, which is in accordance with Magnusson et al.'s (1999) STOs. This was largely due to the challenges and difficulties that students outlined in the teaching and learning of science particularly the limited resources in their schools. The total number of focus groups who perceived that their lessons involved practical work, provision of teaching aids and related the topics taught to their daily life was a far lower frequency than the focus groups who perceived their lessons to be didactic.

Nevertheless, SCL strategies did occur eleven times from the lessons I observed, these corresponded well with Magnusson et al.'s (1999) student centred orientations, and involved activity driven, conceptual change, process inquiry and discovery orientations. The lesson observed mostly involved the topics that centred on separation techniques such as filtration, evaporation and magnetisation. The similarities in topics could be that because teachers were using the same syllabus in their respective schools with specific group of students at the same term time. Teachers in schools with inadequate materials had to improvise materials for their students to conduct practical work. Students' beliefs about science teaching and learning indicated that their preferred ways to learn science involved group work, doing practical work / experiment, participation and discussion, asking questions and explanation using concrete objects from the teacher. This concurs with what teachers believe from my research about how students best learn science. These learning preferences avail learning by doing and the sharing of knowledge and ideas which are SCL approaches, thus increasing students' autonomy (Peters, 2010).

Students' views of science and their beliefs about science teaching and learning could not be interrogated fully by the Magnusson et al.'s (1999) model of PCK because the model does not include the goal and purpose of teaching science, views of science and beliefs about science teaching and learning. Hence Friedrichsen et al. (2011) was used to complement Magnusson et al.'s (1999) model of STOs. The students' views of science as showed in the findings correspond with the beliefs and values of science according to Friedrichsen et al.'s (2011) STOs. These included students' beliefs that science is difficult; helps to improve their hygiene; science is an important, interesting and nice subject, and is a career that can lead to earning a good living.

In conclusion students' perceptions of their science lessons were dominated by teacher centred methods, as they are described by Magnusson et al.'s (1999) STOs. This was as a result of, among other factors, the lack of resources to conduct practicals during science lessons. This finding is in agreement with the teachers' perception that SCL is difficult to implement. Considering Friedrichsen et al.'s (2011) STOs, students' views of science from the findings were both positive and negative. Students viewed that science helps to improve their hygiene, but at the same time they consider science to be a difficult subject due to its mathematical content, numerous diagrams and scientific terms difficult to pronounce. The findings showed that students' most preferred ways to learn science were SCL related, as they preferred group work, doing practical/experiment, participating in discussions, asking questions and explanation using concrete objects.

8.3 Evaluation of RQ2

Magnusson et al.'s (1999) model of STOs was able to interrogate the data to answer RQ2, which critically examined the extent to which teachers' perceptions of SCL have influenced their classroom practices. Magnusson et al.'s (1999) STOs were featured by the science teachers and these were student centred orientations which involved process, activity orientated, conceptual change, discovery, inquiry, project based and guided inquiry. This is because their practices were about guiding students, encouraging students' discussions, participation and involvement, group work, project work and the use of teaching and learning materials. However, the number of teachers who use these approaches was smaller when interviewed compared to when they were observed.

SCL is perceived by teachers as the best pedagogy. Teachers believe that SCL encourages student participation and involvement in the learning process. Teachers perceive that students are able to support and learn from each other. In this way they are able to share their knowledge and experiences during group work and discussions held in the classroom.

Teachers perceive that SCL is activity based. Teachers believe that students remember better when they learn by doing which is attained through practical work. Teachers perceive that in this way their role is to facilitate, support and guide the students.

There were numerous factors revealed that impede SCL practices in the classroom. These factors include lack of resources, large class size, examination orientated syllabus, lack of time, prioritising senior secondary school candidates, students' uncertainty in the subject of science, and inadequate training for teachers to use SCL approaches. The lack of resources in schools lead to few or no practical work conducted by students during science lessons. As a result of this students at SSS are given the opportunity to conduct practical thus leaving those at UBS at a disadvantage. Group sizes in group work were large because of large class size and few materials. Teachers perceive that SCL requires a lot of time for preparation and the overloaded curriculum does not allow this as teachers are expected to cover an extensive syllabus of teaching every term. Teachers perceive that students' uncertainty of science makes them lack interest due to their fear of failure. Teachers feel that they require adequate training to put SCL into practice.

In conclusion, teachers perceived SCL as generally good for learning but felt too constrained by their environment and lack of resources to deliver it routinely. Teachers' perceptions of SCL accords with SCL principles but is often too difficult to implement.

8.4 Evaluation of RQ3

RQ3 critically examined the ways in which science teachers' pedagogical orientations influence their classroom practices. This research question was interrogated by both Magnusson et al.'s (1999) model of PCK and Friedrichsen at al.'s (2011) STOs. Friedrichsen et al.'s (2011) STOs comprise three themes; the goals and purpose of science teaching, views of science, and beliefs about science teaching and learning. In order to relate teachers' orientations to their practices the four remaining components of Magnusson et al.'s (1999) PCK were also used: teacher knowledge of curriculum; teacher knowledge of students' understanding of science; teacher knowledge of instructional strategies; and teacher knowledge of assessment.

The goals and purposes of science teaching: teachers' rationale for teaching science was that they enjoy and like science, to impart knowledge, inspire students, achieve good results and change students' lives and perceptions. Teachers believe that their goals of teaching are achieved through use of science materials, class discussions, group work and practical work. These beliefs are related to SCL approaches.

Teachers' views of science: teacher beliefs and values about science teaching and learning showed that science is difficult, broad and at the same time science is seen as relevant to daily life. The belief that science is difficult corresponds with students' views of science in RQ1 findings.

Beliefs about the science teaching and learning: the findings indicate that the role of the teacher is to teach, to serve as a guide and that the teacher should be well prepared. Students' roles were meant to be investigative and to pay attention to their work. The teachers' role as a guide is in agreement with SCL principle. Teachers believe that science can be best learned by students if they are provided with materials to conduct practical. It is the belief of the teachers that science can be learned by students when the lessons are activity based, asking and answering questions, rectifying students' errors and students working in groups. These beliefs are related to SCL approaches. Teachers also believe that science can be taught through the use of experiment, provision of materials, linking topics to students' daily life activities, taking into account students' prior knowledge and skills and the use of appropriate methodology and teaching and learning resources. These findings accord with teachers' beliefs about how students learn science better and this corresponds with teacher pedagogical content knowledge from Magnusson et al.'s (1999) model of PCK which were teachers' practice and were observable in the classrooms. In other words, teachers' pedagogical orientations influence their classroom practice since:

Teacher knowledge of curriculum: the findings showed that the topics taught by teachers were interconnected. This means that teachers put into account students' prior knowledge before teaching a particular subject matter. In this way teachers are facilitating and building students' new knowledge from what they have already known.

Teacher knowledge of students' understanding of science: the findings revealed a review of the previous lessons and meeting the students' needs by providing adequate teaching and learning resources.

The findings indicated that teacher knowledge of instructional strategies include: provision of appropriate and relevant activities and teaching learning resources, providing a variety of activities, encouraging students to ask questions, promoting students' participation and collaboration, and demonstrating the mastery of subject matter by giving appropriate and relevant examples.

The findings showed that teacher knowledge of assessment is about asking numerous questions and questions asked were not based on knowledge or recall of information.

In conclusion, teacher pedagogical orientations have greatly influenced teachers' classroom practices although this has been hindered by the lack of resources among other constraints.

8.5 Using Magnusson et al. (1999) and Friedrichsen et al. (2011)

Magnusson et al.'s (1999) model of PCK has five components. In this study nine science teaching orientations (STOs) of Magnusson et al. (1999) were used to interrogate the data obtained to address RQ1 and RQ2, which examines the extent to which students' perceptions of their science lessons relate to SCL pedagogies and teachers' perceptions of SCL influence their classroom practices. The nine STOs classified as teacher centred and student centred orientations run through a continuum of traditional teacher centred to student centred methods. Therefore, Magnusson et al. (1999) encapsulates SCL, thus making it a strong analytical tool for examining the data obtained through interviews and focus groups. The remaining four components which are teacher knowledge of curriculum, teacher knowledge of students' understanding of science, teacher knowledge of instructional strategies and teacher knowledge of assessment, referred to as teacher pedagogical content knowledge, were used for analysing the data to address RQ3, which critically examined the extent to which science teachers' own pedagogical orientations influence their classroom practices. These components were observable during the lesson observation in order to triangulate and address all the research questions. In addition to the four components of Magnusson et al. (1999), Friedrichsen et al.'s (2011) model of STOs (which has three dimensions, namely: the goal and purpose of teaching science, views of science, and beliefs about science teaching and learning) was used as a supplement to fill the gap in Magnusson et al.'s (1999) model as an analytical tool for analysing the data obtained through interviews to address RQ3.

Friedrichsen et al.'s (2011) STOs were also used in RQ1 to analyse the data obtained from the focus groups. However, as the focus groups were students, the first dimension, which was the goal and purpose of science teaching, was deliberately omitted since the students were not teachers.

There were relevant findings that were not apparent in either of the models. These were the constraints that the teachers and students face in the teaching and learning of science, thus impeding SCL practices. Both teachers and students mentioned similar constraints during the interviews and focus groups and these were: lack of resources, large class size, examination orientated syllabus, lack of time, prioritising the SSS level, students' views of science as difficult, inadequate training to practise SCL. Thus, one shortcoming of Magnusson et al. (1999) is that it does not take into account the possible obstacles that affect teacher classroom practices. Therefore, it would be appropriate to factor in these obstacles to future models, particularly when conducting research in developing countries where schools are inadequately resourced. This shortcoming indicates an assumption in each model that basic equipment for conducting experiments will be readily available for science teachers. The availability of science kits could influence the STOs, since provision of such materials to students would meet their needs in the learning of science by doing.

Below is a proposed model that I have constructed to help researchers in the future adopt and analyse their data if they wish to research on SCL practices and teacher orientations. The modified version, called Babou's Model of PCK, combines Magnusson et al. (1999) and Friedrichsen et al. (2011) with the addition of the factors affecting SCL practices revealed by this research. My modified model is a new contribution to knowledge in the field of SCL in science education.

Magnusson et al. (1999) PCK	Friedrichsen et al. (2011) STOs
Student Centred Orientations Teacher Centred Orientations Teacher knowledge of curriculum Teacher knowledge of students understanding of science Teacher knowledge of instructional strategies Teacher knowledge of assessment	Goals and purpose of science Views of science Beliefs about science teaching and learning

Challenges and constraints in teaching and learning of science

Lack of resources, large class size, examination oriented syllabus, lack if time, prioritising the SSS level, students view science as difficult, and inadequate training for teachers to practice SCL in the classrooms

Figure 3. Babou's model of PCK

8.6 Summary

This chapter indicates that all the research questions were answered fully. The findings were interesting and bring new information to the research area by their specific focus on science education in the Gambia. In RQ1 the students' accounts of their lessons were dominated by the use of teacher centred method. In RQ2, teachers' perceptions of SCL did influence their classroom practices. To some degree they accepted SCL as good pedagogy but these were not often used by teachers due to the challenges and constraints they encountered during the practice of SCL. SCL is a pedagogy of the privileged since it requires a lot of materials and time for its usage. In RQ3, teacher pedagogical orientations did influence their classroom practices since these link to their PCK such as their knowledge of students' understanding of science, knowledge of assessment, knowledge of instructional strategies, and knowledge of curriculum. However, teachers' classroom practice has been hindered by the limited resources in their respective schools.

Chapter 9: Conclusion and Recommendations

9.1 Conclusion

This chapter presents a summary of the research findings in response to each research question. This is followed by recommendations arising from the research and the ways I intend to disseminate my study findings.

RQ1. To what extent do Gambian Upper Basic School students' perceptions of their science classes relate to student centred learning pedagogies?

The first research question critically examined students' views on their lessons and how these linked to SCL. The findings showed the dominant use of didactic, teacher centred methods. During the focus groups the students described their lessons as didactic: eight out of the twelve focus groups mentioned that their teachers tells, shows and talks and explains to them during their science lessons. According to the student accounts, practical work was hardly done at the Upper Basic level and this was confirmed by teachers during the interviews. Main reasons for few or no practical work were the lack of materials in their schools, large class size and time constraints.

Findings also showed that students perceived science as difficult. The difficulty of science was linked to the numerous diagrams in science, scientific terms that are difficult to pronounce and the mathematical nature of science. The students' aversions to science become more problematic, particularly when they are faced with challenges and difficulties in the teaching and learning of science. For students to be engaged in science lessons, the teacher needs to make sure that the lessons are activity based and that the students are encouraged to do practical work. This would arouse students' interest and increase their enjoyment in the lessons, as indicated in the findings. Students pointed out that practical work is joyful and helps them to remember what they have learned more than what they are being told by the teacher. Equally, students viewed group work as a way of exchanging and sharing ideas. These comments relate to students' preferred method of learning science.

The findings also showed that students view science as important, interesting and a good subject which helps them improve their health and earn a good living.

RQ2. In what ways do science teachers' own perceptions of student centred learning influence their classroom practices?

The second research question critically examined the extent to which teachers' perceptions of SCL influence their classroom practices. The study findings revealed teachers' positive perceptions towards SCL. The teachers perceived that SCL is the best approach since it involves students working in groups where they are able to support one another. It also involves practical work which, according to teachers, enables students to retain what they have learned better than didactic 'talk and chalk' methods. Teachers perceived that their role was to guide and support students. Teachers are there to talk less and write very few notes, and activities are designed to be conducted by the students. The science teachers also perceived that students in a SCL environment are free to express themselves, participate, interact and get involved in the lessons.

In general, the teachers' perceptions of SCL is good for learning, but this hardly influences their classroom practices due to limited resources in schools, large class size, examination orientated syllabus, lack of time, students' aversion to science and inadequate training of some teachers to conduct practical work. From the findings the twelve teachers in general recognised the elements of SCL and some of them, particularly those from the inadequately resourced schools, went to the extent of improvising basic science materials to make sure that students were engaged in practical activities. Such classroom practices were influenced by their perceptions of SCL to some degree, since the topics taught during the lessons observed were practically based and not didactic.

RQ3. In what ways do science teachers' own pedagogical orientations influence their classroom practices?

The third research question critically examined the extent to which science teachers' pedagogical orientations influence their classroom practices. The study findings revealed teachers' pedagogical orientations are compatible with Friedrichsen et al.'s (2011) STOs. The goals and purposes of science teaching for the Gambian science teachers was the joy they have for science. They want to inspire their students to change their life and cultivate a positive perception towards the subject. They also seek to make an educational impact on the students, so that they obtain good results.

The findings showed that teachers' viewed science as important knowledge and skills for life, whilst at the same time science is viewed as a broad and difficult subject to students. The difficultness of science resonates with the students' views discussed earlier on.

The science teachers' beliefs about science teaching and learning indicated their role as a guide and that of their students as autonomous learners. The teachers believe that their students learn science well when they are provided with materials required and engaged to conduct practical work, group work, given activity-based lessons, rectifying students’ errors and students asking and answering questions. The teachers also believe that science can be taught as interesting and that it can be enjoyed by students engaging into practical work / experiment. Consequently, they should be provided with appropriate teaching learning materials and methodology, linking what is taught to the students’ real-life situations and taking into account the students’ prior knowledge and skills. These pedagogical orientations influence teachers’ classroom practices since they are linked to their knowledge of instructional strategies, knowledge of assessment, knowledge of students’ understanding of science and knowledge of curriculum when observed during the lessons.

As a final note, teachers’ perceptions and pedagogical orientations to some degree influence their classroom practices which are barred by the challenges and constraints they are faced with in the classrooms, such as large class size, lack of resources, time constraint and overloaded curriculum.

9.2 Recommendations

This study presents a number of recommendations that need consideration for teachers to effectively and efficiently practise SCL lessons in their classrooms in the Gambian context. Some recommendations are long term and require changes in policy and additional financing. They are complemented by some more immediate and affordable recommendations.

Firstly, consistent work should be done to lobby the government of the Gambia to develop a plan of gradual update and improvement of science laboratories and basic science apparatus including provision of essential materials for Upper Basic Schools.

In addition, the head teachers should consider readjusting their budget were possible to include the purchase of essential materials to supplement the demand of SCL practices. Science and Technology Education Directorate (STED) – a directorate at the Ministry of Basic and Secondary Education (MoBSE) responsible for the enhancement of the teaching and learning of science at Basic and Secondary level of the Gambian education system must take the responsibility to facilitate the purchasing of the materials.

Secondly, a programme should be developed by STED to train and support science teachers with inadequate practical skills and knowledge, as indicated in the findings. This could be addressed by the MoBSE in collaboration with STED. I suggest that as part of this programme, a series of surveys be conducted to identify the qualified teachers who were recruited by the Gambia College and were not science specialists during their Senior Secondary School Education, as well as those teachers who were specialists in science but were not exposed to practical work during their Secondary Education and College training. After the identification process STED needs to outline an experiment or practical work based workshop for teachers without practical work experience at regional level. This can be done in collaboration with Science Teachers Association the Gambia (STAGAM) and with financial support from the ministry, so that at the end of the training the beneficiary teachers are able to conduct experiments on their own and have the confidence to be able to engage their students with practical work. Moreover, I suggest the MoBSE also gives training to the teachers without any knowledge of improvisation, since in the absence of materials one cannot practise a student centred lesson that is activity, experiment based and student focused. The locally improvised materials provided by these teachers would be used as substitutes in the absence of conventional science materials, to address the inadequate science materials in schools. These are cheaper, usually at very low or no cost, readily available and can be used to serve the same purpose as the conventional materials. For example, making beakers and funnels from plastic bottles and using charcoal pot as a source of heat in the absence of a Bunsen burner. STED should develop manuals for improvisation to be distributed to all science teachers at UBS. These can be used by teachers as resource book to help them make basic science apparatus for students' usage during practical work. It is also recommended that science teacher trainees be exposed to improvisation techniques during their training at Gambia College so that by the time they complete their course they would have been fully equipped with the technical knowledge and skills to improvise basic science materials that could be used in their science lessons to enhance the teaching and learning of science.

One of the most prominent factors that impede SCL practices is the large class sizes in five of the six schools in this study. Teachers believe that large class size requires more teaching and learning resources, as well as more time to attend to students' needs, thus increasing teacher workload. Large class size combined with lack of basic science materials in schools leads to talk and chalk method, as the study reveals. Therefore, I will recommend that as part of the government plan of improvement of science education, the MoBSE should look into training and recruiting more science teachers which will eventually decrease class sizes. The target for this level of education should be 30 students per class but any decrease at this stage will be a positive step in the right direction. Smaller class sizes will potentially increase the teacher-student interaction. It will also reduce teacher workload and will offer more time for the teachers to mark students' work and give adequate feedback. Additional classrooms may be needed and understanding that this is a long process the recommendation is to start with highly populated and most affected schools.

In the meantime, I recommend the MoBSE to provide in-service teacher training on classroom management and control. This will help to equip the teachers teaching large class sizes to be able to manage their classes well by encouraging and engaging students in group work, class discussions and presentations, which are key elements of SCL. For example, different activities could be set for different groups and each of these groups could do all the activities by rotating around the class. This will minimise the high demand for material resources, particularly if all the class can do only one activity at a time. Equally, at the Gambia College teachers should be trained how to manage and control large class sizes in order to address the difficulties that these teachers will face after the completion of their course.

Furthermore, the time factor has been singled out as a great concern for teachers to be able to implement student centred lessons in their classrooms. There should be an increase in the number of science periods from five per week to six per week for students to have enough time to interact in active discussions and practical work during science lessons. This is because the use of SCL requires multiple methods of teaching. An increase in the number of science periods will affect other subject areas of the curriculum, but this can be remedied by making sure that the five periods allocated are put together as a double period and triple period per session. In this way there will be enough time for teachers to engage their students in different activities. It is also crucial to include time management skills in the teacher training programmes to help teachers to attain their lesson objectives within the specified time limit.

Additionally, the Gambia Basic and Secondary Education Certificate Examination (GABECE) should include more application based questions and minimise questions that ask students to recall knowledge. This will encourage the teachers to engage students in activity-driven, inquiry, discovery based methods which promote independent learning and discourage rote learning and memorisation of information.

Another important recommendation is the improvement of furniture used in schools. I would recommend that for student centred learning practices to be effective the furniture type should be such that students should be able to form groups easily for discussions or any form of group activity. It is realised from this study that the type of furniture in some schools makes it impossible for group activity, since the tables and benches are designed in such a way that it is difficult to move and to form circles for group work. Teachers however may take responsibility and rearrange in their classrooms to facilitate group work.

Finally, MoBSE in collaboration with STED should encourage teachers and empower them via training to use the SCL approach for the effective teaching and learning of science at Upper Basic school level and across other levels and subject areas. The trained teachers could have a step-down training at their schools and schools within the local area. Use of SCL, such as Activity Student Experiment Improvisation (ASEI) lessons, which are activity-based, student centred, experiment-based and use improvisation, addresses the issue of inadequate teaching learning resources in Upper Basic schools in the Gambia, as it is costly to use conventional materials in all the schools throughout the country. Improvising materials in science lessons will induce learners' interest and make the teaching and learning of science more interesting and meaningful. This is likely to motivate more learners to opt for science and become future scientists in the Gambia who may be capable enough to transform the country into a scientific and highly technological country. The study therefore makes a significant contribution to knowledge, notably to the education policy of the Gambia for teachers to shift from teacher centred to student centred learning.

9.3 Dissemination

The dissemination of my study findings is essential in the Gambian education context. I will take the opportunity to extend my findings through the support of the MoBSE and STED to all the stakeholders in the Gambian education system. One way of doing this is to present my study findings at the regionally held Coordination Committee Meeting (CCM) where all the stakeholders in education converge to explore the issues confronting education in the Gambia. I will consider producing a research poster as a quick and powerful means of dissemination of my study. As a sponsored candidate of the MoBSE it is my responsibility to provide a copy of my thesis to the administration. I will as well consider providing a short report-like executive summary which will focus on key evidence and action points for them to act on. This will avail them the opportunity to learn about the findings from the study and the recommendations proposed for their quick intervention. At the MoBSE, there is an education magazine known as The Enlightener, which will be a useful platform to share my study findings to the entire nation. One of my job roles is to organise continuing professional development (CPD) workshop for teachers. I will therefore seize those moments to share my study findings with the teachers during such trainings. Equally, I intend to share the findings during international workshops and conferences that I will attend in the near future. I understand that upon completion a copy of the thesis will be added to the University of Huddersfield's online repository for individual researchers to access. In the Gambia, I will provide a hard copy of my thesis to the University of the Gambia library and a copy to the Gambia National Library to serve as reference for other researchers in education. Finally, I would like to seize the opportunity with the support of my supervisor to draw key features of the study for academic publication in journals. In this way the findings from this study would be easily shared internationally, being the first study of its kind undertaken in the Gambia.

References

Abrahams, I., & Millar, R. (2008). Does Practical Work Really Work? A study of the effectiveness of practical work as a teaching and learning method in school science. *International Journal of Science Education*, *30* (14), 1945 - 1969. doi: 10.1080/09500690701749305.

Anderson, V. (2009). *Research Methods in human Resource Management* (2nd ed.). London: CIPD.

Arends, R.I., & Kilcher, A. (2010). *Teaching for students learning: Becoming an accomplished teacher*. London: Routledge.

Ashmore, L., & Robinson, D. (Eds.) (2015). *Learning, Teaching and Development Strategies for Action*. London: SAGE Publications LTD.

Aswegen, S.V., & Dreyer, C. (2004). An analysis of the extent to which English Second Language teacher educators are implementing learner - centred teaching and learning: a case study. *South African Journal of Education*, *24* (4), 295 - 300. Retrieved from http://www.ajol.info.

Bada, S.O. (2015). Constructivism Learning Theory: A Paradigm for Teaching and Learning. *IOSR Journal of Research & Method in Education, 5* (6), 66 - 70. doi: 10.9790/7388-05616670.

Baeten, M., Kyndt, E., Struyven, K., & Dochy, F. (2010). Using student centred learning environment to stimulate deep approaches to learning: Factors encouraging or discouraging their effectiveness. *Educational Research Review*, *5* (3), 243 - 260. doi: 10.1016/j.edurev.2010.06.001.

Barmby, P. Kind, P., & Jones, K. (2008). Examining Changing Attitudes in Secondary School Science, *International Journal of Science Education*, *30* (8), 1075 - 1093. doi: 10.1080/09500690701344966.

Bartlett, S. & Burton, D. (2012). *Introduction to Education Studies* (3rd ed.). London: SAGE Publication.

Bates, B. (2016). *Learning Theories Simplified*. London: SAGE Publication Ltd.

Bazeley, P. (2009). CONSTRUCTING AN ARGUMENT THROUGH DATA ANALYSIS. In J. Higgs, D. Horsfall, & S. Grace (Eds.). *Writing Qualitative Research on Practice* (pp. 195 - 205). Boston: Sense Publishers.

Bennett, J., & Hogarth, S. (2009). Would You Want to Talk to a Scientist at a Party? High school students' attitudes to school science and to science. *International Journal of Science Education, 31* (14), 1975 - 1998. doi: 10.1080/09500690802425581.

BERA. (2018). *Ethical Guidelines for Educational Research*. London: British Educational Research Association.

Bloor, M., Frankland, J., Thomas, M., and Robson, K. (2001). *Focus Group in Social Research.* London: SAGE Publication.

Boesdorfer, S. & Lorsbach, A. (2014). PCK in Action: Examining one Chemistry Teacher's Practice through the lens of her Orientation Toward Science Teaching. *International Journal of Science Education, 36* (13), 2111 - 2132. doi: 10.1080/09500693.2014.909959.

Bolshakova, V.L.J., Johnson, C.C., & Czerniak, C.M. (2011). "It depends on what science teacher you got": urban science self-efficacy from teacher and student voices. *Cultural Studies of Science Education, 6* (4), 961 - 997. doi: 10.1007/s11422 – 011 – 9346 - 2.

Brandes, D., & Ginnis, G. (1994). *A guide to Student Centred Learning*. London: Stanley Thorns (Publishers) Ltd.

Braun, V., & Clarke, V. (2006). Using thematic analysis in Psychology. *Qualitative Research in Psychology*, *3* (2), 77 - 101.doi: 10.1191/1478088706qp063oa.

Braund, M., & Driver, M. (2005). Pupils' perceptions of practical science in primary and secondary school: implications for improving progression and continuity of learning, *Educational Research*, *47* (1), 77 - 91. doi: 10.1080/0013188042000337578.

Brinkmann, S. (2015). Learner –centred education reforms in India: The missing piece of teachers' beliefs. *Policy Futures in education*, *13* (3), 342 - 359.doi: 10.1177/1478210315569038.

Brodie, K., Lelliott, A.D., & Davis, H. (2002). Forms and substances in learner-centred teaching: teachers' take-up from an in-service programme in South Africa. *Teaching and Teacher Education*,*18* (5), 541 - 559. doi: 10.1016/S0742-051X (02) 00015-X.

Brown, J. K. (2008). Student-centered instruction: Involving students in their own education. *Music Educators Journal*, *94* (5), 30 - 35. Retrieved from http://www.journal.sagepup.com.

Bryman, A. (2016). *Social research methods* (5th ed.). London: Oxford University Press.

Burns, R. B. (2000). *Introduction to Research Methods* (4th ed.). London: SAGE Publications.

Burton, D., & Bartlett, S. (2005). *Practitioner Research for Teachers*. London: SAGE.

Cansiz, N. & Cansiz, M. (2016). Preservice science teachers' orientations towards teaching science to middle schools. *International Journal on New Trends in Education and their Implications, 7* (3), 69-78. Retrieved from http://www.ijonte.org.

Clarke, J. (2010). Student centred teaching methods in a Chinese setting. *Nurse Education Today*, *30* (1), 15 - 19. doi: 10.1016/j.nedt.2009.05.009.

Clough, P., & Nutbrown, C. (2012). *A Student's Guide to Methodology*. London: SAGE Publication Ltd.

Collins, J. W., & O'Brien, N. P. (2003). *The Greenwood dictionary of education*. Westport: Greenwood Press.

Cooper, R. D. & Schindler, S. P. (2014). *Business research methods*. New York: McGraw-Hill/Irwin.

Costa, M. J. (2013). Commentary: What does "student-centered" mean and how can it be implemented? A systematic perspective. *Biochemistry and Molecular Biology Education*, *41* (4), 267 - 268. doi: 10.1002/bmb.20709.

Creswell, J. (2009). *Research Design: Qualitative, Quantitative, and mixed methods approaches*. Los Angeles: Sage Publication, Inc.

Creswell, J.W. (1994). Research Design: *Qualitative & Quantitative Approaches*. London: SAGE Publications.

Creswell, J.W. (2007). *Qualitative Inquiry and Research Design: Choosing Among five approaches* (2nd ed.). London: SAGE Publications.

Creswell, J.W. (2012). *Educational Research*: *Planning, conducting and evaluating quantitative and qualitative research* (4th ed.). Boston: Pearson Education.

Darby, L. (2005). Science students' perceptions of Engaging Pedagogy. *Research in Science Education, 35* (4), 425 - 444. doi: 10.1007/s11165-005-4488-4.

Darsih, E. (2018). LEARNER-CENTRED TEACHING: WHAT MAKES IT EFFECTIVE. *Indonesian EFL Journal*, *4*(1),33 - 42. doi:10.25134/ieflj. v4i1.796.

Dawson, D.C. (2009). *Introduction to Research Methods: A practical guide for anyone undertaking a research project* (4th ed.). Oxford: How to Books Ltd.

Demirdöğen, B. (2016). Interaction Between Science Teaching Orientation and Pedagogical Content Knowledge Components. *Journal of Science Teacher Education*, *27* (5), 495 - 532. doi: 10.1007/s10972-016-9472-5.

Denscombe, M. (2014). *Research guide: For small-scale social research projects*. Maidenhead: Open University Press.

Denzin, N. K & Lincoln, Y. S. (2000). *Handbook of Qualitative Research* (2nd ed.). London: SAGE Publications.

EI & ESU. (2016). *Time for new paradigm in education student centred learning: Student centred learning SCL tool kit*. Retrieved from http:// www.http/esu.oline.org.

Finlay, L. (2002). "Outing" the research: The Provenance, Process, and Practice of Reflexivity. *Qualitative Health Research*,*12* (4), 531 - 545. doi:10.1177/104973202129120052.

Flick, U. (2011). *Introducing Research Methodology: A Beginner's Guide to Doing a Research Project*. London: SAGE.

Flick, U. (2018). *An introduction to qualitative research* (6th ed.). London SAGE.

Flick, U. (2014). *An introduction to qualitative research* (5th ed.). Los Angeles: SAGE.

Flutter, J., & Rudduck, J. (2004). *Consulting Pupils: What's in it for schools?* London: Routledge Falmer.

Friedrichsen, P., Van Driel, J., & Abell, S. K. (2011). Taking a Closer Look at Science Teaching Orientations. *Science Education*, *2* (95), 358 - 376. doi: 10.1002/*sec*.20428.

Froyd, J. & Simpson, N. (2010).*Student- centred learning addressing faculty questions about student centred learning* .Retrieved from http://www.ccliconference.org.

George, M. (2012). Teaching Focus Group Interviewing: Benefits and Challenges. *Teaching Sociology*, *4* (3), 257-270.doi:10.1177/0092055x12465295.

Gibbs, G. (1981). *Teaching students to learn: A student- centered approach*. London: Open University Press.

Gibbs, A. (2012). Focus groups and group interviews. In Arthur, M. Waring, R. Coe and L.V. Hedges. *Research Methods & Methodologies in Education* (pp.186-192). London: SAGE Publication Ltd.

Gomez-Arizaga, M. P. Bahar, A. K., Maker C.J., Zimmerman, R. & Pease, R. (2016). How Does Science Learning Occur in the Classroom? Students' Perceptions of Science Instruction During the Implementation of the REAPs Model. *Eurasia Journal of Mathematics, Science & Technology Education*,*12* (3), 431 - 455. doi: 10.12973/Eurasia.2016.1209a.

Gray, D.E. (2009). *Doing Research in the Real World* (2nd ed.). London: SAGE.

Gray, D.E. (2014). *Doing Research in The Real World* (3rd ed.). London: SAGE.

Grbich, C. (2007). *Qualitative data analysis. AN INTRODUCTION*. London: SAGE.
Gregory. R. & Mueller, R.O. (2010). The Reviewer's Guide to Quantitative Methods in the Social Sciences. In T.R. Knapp and R.O. Mueller (Eds), *Reliability and validity of instruments* (pp. 337 - 343). London: Routledge.

Henn, M., Weinstein, M., & Foard, N. (2006). *A short introduction to Social Research*. London: Sage Publications.

Henn, M., Weinstein, M., & Foard, N. (2009). *A Critical Introduction to Social Research* (2nd ed.). London: SAGE.

Herranen, J., Vesterien, V.M., & Aksela, V. (2018). From Learner – Centered to Learner - Driven Sustainability education. *Teaching and learning for Sustainability*,*10* (4),1 - 14. doi: 10.3390/su10072190.

Horn, I.H. (2009). Learner - centredness: an analytical critique. *South African Journal of Education, 29* (4), 511 - 525. doi: 10.15700/saje. v29n4a289.

Hyun, E. (2006) Transforming instruction into pedagogy through curriculum negotiation. *Journal of Curriculum and Pedagogy*,*3* (1), 136 - 164.

Idogho, J.A. (2016). Towards a student-centred learning in Nigerian Schools: Drama in education and progressive pedagogy. Creative Artist: *A journal of Theatre and Media studies*, *10* (1), 38 - 65. Retrieved from http:// www.ajol.info.

Irungu, M. N, & Mercy, M. (2013). Evaluation of strengthening of mathematics and science in secondary education (SMASSE) program. A case study of Murang'a South District, Kenya. *International Journal of Education Learning and Development 1* (1), 46 - 60. Retrieved from http:// www.ea-journals.org.

Jenkins, E. W., & Nelson, N.W. (2005). Important but not for me: students' attitudes towards secondary school science in England, *Research in Science & Technological Education*, *23* (1), 41 - 57. doi: 10.1080/02635140500068435.

Jing-Jing, H.U. (2014). A critical review of Pedagogical Content Knowledge component: nature, principle and trend. *International Journal of Education and Research, 2* (4), 411 - 423. Retrieved from http:// www.ijern.com.

Kamau, K.J., Wilson, K.L. and Thinguri, R. (2014). An evaluation of the effectiveness of SMASSE programme in performance of science and mathematics in primary schools in Kenya. *International Journal of Education and Research, 6* (2), 1 - 10. Retrieved from http:// www.ijern.com.

Kind, V. (2009). Pedagogical content knowledge in science education: perspectives and potential for progress. *Studies in Science Education*, *45*(2), 169 - 204.doi: 10.1080/03057260903142285.

Kind, V. (2015). Preservice Science Teachers' Science Teaching Orientations and Beliefs About Science. *Science Education, 1* (1), 122 - 152. Retrieved from http://www.wileyonlinelibrary.com.

King, N., & Horrocks, C. (2010). *Interviews in Qualitative Research.* London: SAGE.

Koshy, V. (2005). *Action research for improving practice: A practical Guide.* London: SAGE.

Krueger, R. A., & Casey, M.A. (2009). *Focus Groups: A Practical Guide for Applied Research* (4th ed.). London: SAGE.

Kumar, R. (2011). *Research Methodology. A step – by- step guide for beginners* (3rd Ed.). London: SAGE.

Kvale, S. (2007). *Doing interview*. London. SAGE Publication.

Kvale, S., & Brinkmann, S. (2015). *Interviews: Learning the Craft of Qualitative Research Interviewing* (3rd ed.). Thousand Oaks, CA: Sage Publications.

Lathika, K. (2016). Student Centred Learning. *International Journal of Current Research and Modern Education* (*IJCRME*), *1*(1), 677 - 680. Retrieved from http://www.ssrn.com/abstract=2960481.

Laux, K. (2018). A theoretical understanding of the literature on students' voice in the science classroom. *Research in Science & Technology Education*, *36*(1), 111 - 129. doi: 10.1080/02635114320171353963.

Lawrence-Wilkes, L. & Ashmore, L. (2014) *The Reflective Practitioner in Professional Education*. Basingstoke: Palgrave.

Lea, S.J., Stephenson, D., & Troy, J. (2003). Higher Education Students' Attitudes to Student-centred Learning: Beyond 'educational bulimia'?. *Studies in Higher Education*, *28* (3), 321 - 334. doi: 10.1080/03075070309293.

Linn, M.C., & Burbules, N.C. (1993). Construction of knowledge and group learning. In K. Tobin (Ed.), *The practice of constructivism in science education* (pp. 91 - 119). Washington, DC: American Association for the Advancement of Science (AAAS).

Logan, M.R., & Skamp, K. R. (2013). The impact of teachers and their science teaching on students' 'science interest': A four- year study, *International Journal of Science Education*, *35* (17), 2879 - 2904. doi: 10.1080/09500693.2012667167.

Loggerenberg-Hattingh, A.V. (2003). Examining leaving achievement and experiences of science learners in a problem- based learning environment. *South African Journal of Education*, *23*(1), 52 - 57. Retrieved from http://www.ajol.info/index.php/saje/article/view/24846.

Lyons, T. (2006). Different Countries, Same Science Classes: Students' experiences of school science in their own words, *International Journal of Science Education*, *28*(6), 591 - 613. doi: 10.1080/09500690500339621.

Magnusson, S., Krajcik, J., & Borko, H. (1999). Nature, sources and development of pedagogical content knowledge for science teaching. In J. Gess-Newsome & N. G. Lederman (Eds.), *Examining pedagogical content knowledge* (pp. 95 – 132). Dordrecht, The Netherlands: Kluwer.

Marshall, C. & Rossman, G. B. (1999). *Designing Qualitative Research* (3rd ed.) London. SAGE Publications.

Mason, J. (2002). *Qualitative Research* (2nd ed.). London: SAGE Publication.

Matthews, B & Ross, L. (2010). *RESEARCH METHODS: A practical guide for the social science*. Essex: Pearson Education Limited.

McCabe, A. & O'Connor, U. (2014). Student - centred learning: the role and responsibility of the lecturer. *Teaching in Higher Education, 19* (4), 350 - 359. doi: 10.1080/13562517.2013.86011.

McLafferty, I. (2004). Methodological Issues in Nursing Research: Focus group interview as a data collecting strategy. *Journal of advance Nursing*, *48*(2), 187 - 194.

Melese, W., Tadesse, T., & Asefa, W. (2010). The Practice of Learner- Centered Method in Upper Primary Schools of Ethiopia. *Ethiop.J.Educ.& Sc., 4* (2), 27 - 44.doi: 10.4314/ejesc. v4i2.51672.

Metto, E. & Makewa, L.N. (2014). Learner- Centered Teaching: Can It work in Kenyan Public Primary Schools?. *American Journal of Educational Research, 2* (11A), 23 - 29. doi: 10.12691/education-2-11A-4.

MoBSE. (2004): *National Education Policy 2004 - 2015.* Ministry of Basic and Secondary Education, Banjul, The Gambia.

MoBSE. (2016). *The Gambia Education Statistical Yearbook – 2016.* Retrieved from http:// www.edugambia.gm/data-area/publications/year-book-2016.html.

MoBSE. (2015). *The Gambia Education Statistical Yearbook – 2015.* Retrieved from http:// www.edugambia.gm/data-area/publications/year-book-2015.html.

MoBSE. (2014). The Gambia Education Statistical Yearbook-2014. Retrieved from http:// www.edugambia.gm/data-area/publications/year-book2014.html.

MoBSE. (2017). *The Gambia Education Statistical Yearbook – 2017.* Retrieved from http:// www.edugambia.gm/data-area/publications/year-book-2017.html.

Moyles, J., Adams, S., & Musgrove, A. (2002). *Study of pedagogical effectiveness in early learning (SPEEL).* London: DfES. Available form http:// www.dora.ioe.ac.uk/4591/1/RR363.pdf.

Mtika, P., & Gates, P. (2010). Developing learner –centred education among secondary trainee teachers in Malawi: The dilemma of appropriation and application*: International Journal of Educational Development, 30*(4), 396 - 404. doi: 10.1016/j.ijedudev.2009.12.004.

Muijs, D. (2004). *Doing Qualitative Research in Education with SPSS*. London: SAGE Publication Ltd.

Murphy, C., & Beggs, J. (2003). Children's perceptions of school science. *School Science Review*, *84* (308), 109 - 116. Retrieved from http:// www.pdfs.semanticsscholar.org.

Mwelese, J.K. and Atwoto, J.O. (2014). The influence of ASEI-PDSI approach on Students' view and attitudes towards mathematics instruction. *Journal of Education and Practice*, *24* (5), 146 - 152. Retrieved from http://www.iiste.org.

Neuman, W.L. (2011). *Social Research Methods: Qualitative and Quantitative approaches* (7th ed.). London: Pearson.

Newby, P. (2010). *Research Methods for Education*. Essex: Pearson Education Limited.

Nilsson, P. & Vikström, A. (2015). Making PCK Explicit- Capturing Science Teachers' Pedagogical Content Knowledge(PCK) in the Science Classroom. *International Journal of Science Education, 37* (17), 2836 - 2857. doi: 10.1080/09500693.2015.1106614.

O'Neill, G., & McMahon, T. (2005). *Student –centred learning: what does it mean for students and lecturers*? Retrieved from: http:// www.aishe.org.

O'Sullivan, M. (2004). The reconceptualization of learner –centred approaches: A Namibian case study*: International Journal of Education Development*, *24*(6), 585 - 602. doi:10.1016/S0738-0593 (03)00018-X.

Oduor, S., Orado, G., and Gathambiri, I. (2008, October). *Enhancing Classroom Practice for Effective Teaching and Learning Mathematics and Science in Africa*. Conference paper presented at CEMASTEA, Nairobi.

Ogwel, A., Odhiambo, J., and Kibe, S. (2008). Impact of SMASSE INSET on students' capacity through improved teaching and learning in the classrooms*. Paper presented at the 8th SMASE-WECSE Regional Conference held at KCCT Mbagathi, Nairobi, Kenya. Retrieved from* http://www.academia.ed.

Osborne, J., & Collins, S. (2000). Pupils' and parents' views of the school science curriculum. London: King's College London.

Osborne, J., Simon, S., & Collins, S. (2003). Attitudes towards science: A review of the literature and its implications*, International Journal of Science Education*, *25* (9), 1049 - 1079. doi: 10.1080/0950069032000032199.

Owen, S., Dickson, D., Stanisstreet, M., & Boyes, E. (2008). Teaching physics: Students' attitudes towards different learning activities, *Research in Science & Technological Education*, *26* (2), 113 - 128. doi: 10.1080/02635140802036734.

Peters, E.E. (2010). Shifting to a Student - Centered Science Classroom: An Exploration of Teacher and Student Changes in Perceptions and Practices. *Journal of Science Education, 20* (3), 329 - 349. doi: 10.1007/s10972-009-9178-z.

Punch, K. F. (2014). *Introduction to social research: Quantitative and qualitative approaches* (3rd ed.). Los Angeles, California: SAGE.

Punch, K.F. (2009). *Introduction to Research Methods in Education*. London: SAGE.

Punch, K.F., & Oancea, A. (2014). *Introduction to Research Methods in Education* (2nd ed.). London: SAGE.

Robinson, C. & McCartan, K. (2016). *Real World Research. A resource for users of social research methods in applied settings*. Chichester: Wiley.

Robson, C. (2011). *Real World Research. A Resource for Users of Social Research methods in Applied Settings* (3rd ed.). London: Wiley.

Saunders, M., Lewis, P., & Thornhill, A. (2003). *Research Methods for Business Students* (3rd ed.). London: Pearson Prentice –Hall.

Save the Children-Sweden. (2005). A situational analysis of education in The Gambia. Retrieved from http:// www.htp/nsagm.weebly.com.

Schuh, K. L. (2004). Learner - centered principles in teacher - centered practices?. *Teaching and Teacher Education*, *20* (8), 833 - 846. doi: 10.1016/j.tate.2004.09.008.

Schunk, D. H., & Zimmerman, B. J. (Eds.). (1994). *Self-regulation of learning and performance: Issues and educational applications*. Hillsdale, NJ, US: Lawrence Erlbaum Associates, Inc.

Schweisfurth, M. (2011). Learner - Centred Education in Developing Country Contexts. From solution to problem? *International Journal of Educational Development*, *31*(5), 425 - 432. doi:10.1016 /j. ijedudev.2011.03.005.

Schweisfurth, M. (2013). *Learner-Centred Education in International Perspective: Whose pedagogy for whose development*. London: Routledge.

Seng, E. L.K. (2014). Investigating Teachers' Views of Student-Centred Learning Approach. *International education studies*, *7*(7), 143 - 148. doi:10.5539/ies. v7np143.

Shaffer, I. (2016). *Elementary Teachers' Perceptions and experiences in the Learner-Centred Instructional setting* (Doctoral thesis). Available from ProQuest LLC (ProQuest Number: 10242287).

Sikoyo, L. (2010). Contextual Challenges of Implementing Learner Centred Pedagogy: The Case of Problem – Solving Approach in Uganda. *Cambridge Journal of Education*, *40*(3), 247 - 263. Retrieved from http:// www.search.proquest.com/docview/815957393?accountid=11526.

Singh, N. (2011). Student - centered learning(SCL) in classrooms - A comprehensive overview. *Educational Quest, 2* (2), 275 - 282. Retrieved from http:// www.semanticscholar.org.

Smart, K. L., Witt, C., & Scott, J.P. (2012). Towards Learner Centred Teaching: An Inductive Approach. *Business Communication Quarterly*, *75* (4), 392 - 403. doi: 10.1177/1080569912459752.

Song,S. (2015). Cambodian teachers' responses to child –centred instructional policies: A mismatch between beliefs and practices. *Teaching and Teacher Education*, *50*, 36 - 45. doi:10.1016/j.tate.2015.04.004.

STED (2011). *Science and Technology Education Policy*. Ministry of Basic and Secondary Education, Banjul, The Gambia.

Thanh, P.T.H. (2010). Implementing a student - centered learning approach at Vietnamese higher education institutions: Barriers under layers of Casual Layered Analysis(CLA). *Journal of Futures Studies*,*15* (1), 21 - 38. Retrieved from http:// www.jfs.tku.educ.tw.

Tobin, K., & Tippins, D. (1993). Constructivism as a referent for teaching and learning. In: K. Tobin (Ed.), *The Practice of Constructivism in Science Education* (pp. 3-21). Washington, DC: AAAS Press.

Toplis, R. (2012). Students' views about secondary school science lessons: The role of practical work. *Research in Science Education, 42* (3), 531 - 549. doi: 10.1007/s11165-011-9209-6.

UTG. (2014). University of the Gambia, Kanifing, the Gambia. Retrieved from http://www.utg.edu.gm.

Wambui, N. (2006). *ASEI movement*. Retrieved from: http://www.criced.tsukuba.ac.jp.

Wang, D. (2011). The dilemma of time: Student - centered teaching in the rural classroom in China. *Teaching and Teacher Education*, *27* (1),157 - 164. doi: 10.1016/j.tate.2010.07.012.

Wiles. R. (2013). *What are Qualitative Research Ethics?*. London: Bloomsbury Academic.

Yilmaz, K. (2008). Social studies teachers' views of learner-centered instruction. *European Journal of Teacher Education, 31* (1), 35 - 53. doi:10.1080/02619760701845008.

Yin, R. K. (2012). *Application of case study approach* (3rd ed.). London: SAGE

Yin, R. K. (2016). *Qualitative research from start to finish* (2nd ed.). London: Guilford Press.

Zain, S.H.F.S., Rasidi, M.E.F., & Abidin, Z.I.I. (2012). Student - Centred Learning in Mathematics – Constructivism in the Classroom. *Journal of International Education Research-Fourth Quarter*,*8* (4), 319 - 328. Retrieved from http:// www.cluteinstitute.com.

Zeki, C.P. & Güneyli, A. (2014). Student Teachers' Perceptions about Their Experiences in Student Centered Course. *South African Journal of Education, 34* (3), 1 - 11. Retrieved from http:// www.sajournalofeducation.co.za.

Appendices

Appendix 1: Observation Check List

Below is a check list of the lesson observation adopted and modified as activities in a best practice Student centred Learning Classroom from (Small, 2011 cited in Schweinfurt, 2012, p. 11) using the four PCK components by Magnusson et al. (1999) as themes.

Lesson Observation Check List

Observable item	Observed
Teacher Knowledge of Curriculum	
▪ Linking prior knowledge to new knowledge ▪ Making sure that the topics taught or themes are interconnected ▪ Activities set up met the learning objective(s)	
Teacher Knowledge of Instructional strategies	
• Encouraging students to ask questions • Promoting student participation and collaboration • Making variety of activities • Providing appropriate and relevant activities and teaching learning resources • Mastery of subject matter by giving appropriate and relevant examples • Summarising the main important points of the lessons	
Teacher Knowledge of students understanding of science o Addressing students' misconceptions o Helping students with difficulties o Meeting the needs of students by providing adequate teaching learning resources	

○ Give a brief revision of the previous lesson ○ Taking into account student's pre-requisite skills and knowledge	
Teacher knowledge of assessment ➢ Asking numerous number of questions ➢ Getting students to restate their responses where necessary ➢ Question asked not only based on knowledge or recall. ➢ Allows students thinking time	
Student Involvement - Are students engaged actively in lesson activities - Are students encouraged to give/demonstrate their prior experiences / knowledge /skills - Are students giving the opportunity to carry out practical activities/discussion tasks/ calculations - Are students given the opportunity to interact in pairs work, small groups	

Appendix 2: Interview schedule

My research is about science and the teaching of science; tell me about how you teach science.

What would the students say about science lessons in this school? Do many continue with science? Is achievement good?

Do you use SCL in your classroom? Describe this for me?

What do you understand by the term Student Centred Learning (SCL)?

- Can you describe for me the ways in which you teach science here?

  Would you classify any of these as SCL?

- On reflection, how did that compared with a teacher centred approach?

How does teachers' perceptions influence their practice in the classroom?

- ❖ Tell me how you will teach a science topic that involves practical activity/experiment?
- ❖ Do your students enjoy science lessons? How do you know? If not, what are some of your obstacles?
- ❖ How would you describe a normal science lesson in your classroom?
- ❖ Are students' prior knowledge and skills considered before teaching a particular topic?
- ❖ How do you ensure that your students retain what they have learnt?
- ❖ Are students enabled to explain certain basic concepts to you or their colleagues during lessons?
- ❖ What mechanisms did you put in place to address the problem in order to have a successful lesson?
- ❖ What professional development do you have /had since beginning science teaching?

What are the orientations of science teachers in The Gambia?

- Why do you choose to teach science?
- What is your goal when you teach science?
- What kind of learning events/activities do you design to achieve your goals and purposes of science teaching?
- What is your role as a science teacher?
- What are your students' role during science lesson?
- How do you ensure that students learn science well?

Does science teachers' pedagogical orientation influence their classroom practices?

- ✓ *How would you carryout simple experiments or activities to show the changes of state of matter?*
- ✓ *Explain how you would enable students to separate a mixture of sand and salt?*
- ✓ *Have you ever enable students to carry out project work? Tell me about it?*

Appendix 3: Focus group schedule

My research is about science and the teaching of science;
Students I am here for science, tell me about your science lessons?

To what extent do Gambian Upper Basic School students' perceptions of their science classes relate to student centred learning pedagogies?

- ➢ Tell me about science lessons here in this school.
- ➢ What do you think of science as a subject?
- ➢ Do you have the intention of specialising in science at Senior Secondary level? Why? Why not?
- ➢ Can you tell me about something you enjoyed learning about? How was this taught by the teacher?
- ➢ What helps you to learn better in a science class?
- ➢ What makes it difficult to learn science?
- ➢ How do you learn best?
- ➢ Does your teacher offer support during class tasks? Example?
- ➢ Do you work independently or in groups in science?

Appendix 4: Focus group transcript

Focus group transcript -ST3

This is Mr. X's class right. Students from Mr. X, this is the 3rd focus group from 3rd teacher's class I have interviewed. Now, students good afternoon once again. Let's go straight into the interview. **Babou**: Tell me about your science lessons here in the school. **Student from T3**: Science lesson? **Babou**: Yes. **Student from T3**: Anyway about the problems or what? Tell me about your science lessons, how it is taught? How you feel about it and so on? **Student from T3**: I think we have good teachers but the only problem is we don't have enough facilities. Like in grade seven giving us to the apparatus for us to do the experiment was the only thing lacking but apart from that everything has been fantastic. We have experience teachers and that is all. Tell me about your lessons. **Student from T3**: Science lessons are good and is really effective, as he said like this experiment we did should have been done long ago since in grade 7. Going to class having our lessons is very good we don't have any problem with that**. Student from T3**: I think they have said it all, like science in School A, herein my own experience it has been always fantastic. Teachers are qualified, they teach with zeal, like they always give what they have and we just feel so happy with that, and he also said it all, the only thing we are lacking is the apparatus and the experiment we are supposed to do since we were in grade 7 and 8 but thanks be to God and I belief that everything is fine with us. **Babou** : Do you mean you have not been conducting practical lessons during the sciences? **Student from T3:** Only few I can remember one or two since grade 7. **Student from T3**: For the past grades we have not it is only this grade 9 that we have started doing some. **Babou**: So it was more of theoretical teaching than practical? **Student from T3**: Yes. You are smiling do you want to say something? Yes, our science teachers are very good teachers when they are teaching us we always understand but only thing is the apparatus since we were in grade 7 and 8 we don't use to conduct experiment only teaching but their teaching is always fantastic. **Babou**: This is a Senior Secondary School in combination with Junior School and there are labs, I don't know why the teachers are not using the labs, probably I will discuss with your teacher about that and know the reason and dig into the problem.

What do you think of science as a subject at your level? **Student from T3:** I think is fantastic, ever since I just love studying science. Since I was a kid I was ever curious, so out of science a lot of my problems have been solved. The experiments if I don't understand something, after doing the experiment I see the truth behind it. So I like science a lot, I think that is very good. What do you think of science as a subject? Any additional comments? **Student from T3**: Science as a subject like improves us and the … ehe so us the reward knowing, hearing about what is going on, science is all about what is going on in our atmosphere, we come to learn about it as we go on the process.

Do you have intention of specialising in science at Senior Secondary level? **Student from T3**: Yes. All of you? **Student from T3**: Not me, yeah, I will prefer doing commerce. You prefer to do commerce, why do you want to specialise in science at senior secondary level? **Student from T3**: If there was any second thought I will do science rather than commerce because like I was saying the curious. I am very curious and I want to know everything. Everything I see I want to know what is the cause of it because I see that science is the key and answer to all. Okay , why then are you not wanting to specialise in science ? **Student from T3**: Well I can see that I am not very good in mathematics and that is why I want to do commerce. Apart from that I would have love to specialise in science. So the rest of you why do you want to specialise in science? **Student from T3**: For me science is a very amazing subject and I love science since primary school. Like science have taught me many things that the world has not taught me, even things that my parents have not taught me. As he said it has taught us about our surrounding, our life style things that have been discovered, how to live and many things. Science have been inspirational to me and it makes me feel like I want to study science in the future and discover more things that others have not and to be an inspiration and help on to the world.

Can you tell me something you enjoy learning about in science? **Student from T3**: Yes I will say matter. **Babou**: Which topic on matter? **Student from T3:** Changes of state of matter we did it and carried out the experiment that shows that it has mass and occupies space. **Student from T3**: Like changes of matter I did so many experiment based on that. I put ice cubes. **Babou**: Individually or it was a class activity? **Student from T3:** We did it in the classroom with the teacher and even individually I did it at home to see whether in the atmosphere water vapour is present. We take ice cube and put it in the beaker and observe after 2 to 3 minutes to see any particle outside to see that it is condensed. Theoretically we have learn that water vapour can be condensed in order to have liquid by doing such practical you realise that those facts are true.

Babou: What else do you enjoy learning about under this particular topic? **Student from T3**: I could remember a teacher from Grade 7, he brought about two balances in class to show that air occupies space and has weight, so he blew a balloon and tied it on a rope and another one he did not. So he held it and the one that he blew air into, like was going down showing that air occupies space and has weight and the one without air was left on top and this shows that matter is very significant and that matter is anything that occupies space and has weight.

Babou: What helps you to learn better in a science class? **Student from T3**: I think it is the experiment. How he teaches and the teachers' motivation. How effective the class will be.

Babou: What makes it difficult to learn about science? **Students from T3:** Like we said earlier on the apparatus, most of the time is based theoretically. Theory, theory all time the teacher is explaining but there is no materials to proof to you what the teacher is explaining and at time you are kind of lost. So I think is the material side of it. **Babou**:So in order words is the lack of adequate materials? **Students from T3**: Yes. **Babou**: I don't think there is lack of materials in this school because you have a fully equipped chemistry, physics and biology labs, what do you think? **Student from T3**: It is limited, is not for our level. Most of it is based at Senior level. **Student**

from T3: Most of the time also the physics and chemistry part are very tough, the calculations.

Babou: How do you learn best? **Student from T3**: My learning is kind of different, normally after school when I go home at night I usually browse the internet researching continuously both topic that has been taught, that has not been taught. I keep on researching to know better so that I could perform both academically and even outside school I will have the understanding for the future. So I understand mostly by researching. **Babou** : So you learn best by research, next. **Student from T3**: I learn best through the teacher explanation, when he explains it perfectly through to my own understanding and level. I understand it better than reading the books. Through his explanation I understand more than going through the notes. **Student from T3**: There are various ways in which I learn science. As a scientist, one of the qualities of a scientist is that you have to curious. I tried to be curious like if someone said something I tried to question and ask about what you have said to know more about that particular thing. Mr xxx is someone who can explain a lot. He helps me to learn science and as I said I ask a lot and my father is a literate in science so most of the time I go to him and ask him if I have doubts in many things. Last but not the list I myself I have to read my books too, reading your books also make you to understand more. **Babou** : What I understand from you is that you learn best through your teacher, parent, and textbook right? **Student from T3**: Yes. **Student from T3**: I learn best whenever I go home and take my books and read them again. This is the time I understand more. **Babou**: So you learn best by reading. **Student from T3**: Yes. Babou: Right.

Babou: Does your teacher offer you support during class activities? Can you give me an example? **Student fromT3**: Like if you don't understand something, during class may be you will be nervous to say something when everybody say they understand but you can go privately to him and ask for his assistance and he helps.

Babou: Dou you work independently or in groups? **Student from T3:** Yes both of them. Sometimes he gives us group work. You know in St. Peters that is a custom. First test is individual, second test is also individual and third test you go out as a group and research on a particular topic or on a particular subject and when you come as a group you discuss and say what you know about the particular topic. You go and present it out for everybody to understand and we correct you if you are wrong and we encouraged each other, that is how we learn. We also learn individually by doing test asking questions. **Student from T3**: For me the ways I learn is by seating with friends ask each other questions and I learn individually if I am at home.

That has brought us to the end of the interview if there is any additional information. Otherwise thank you very much for your time. **End of focus group interview**

Appendix 5: Interview Transcript

Face to face interview transcript T3

Babou: Good morning. T3. **T3**: Good morning. First of all before we start with the interview we will have a discussion on the lesson observed yesterday. Having gone through I just have few questions to ask and there after we move straight to the interview proper.

Babou: Now, why was the class divided into only two big groups instead of dividing them into many smaller groups? **T3**: This is because we do not have enough compounds that is why I decided to divided the class into two. If there were enough compounds available we would have divided the class into different groups and in smaller number and given them each the sample number required but the problem was there was not enough compound that is why I divided the class into two groups. Basically materials are not enough. You could even see when I gave them test tubes one group got 4 test tubes and the other one got 3 test tubes only. That is because of the fact that we do not have enough materials in the lab here, yeah. **Babou**: Okay

Babou: Did you realise that some students were chatting while you were explaining? **T3**: Yes. What were you supposed to do? This girl has been lying down the class throughout until when the class activities started. This was the most interested part of your lessons when you give them the materials and they started discussing. You could see the argument there: Is neutral no, is acid no. **T3**: That shows that in science you have to engage the students all the time. If you keep on talking to students like that, in vague like that or in abstract like that. Like you said they tend to sleep, they tend to cause noise but if you give an activity to do in class they become very active in class.

Babou: One of the group classified Copper Sulphate as an acid, what must have gone wrong? **T3**: That is why at the end of the class I told them very clearly that copper sulphate is not an acid is a salt, yeah. So maybe I think they used the red litmus paper on it and then they saw a kind of colour change that is why they gave that conclusion. But I make that conclusion very clear at the end of the class that you know those who identified Copper Sulphate as an acid, they are wrong.

Babou: What would you say about you lesson? **T3**: If you consider the lesson yesterday it was student centred because they did more activity by interacting with the chemical compounds that were giving to them. So it was more or less student centred. I just gave them the introduction so that they can actually identify the substance in to their different classes. Basically it is more of student centred, yeah. That is why I said we have the classes in the lab instead of the classroom because to carry the substance from the lab to their class would be a problem. That is why we went there so that we can have a student learning atmosphere, something like that. Babou: Is the furniture in class suitable for group work?**T3**: Yes you can join the tables easily, it is not a problem. Babou : So thank you very much and let us move now to the interview proper.

End of lesson observation discussions

Face to face interview

Babou: My research is about science and teaching of science .Tell me about how you teach science?**T3**: Okay, the way I teach science is more or less… I normally teach science based on two fronts. Sometimes we do more of teacher centred learning in most cases and in few cases were applicable or needed we use student centred learning approach were by we expose students to different materials and then interact with the materials and then come up with their own ideas or their own conclusions. But we normally guide them even in class, even if we are discussing in class, the teacher comes there as a guide, you understand and then show them what to do. If I ask questions they respond. If there is any need for rectifications and clarification, I make that and then we move on. But basically here science is normally taught more of theory. We use more of theory that is the fact because materials are not available and also we run to meet the time so that we can be done with the syllabus for their final exams, yes.

Babou: I could remember students telling me that they hardly have practical since in their grade 7 until now that they are in grade 9 they started having few practical what actually is the cause of that? **T3**: I started teaching them this academic year and not in grade 7 but in grade 8 and grade 9 I started handling them. The reason why we do that is, we normally run… like I said we try to cover the syllabus on time before their final exams. Because if you don't cover a lot and then they happen to have their exams if they do not perform the blame comes back to you from the administration. That is why at most cases we teach the student theoretically rather than giving them practicals in the labs. We have three labs here but I think based on the time frame we were give the grade 9 students we don't normally engaged them in activity in the school lab. Because I could remember there were some teachers who were blamed for not having a particular grade in the final exams. That is GABECE exams and they started pointing fingers at them. So at most cases most teachers run away from that particular trouble by trying to teach students theoretically and trying to finish the syllabus in time and then preparing for the exams. In fact, right now as we speak the science areas is a problem. We have two areas: You have the remedial classes and we have the normal classes and Saturday classes also. I teach them in the remedial classes and also teach some groups in the Saturday classes. The one done normally from Monday to Friday that is the week days there is a problem because the teachers are not going because the system is not properly organised. As a result, there are some areas which we didn't cover still so to speak which cannot be covered in those classes based on poor organisation. That is how things are. Right now we have almost two weeks before the exams.

Babou: What would the students say about science lessons in the school? **T3**: Actually what they will say is like I mentioned before they will say that we learn science without practicing. That is what they will say, that is the fact. They will say that we learn science in the form of theory and not practicals or few practicals. I personally this the second time I have taken them to the school chemistry lab to actually interact with the chemical compound. But I saw that it is important because we talk about compounds and those compounds they ask me questions in the class and I told them let's go the lab to see the samples for yourself. **Babou**: The school has all the labs why is it still difficult for you to have access to the materials? **T3:** The materials are there but they are not enough. They are insufficient, yes. Like I said even for us to get H_2SO_4 was not even possible yesterday. It was not available yesterday because the materials are insufficient.

Babou: Do you use students centred learning in class? **T3**: Yes we do. **Babou**: You did say previously that you use both student centred and teacher centred. Can you describe when you use student centred? **T3**: What we do we ask students questions and then they respond, yes. At most case we ask them to discuss within themselves, try to find some kind of responses when they acquire those responses we give them the floor to express themselves. So when they express themselves I guide them on their mistakes or errors. Okay, that is how we normally teach them in the class based on child centred approach. And also more importantly we normally keep them or allow them to seat in groups. So if you go to the class you find out that the table are packed in such a way that the students seat in groups that makes it easy for us to teach them, yes based on child centred approach. So in some areas like I said before some topics are somehow strange to them even you allow the students to interact within themselves they don't come with some kind of reasonable answers or responses. So what they do is we normally discuss or I personally come to class and discuss with them. If you prepare the lesson, when I come teach the students and then, first of all I have my lesson plan and from there I go by my lesson plan and teach them but basically I normally do the activity in some cases. In that case I will say is teacher centred because I do most of the activity in some topics or areas. **Babou**: If you compare these two methods which of the methods do you prefer most and why? **T3**: The child centred approach is the best because students learn by themselves. Sometimes they come with ideas which even you don't know. Yes but it has a disadvantage because it doesn't safe time. That is one of its disadvantages. **Babou**: So you mean is time consuming? **T3**: Yes, is time consuming because you have to allow the students to interact. Sometimes you can give them a sub- topic or topic to discussion on which will take us fifteen minutes normally when a teacher comes discuss it but if you give them such a topic they spend a lot of time on that. To me is sometimes time consuming but that is one of the disadvantage but basically is a good approach or one of the best approaches in teaching and learning.

Babou: So what do you understand by the term student centred learning? **T3**: My understanding is that you give more room to the students to interact with materials, see the materials, or learning materials or try to eehh, give their own conclusions. Or in short you know is like learning by interacting with materials and coming with their own ideas about how they perceive things with regard to that particular area. Yes it doesn't mean that the teacher have to come to class and do all what not in the class without involving the students but you allow the students to learn or do certain things to be able to achieve something on their own with the guidance of the teacher.

Babou: So can you describe for me the ways in which you teach science here? **T3**: Generally, like I said, you know let me be specific to the junior secondary school area it is more of theory like I said before. You can take the students to the lab for them to interact with materials but at most cases are very rare. Yes most cases we teach based on eeh teacher centred, yes. **Babou**:So would you classify the way you teach generally as student centred learning? **T3**: No I wouldn't.

Babou: Tell me how you will teach a practical topic that involves a practical activity or experiment? **T3**: When you teach a science topic which involve practical work. First of all you must have the aim or objective. If you have your aim or objective, you try to gather some materials. Those materials are sometimes are locally available or sometimes they are available in the school lab there. So you set your procedures, that is the step you are going to take to carry out that particular activity and then from there you have your observation of the activity, what students are doing and then from there you have your general conclusion. These are the ways we teach practical topics.

Babou: Do your students enjoy science lessons? **T3**: With me I will say most of them enjoy my lessons because I normally make things very clear to them. The group we have is the best class in the grade 9 component. **Babou**:You mean the class I observed yesterday? **T3**: Yes: sometimes they will go extra mile to be able to find out certain things even if you tell them in class. Sometimes with this student centred learning if you tell them what is important they tend to enjoy it. I think they enjoy it more when they interact with materials.

Babou: How will you describe a normal lesson in your classroom? **T3**: Is like a mixed feeling. Sometimes you find out that students, they will be carried away based on what they are exposed to in that class and sometimes if things become somehow strange to them and they did not see anything, they kind of feel bored. I think that is seen on daily bases, yes in science classes. Like how we started even well before the activity yesterday when I was brainstorming you could see some of them were trying to play here and there, bend their heads down but when we started the activity they started catching up. That is the general feeling in the class on daily bases, yes. Sometimes if you can tell them certain things, okay they will follow them but as time goes on when they realise that you are telling them something that they cannot see they feel bored and sometimes you have to go extra miles by trying to put them in the picture of how they interact with these things in real life. We dealt with compound, we give their common names, their chemical names and their UMPAC names. So when it comes to common names and they realise that this compound is called this particular name in local language they kind of embrace it. Like for example sodium hydroxide and also calcium oxide. If you tell them calcium oxide in English fine, they know the word. Actually they deal with this stuff in their daily life. You kind of tell them that this compound is called this in Mandinka or Wolof. Like for example if you tell them quick lime you go further and tell them this is called "Lasso" or white wash(Calcium carbonate). They tend to embrace it, if you try to do such a thing even if you are not exposing them to the materials naturally or directly they don't tend to feel very interesting.

Babou: Are students' prior knowledge and skills considered before teaching a particular subject matter or a topic? **T3**: Yes I do relate to the former topics taught to make sure that at least students know something from a particular topic before moving to another and also they have to be connected. Yes that is very important and we do that always. You have to make sure that students have some idea previously before they are exposed to a particular lesson, yes we do that. **Babou**: How do you investigate on what the students know? **T3:** Normally based on the topics, you know a topic can be very broad. You teach it based on sub-topics, you must be able to relate. For example talking about valences. The students should know the first twenty elements and their chemical symbols. You understand. They must know their electronic configuration before they come to valences, yes. Before you teach valences at least the students should be exposed to electronic configuration and the first twenty elements and their symbols first. So I think those two things can be somehow related. So before you teach valences you must teach the students based on what they have known prior to Valences.

Babou: How do you ensure that your students retained what they have learnt? **T3**: That is normally done in various ways. Sometimes when you are introducing your topic you can ask questions related to the previous discussions and then ask students what they have learnt the previous day in order to help them at least remember some of the things that you have done in the past. You give them class exercise and sometimes assignments will help to enable them remember what they have learnt before, you understand. Also like I said group activity or group work so they will be able to work on a particular area and be able to remember what they have done before. Basically they are some of the mechanism that we normally use or that I normally do to make sure that students remember what they have learnt.

Babou:What professional development do you have since you started teaching science? **T3**:I have attended some science based workshops. Those are some of the things that I have been exposed to, yes which also helped me in the teaching of science. Yes I attended one in Siffoe, about 2 -3 days ago. **Babou**: What was it about? **T3**: It was based on Physics. **Babou** : Upper Basic or Senior level?**T3**: It was the senior level unfortunately I don't teach at the senior level though we discuss some areas that were meant for Upper Basic level like pulleys. Also I attended one in Jangjangbureh. **Babou**: What was that about? **T3**:A science based workshop on how to improve the capacity of teachers in teaching science. We had discussions on so many issues. That one also helped me in the teaching of science. It has given me an edge, an experience in the teaching of science in school. And also school based workshop are also conducted to enable us to prepare ourselves as teachers in the areas of science; also how to be able to use locally available materials to be able to make teaching and learning aids basically science basically by using materials. Sometimes these materials are available locally sometimes they are not. When they are not available in the lab you improvise which we normally refer to locally available materials, yes. I could remember we had a workshop here where we were taught on how to prepare Hoffman's voltammeter using locally available materials like bottles, syringes, and stuff like that and it was very nice, it was very interesting. So those are the few areas I am able to gather few experience and ideas in the area of science.

Babou: Why do you opt to teach science? **T3**: First of all after doing science at Senior School, College level, I decided to stick with it due to the fact that science is life. Yes because everything you do in life is equal to science. That is why science is very interesting and I stick my life to it so that I can be able to understand how the changes in the world are taking place, like innovation even in real life. Like I said before science is life anything you do science can explain it better. That is why I have this zeal to teach and learn about science. That is what am still doing.

Babou: What is your goal when you teach science? **T3**: My goal when I teach science, my ultimate objective is to pass an idea to be able to change the life or change the life and perception of my students based on a particular area. Students have to see science as a real thing. There is a girl whom I teach at the study class she told me that some of the things you teach are not real, we just say them but are not real. So that is my job to change the perception of that particular student to make sure that she understands that science is a practical subject and can be seen in real life, yes. So there was a time we had a discussion on separation of mixtures and on to distillation. There was a question which says state two practical application of distillation at industrial level. I told her that even the natural mineral water you are drinking is made based on distillation. The alcohol people consume is made based on distillation and which you learning in school and which means science is real. Anything that you are doing in science is real. I told her that about reflection. I told her that even your shadow is reflection. But she has now changed her mind and start telling me that she has been seeing what I have been talking about. Soap making at home, saponification is science and they are learning this from school but they are not seeing this as important. So that is my job when I teach science my ultimate objective is to pass the information that will change the life of students and their perception. That is why if you go to the classes I teach most of the students would say I want to do science when I go to senior level. So it all boils down to making things clear to students on what science is all about in real life.

Babou: What kind of learning activities do you designed to achieve your goals and purpose in teaching and learning science? **T3**: This particular question I think I have two areas. One I sometimes kind of teach students based on my own eeeh let's say I kind of do most of the activity to be able to pass the information. Secondly I sometimes give the floor to student to be able to speak their mind and then discussions come in the class and there is argument here and there but in the end we agree on a particular thing based on my guidance. I am here to guide them and pass them information to teach. At most cases that are how I design my scheme of work or my lesson plan. **Babou**: In order words you group the students for discussion and some time you explain for them to understand better? **T3**: Yes.

Babou: How do you ensure that students learn science well? **T3**: In the classroom situation? **Babou**: Yes: You have to.. one way I do this is that… eehh, first of all preparation. **Babou**: What preparation do you do? **T3**: We do lots of preparations. First of all you have to prepare your lesson, from there you prepare yourself based on the materials you have gather to deliver in class. Yes if you are to teach science effectively you must be strong meaning you have to do your own research so that if you go to class you can have confident in class. Meaning you don't have to be changing your mind there saying this is not correct but now correct. It all boils down to what we call preparation. You prepare yourself meaning you do your lesson plans from there you also prepare based on your topic, based on the materials you want to teach in class. You prepare yourself very well go to class you deliver. So if you want to teach effectively as a teacher you must have the required knowledge that is by doing extra, by research. If you make research and then copied ideas you passed the ideas in class from there you move on but you cannot go to science class unprepared and then you are not prepared, lessons are not prepared you have not prepared yourself on the areas that you supposed to teach it's gonna be a problem, it will not work. That is why you go to some classes, you find out that the students are causing noise there is no unity because of the fact that teacher has not prepared himself.

Babou: How would you carry out a simple experiment or activity to show the changes of state of matter? **T3**: A very, very simple experiment that you can do is by using ice. If you expose the ice to the environment for example in the classroom it will melt and changes to water. Though to have the ice changes directly to gaseous state will take time but that can give you an idea of how you can explain how ice can change into water because ice is a solid and water is a liquid that is the simplest way to do that at the classroom level.

Babou: Can you explain how you will enable students to separate a mixture of sand and salt? **T3**: Sand and salt can be separated by using hand picking. I understand but how about fine salt particles not large particles. **T3**: You can, you can sieve it or you can filter it. If the salt particles are fine enough you can sieve it if they are large enough you can hand pick it. **Babou**: Do you only filter it and stop there? **T3**: No, no if you filter the mixture sometimes you might have some sand particles that will escape and some dirt in the solution so you can go further by adding some water into the solution sorry that will not work because the solid will dissolve in water. If you do that and that does not work i think you can do….. eeeh may be you re-filter it again to make sure that the dirt are separable. Because if you look at sand and salt. **Babou**: But it will still be in liquid form. **T3**: You mean if you add water in there? **Babou** : Yeah. What am saying here is that if you mixed fine salt and sand together and give it to your students and ask them to separate the sand from the salt what do you expect them to do? **T3**: Ok, though it will be very challenging like I said after filtering it you can eeh decant the water, you can do decantation. If you decant you will get your salt solution. After having your slat solution, you can now evaporate the water then you can have you salt particle again.

Babou: Yes taking you back to the lesson observation yesterday you spoke about replacing hydrogen with metals like if you have HCl the hydrogen is replaced by a metal then you have what we called a salt, what were you trying to talk about here? **T3**: I was trying to make the definition of salts clearer because a salt is form when hydrogen ions are replaced by a metal. I was trying to give them for example HCl if the hydrogen ion there is replaced by sodium, it now becomes NaCl. Therefore, the metal that replaces hydrogen is sodium and therefore you have a salt that is called NaCl.

Babou: Have you ever enable students to carry out a project work? Yes we give them projects. We exposed them to different topics. Let's say we divide the class into different groups and then you give each group a topic so you also organise them in such a way that they have a secretary and then all the members of the group will seat and do research on that particular topic so in the end they come with materials and project in class and most cases we award marks for them. This is normally done across all the grades in the school from 7 to 12 though we have not started this year but last year we did it. **Babou**: What kind of topics actually has you being given them to make research on? **T3**:They are on electricity, reflection of light and different topics like digestive system, circulatory system, basically the systems. When they come to class you the teacher organises the presentation. Sometimes it can take three students in a group to present but we encourage every student to participate. In class questions are asked and every student is given the chance to answer. It has been a culture here.

Babou: Do you have any other information that you want to mention before we come to the end of this interview? **T3**:I think with the teaching of science it can be enhance more if we have the required teaching materials you will be able to teach science I think we are lucky to have labs but some schools they have no material and teachers teach in the abstract. I think the authorities should look into that and at least bring materials that will help science teachers deliver in their area rather than based teaching on teacher centred approach I think that will be very, very important. **Babou**: So if you are to teach which method will you prefer? **T3**: Child centred approach is more interesting and then students don't feel bored in class. They learn and see for themselves.

End of Interview:

Appendix 6: Focus group extract

Data Extract	Coded for
Student from T3: I think we have good teachers but the only problem is we don't have enough facilities. Like in grade seven giving us to the apparatus for us to do the experiment was the only thing lacking but apart from that everything has been fantastic. We have experience teachers and that is all. Tell me about your lessons. **Student from T3**: Science lessons are good and is really effective, as he said like this experiment we did should have been done long ago since in grade 7. Going to class having our lessons is very good we don't have any problem with that**.** **Student from T3**: I think they have said it all, like science in school A, herein my own experience it has been always fantastic. Teachers are qualified, they teach with zeal, like they always give what they have and we just feel so happy with that, and he also said it all,	Students view about their science lessons: 1.Have good teachers 2. Lack of facilities/apparatus to conduct experiment 3. Have experience teachers.

the only thing we are lacking is the apparatus and the experiment we are supposed to do since we were in grade 7 and 8 but thanks be to God and I belief that everything is fine with us. **Student from T3:** Only few I can remember one or two since grade 7. **Student from T3**: For the past grades we have not it is only this grade 9 that we have started doing some. Yes, our science teachers are very good teachers when they are teaching us we always understand but only thing is the apparatus since we were in grade 7 and 8 we don't use to conduct experiment only teaching but their teaching is always fantastic.	4. Lack of practical in science lessons
Student from T3: I think is fantastic, ever since I just love studying science. Since I was a kid I was ever curious, so out of science a lot of my problems have been solved. The experiments if I don't understand something, after doing the experiment I see the truth behind it. So I like science a lot, I think that is very good.	5.Student like science
Students from T3: Like we said earlier on the apparatus, most of the time is based theoretically. Theory, theory all time the teacher is explaining but there is no materials to proof to you what the teacher is explaining and at time you are kind of lost. So I think is the material side of it. **Student from T3**: It is limited, is not for our level. Most of it is based at Senior level. **Student from T3**: Most of the time also the physics and chemistry part are very tough, the calculations. **Student from T3**: Well I can see that I am not very good in mathematics and that is why I want to do commerce. Apart from that I would have love to specialise in science. **Student from T3**: Like changes of matter I did so many experiment based on that	Challenges/constraints in the learning of science: 1.Lack of materials 2.Mathematical part of science

Student from T3: For me science is a very amusing subject and I love science since primary school. Like science have taught me many things that the world has not taught me, even things that my parents have not taught me. As he said it has taught us about our surroundings, our life style things that have been discovered, how to live and many things. Science have been inspirational to me and it makes me feel like I want to study science in the future and discover more things that others have not and to be an inspiration and help on to the world. **Student from T3**: I think it is the experiment. How he teaches and the teachers' motivation. How effective the class will be. **Student from T3**: My learning is kind of different, normally after school when I go home at night I usually browse the internet researching continuously both topic that has been taught, that has not been taught. I keep on researching to know better so that I could perform both academically and even outside school I will have the understanding for the future. So I understand mostly by researching. **Student from T3**: I learn best through the teacher explanation, when he explains it perfectly through to my own understanding and level. I understand it better than reading the books. Through his explanation I understand more than going through the notes. **Student from T3**: There are various ways in which I learn science. As a scientist, one of the qualities of a scientist is that you have to curious. I tried to be curious like if someone said something I tried to question and ask about what you have said to know more about that particular thing. Mr xxx is	Topics students enjoy learning: 1.Changes of state of matter. Students view about science 1.Knowing about our surrounding 2.Inspirational subject Best ways learn science: 1. Doing experiment 2. Teachers motivation 3. Class effectiveness 4.The use of internet 5. Through teachers' explanation 6.Asking questions 7.Book reading (Textbook) 8.Learning from my parents

someone who can explain a lot. He helps me to learn science and as I said I ask a lot and my father is a literate in science so most of the time I go to him and ask him if I have doubts in many things. Last but not the list I myself I have to read my books too, reading your books also make you to understand more. **Student from T3**: Yes. **Student from T3**: I learn best whenever I go home and take my books and read them again. This is the time I understand more. **Student from T3:** We did it in the classroom with the teacher and even individually I did it at home to see whether in the atmosphere water vapour is present. We take ice cube and put it in the beaker and observe after 2 to 3 minutes to see any particle outside to see that it is condensed. Theoretically we have learned that water vapour can be condensed in order to have liquid by doing such practical you realise that those facts are true **Student from T3:** Yes both of them. Sometimes he gives us group work. You know in School A that is a custom. First test is individual, second test is also individual and third test you go out as a group and research on a particular topic or on a particular subject and when you come as a group you discuss and say what you know about the particular topic. You go and present it out for everybody to understand and we correct you if you are wrong and we encouraged each other, that is how we learn. We also learn individually by doing test asking questions. **Student from T3**: For me the ways I learn is by seating with friends ask each other questions and I learn individually if I am at home.	Student centred orientation: Activity-driven/inquiry base, process, and conceptual change 1.Through experiment 2.Group work 3.Group presentation and discussions. 4.Independent learning

Appendix 7: Interview extract

Data Extract	Coded for
T3: Sometimes we do more of teacher centred learning in most cases and in few cases were applicable or needed we use student centred learning approach were by we expose students to different materials and then interact with the materials and then come up with their own ideas or their own conclusions. But we normally guide them even in class, even if we are discussing in class, the teacher comes there as a guide, you understand and then show them what to do. If I ask questions they respond. If there is any need for rectifications and clarification I make that and then we move on. But basically here science is normally taught more of theory. We use more of theory that is the fact because materials are not available and also we run to meet the time so that we can be done with the syllabus for their final exams, yes. The reason why we do that is, we normally run… like I said we try to cover the syllabus on time before their final exams. Because if you don't cover a lot and then they happen to have their exams if they do not perform the blame comes back to you from the administration. That is why at most cases we teach the student theoretically rather than giving them practicals in the labs. We have three labs here but I think based on the time frame we were give the grade 9 students we don't normally engaged them in activity in the school lab	Belief about teaching and learning science: How science is taught: 1.Use both teacher and student centred method 2.Student materials interaction 3.Guide students 4. Ask questions and obtain responses 5. Rectifies and clarifies students misunderstanding and errors. Didactic: Theoretical teaching Challenge/Constraints: 1.Lack of materials 2.Rush to complete the syllabus 3.Lack of time 4.Pressure from the school administration
T3:Because I could remember there were some teachers who were blamed for not having a particular grade in the final exams. That is GABECE exams and they started pointing fingers at them. So at most cases most teachers run away from that particular trouble by trying to teach students theoretically	Teachers blamed for not meeting the school performance target.

and trying to finish the syllabus in time and then preparing for the exams.	
T3: Actually what they will say is like I mentioned before they will say that we learn science without practicing. That is what they will say, that is the fact. They will say that we learn science in the form of theory and not practicals or few practicals. **T3:** The materials are there but they are not enough. They are insufficient, yes. Like I said even for us to get H_2SO_4 was not even possible yesterday. It was not available yesterday because the materials are insufficient.	Teachers projection of what the students might say about their lessons: 1.Learn science without or few practicals 2. Learn science in the form of theory. 3. Inadequate materials
T3: What we do we ask students questions and then they respond, yes. At most case we ask them to discuss within themselves, try to find some kind of responses when they acquire those responses we give them the floor to express themselves. So when they express themselves I guide them on their mistakes or errors. Okay, that is how we normally teach them in the class based on child centred approach. And also more importantly we normally keep them or allow them to seat in groups. So if you go to the class you find out that the table are packed in such a way that the students seat in groups that makes it easy for us to teach them, yes based on child centred approach	Student centred orientation: Conceptual change and discovery orientation: 1.Teacher ask questions 2.Students response to questions 3.Teacher guides 4.Allow students to seat in groups
T3:If you prepare the lesson, when I come teach the students and then, first of all I have my lesson plan and from there I go by my lesson plan and teach them but basically I normally do the activity in some cases. In that case I will say is teacher centred because I do most of the activity in some topics or areas.	Teacher' understanding of teacher centred method Didactic: 1.Teacher conducts the activities 2.Prepares and teach the lesson
T3: The child centred approach is the best because students learn by themselves. Sometimes they come with ideas which even you don't know. Yes but it has a disadvantage because it doesn't safe time. **T3**: Yes is time	Perception of SCL: 1.With SCL students learn by themselves 2.SCL is the best approach 3.Students come with new ideas 4.It is time consuming-disadvantage

consuming because you have to allow the students to interact.	
T3: My understanding is that you give more room to the students to interact with materials, see the materials, or learning materials or try to eehh, give their own conclusions T3:Yes it doesn't mean that the teacher have to come to class and do all what not in the class without involving the students but you allow the students to learn or do certain things to be able to achieve something on their own with the guidance of the teacher.	Teachers' understanding of SCL: 1.Guidance from the teacher 2.Allow students to get involved 3.Interact with materials
T3: Generally, like I said, you know let me be specific to the junior secondary school area it is more of theory like I said before. You can take the students to the lab for them to interact with materials but at most cases are very rare.	Teacher centred orientation: Didactic: 1.Talk and chalk method 2.Conduct few practicals
T3: When you teach a science topic which involve practical work. First of all you must have the aim or objective. If you have your aim or objective, you try to gather some materials. Those materials are sometimes are locally available or sometimes they are available in the school lab there. So you set your procedures, that is the step you are going to take to carry out that particular activity and then from there you have your observation of the activity, what students are doing and then from there you have your general conclusion. These are the ways we teach practical topics.	Belief about teaching and learning science: How science is taught: Practical work or experiment: 1.Aim 2.Materials 3.Procedure 4.Observation 5.Conclusion
T3: With me I will say most of them enjoy my lessons because I normally make things very clear to them. The group we have is the best class in the grade 9 component. I think they enjoy it more when they interact with materials.	Teacher's view about students' enjoyment in science: 1.Students enjoy science when they interact with materials
T3: That is normally done in various ways. Sometimes when you are introducing your topic you can ask questions related to the previous discussions and then ask students what	Belief about science teaching and learning How students learn science: 1.Asking questions 2.Giving class exercise

they have learnt the previous day in order to help them at least remember some of the things that you have done in the past. You give them class exercise and sometimes assignments will help to enable them remember what they have learnt before, you understand. Also like I said group activity or group work so they will be able to work on a particular area and be able to remember what they have done before.	3.Group activity
T3: Yes I do relate to the former topics taught to make sure that at least students know something from a particular topic before moving to another and also they have to be connected. Yes that is very important and we do that always. You have to make sure that students have some idea previously before they are exposed to a particular lesson, yes we do that	Teacher knowledge of student understanding of science: 1.Putting student prior knowledge into account: Teacher knowledge of curriculum: 2.Making sure the topics are connected
T3: It was based on Physics. **T3**: It was the senior level unfortunately I don't teach at the senior level though we discuss some areas that were meant for Upper Basic level like pulleys. **T3**:A science based workshop on how to improve the capacity of teachers in teaching science. We had discussions on so many issues. That one also helped me in the teaching of science. It has given me an edge, an experience in the teaching of science in school. And also school based workshop are also conducted to enable us to prepare ourselves as teachers in the areas of science; also how to be able to use locally available materials to be able to make teaching and learning aids basically science basically by using materials. Sometimes these materials are available locally sometimes they are not. When they are not available in the lab you improvise which we normally refer to locally available materials, yes. I could remember we had a workshop here where we were taught on how to prepare Hoffman's voltammeter using locally available materials like bottles,	CPD attended: 1.Physics workshop 2.Improving the capacity of science teachers 3.School based workshop 4. Improvisation workshop

syringes, and stuff like that and it was very nice, it was very interesting	
T3: First of all after doing science at Senior School, College level, I decided to stick with it due to the fact that science is life. Yes because everything you do in life is equal to science. That is why science is very interesting and I stick my life to it so that I can be able to understand how the changes in the world are taking place, like innovation even in real life. **T3**: My goal when I teach science, my ultimate objective is to pass an idea to be able to change the life or change the life and perception of my students based on a particular area. Students have to see science as a real thing. So that is my job when I teach science my ultimate objective is to pass the information that will change the life of students and their perception. That is why if you go to the classes I teach most of the students would say I want to do science when I go to senior level. So it all boils down to making things clear to students on what science is all about in real life.	Teacher's view of science: Belief about science: 1.Science is life 2.Science is interesting 3.To understand the innovation taking place Goals and purpose for teaching science: Rationale for teaching science: 1.Change student's life and perception 2.Pass information that will change students' life and perceptions
T3:One I sometimes kind of teach students based on my own eeeh let's say I kind of do most of the activity to be able to pass the information. Secondly I sometimes give the floor to student to be able to speak their mind and then discussions come in the class and there is argument here and there but in the end we agree on a particular thing based on my guidance. T3:You prepare yourself meaning you do your lesson plans from there you also prepare based on your topic, based on the materials you want to teach in class. You prepare yourself very well go to class you deliver	Goal and purpose of science teaching: Learning activities designed to achieve the goals 1.Class Discussions 2.Guidance from the teacher Belief about science teaching and learning: Role of the teacher: 1.Teacher should be well prepared
T3:Yes we give them projects. We exposed them to different topics. Let's	Student centred orientation:

say we divide the class into different groups and then you give each group a topic so you also organise them in such a way that they have a secretary and then all the members of the group will seat and do research on that particular topic so in the end they come with materials and present in class and most cases we award marks for them.	Activity driven, project- based orientation. 1.Divide students into smaller groups 2.Various topics given 3.Students come with materials and present
T3:They are on electricity, reflection of light and different topics like digestive system, circulatory system, basically the systems. When they come to class you the teacher organises the presentation.	Topic given as project work: 1.Electricity 2. Reflection of light 3.Digestive system 4.Circulatory system
T3:I think with the teaching of science it can be enhance more if we have the required teaching materials you will be able to teach science I think we are lucky to have labs but some schools they have no material and teachers teach in the abstract.	Belief about teaching and learning science: How science is taught: 1.Availability of material would enhance the teaching of science.

Appendix 8: Lesson observation extract

Data extract	Coded for
T3: This is because we do not have enough compounds that is why I decided to divided the class into two. If there were enough compounds available we would have divided the class into different groups and in smaller number and given them each the sample number required but the problem was there was not enough compound that is why I divided the class into two groups. Basically materials are not enough. You could even see when I gave them test tubes one group got 4 test tubes and the other one got 3 test tubes only. That is because of the fact that we do not have enough materials in the lab here, yeah.	Reason for having large group size: 1.Inadequate materials

T3: That shows that in science you have to engage the students all the time. If you keep on talking to students like that, in vague like that or in abstract like that. Like you said they tend to sleep, they tend to cause noise but if you give an activity to do in class they become very active in class.	Activity driven, process, inquiry and discovery 1.Students' engagement.
T3: If you consider the lesson yesterday it was student centred because they did more activity by interacting with the chemical compounds that were giving to them.	Activity driven, discovery and inquiry base 1.Student- material interaction 2.More activity to be done by students.

Appendix 9: Analysis of RQ1

RQ1. To what extent do Gambian Upper Basic School students' perceptions of their science classes relate to student centred learning pedagogies.

Themes	Sub-themes	Codes	Evidence
Teacher centred orientation	**Didactic**	**ST1: 1. Teacher shows** **2. The teacher tells** **3.The teacher explains** **4. The teacher ask us to know**	**Student from T1:** It was taught by showing us the diagram on the heart and part of the heart and their functions. Yeah, he even used some of as examples. He tells us and explains to us how the blood is circulated. **Student from T1:** Adaptation is just talking about these things the life of organisms. He taught us about toad, fish, agama lizard, he told us the difference between toad and frog. And also he told us about the toad, fish, this thing like toad is amphibian, he show us the diagram, label it for us and he told us the differences like toad live longer, aan the frog live longer in water than this things aah. **Student from T1:** Aah ,he once asks us to know the 20 elements of the periodic table so that we know them individually like the elements and their symbols, their atomic numbers, metals and non-metals.
	Didactic:	ST2: 1. Topic taught through explanation	**Student's from T2:** He taught us how it happens, at which age do you see in your body changes and stuff like that. Like the menstruation flow she talked about how did it come about and how long did it last.

Teacher centred orientation	Didactic	ST4: 1. The teacher told them ST5: 1 talks and wants everybody to understand.	**Student from T4**: He told us that energy is the ability to do work. **Student from T5**: For me how she teach, if she is teaching she wants everybody to understand, and the way she talks, that is the reason why I like her. Her teaching is very, very nice. **Student from T5**: She makes us to understand well. When she is teaching she used to do it easy, easy, and easier.
Teacher centred orientation	Didactic	1.The teacher explains	**Student fromT6**: He takes his time, explains it, students will understand and he will ask questions in return and if we don't understand anything we will ask him and he will made it clear in our mind.
Teacher centred orientation	Didactic:	1.Teacher talks a lot and explains 1.Teacher gives notes 2.Teacher explains 3.Asking questions	**Student from T7**: T7 helps us a lot because he talks a lot and explains **Student from T10**: Like when he comes to class he writes notes. He will explain some of the things. After writing those notes he will have to explain after explaining he will ask questions do you understand, if all the class understand then we have to ask each other questions. If no questions he will ask us questions to know the understanding, we have.
Teacher centred orientation	Didactic	2.Teacher tells us.	ST11 He tells us the definitions, difference of plants and animals.

Student centred orientation	**Activity driven, process and conceptual change** Activity driven, process, and conceptual change Activity driven/inquiry base, process, conceptual change	**1.Exchanging ideas** **2.Students understand better when they explain to each other** 1.Group work: ST3:1. Through experiment 2.Group work 3.Group presentation and discussions. 4.Independent learning ST4: 1. Presentation	Sometimes in groups and sometime independently not always. **Student from T1:** We bring different ideas and take the best. **Student's from T2:** We work independently, like when you don't understand that's the time we do group work then we share ideas. **Student from T3:** We did it in the classroom with the teacher and even individually I did it at home to see whether in the atmosphere water vapour is present. We take ice cube and put it in the beaker and observe after 2 to 3 minutes to see any particle outside to see that it is condensed. Theoretically we have learned that water vapour can be condensed in order to have liquid by doing such practical you realise that those facts are true **Student from T3:** Yes, both of them. Sometimes he gives us group work. You know in School A that is a custom. First test is individual, second test is also individual and third test you go out as a group and research on a particular topic or on a particular subject and when you come as a group you discuss and say what you know about the particular topic. You go and present it out for everybody to understand and we correct you if you are wrong and we encouraged each other, that is how we learn. We also learn individually by doing test asking questions.

Student centred orientation	Conceptual change, process, Activity driven	2.Rectification of students' errors 3.Group work and individual work	**Student from T4**: Like during group work if we don't understand we call him to come and give us some explanation. During presentation if you present anything wrong he rectifies it. He also tells us to write any question we don't know and bring it to him for explanation **Students from T4**: We sometimes work in groups and at time individually.
Student centred orientation	Activity driven, process, activity driven	ST5:1. Group work 2.Exchange of ideas	**Student from T5**: If she gives you group work she comes round to see if you are doing it correctly. By telling us to come for Saturday classes. I think that is the only thing. **Student from T5**: Yes we work both in groups and independently in class. Like if he gives us class test we work independently but if she gives us group work we come together and work in groups. **Student from T5**: We enjoy group work because we exchange our ideas but with individual work you are the only one to think what to do
Student centred orientation	Activity driven, discovery, inquiry process and conceptual change:	: ST6: 1. Asking questions 2. Relating topic to student's daily life. 3.Teacher making fun 4.Learning by doing will help students to remember more than when the teacher tells them.	**Student from T6**: Not only explanations, sometimes if we don't understand it he twists explanation in another form just like in our daily activities of our life so that we can understand. He knows that we are used to those things so if he explains it we used to understand. **Student from T6**: When the teacher was explaining it, he used a lot of ways in teaching it. For example, even if you are angry he uses funny words and that makes us like it. We really like those type of topic that are really interesting. **Student from T6**: Normally he just offers a little bit of support because most of the donkey job is done by us. He is just

Student centred orientation	Activity driven, conceptual change and process:	1.Group work and discussions 2.Individual work 3.Practicla work	preparing us for the battle ahead so he urges for him to do little and we do the remaining but he is really good. For example, if he is the one doing the examples every time when it comes in the exams we will not have the understanding required to answer those question but if he leaves us to do them on our own we will understand it better rather than him doing it all the time. So I like the way he does it T7: if you don't understand he takes his time and give us practicals and the school is doing their level best. **Student from T7**: Yes, the environment is conducive, we are comfortable in class. We listen and all the teachers are doing wonders and class size is small with 24 students in class. Also we have good science teachers. **Student from T7**: If we are given tough assignments we work in groups and discuss. We exchange and share our ideas during the group discussion. We do individual work like if we are given exams or classwork. **Student from T7**: Yes, through a group leader, then the teacher decides if it is good or not. Then later correction is done.
Student centred orientation	Activity driven, process and conceptual change, inquiry orientation	1.Experiment 2.Groupwork 3.Providing teaching aids 4.Asking and answering question 5.Discussions,	**Student from T8:** Since the beginning of the term we are cooperating with her. First thing she is kind to us yeah, she always came to class early as possible as she introduced the lesson to us we cooperate with her. Sometimes she do give us experiment, homework, yeah. **Student from T8**: For our science teacher she is very kind to and gives us class work and group work to do it in the class or at home. **Student from T8**:Since she started introducing the topic she wrote it on a van guard and paste it as a teaching aid so she

		6.Sharing of ideas 7. Independent work 8.Teacher gives support to students	start introducing and asking us questions and answering so as we go on we try to understand much better. **Student from T8**: When she gives us group work we work in groups when she gives us assignment we do it independently. **Babou**: What happens during your group work? **Student from T8**: We bring our opinions, discuss and compare. **Student from T8**: Yes we are helped by her sometimes she do gives us some group work. She will form two to three groups like that when you tell her madam come here I do not understand this she will come and explain that.
Student centred orientation	Activity driven, inquiry and discovery process, conceptual change	ST9:1. Group work during practical 2.Individual work – homework 3.Sharing of ideas 4.Learning from each other better than the teacher	**Student T9:** We work sometimes independently and sometimes in groups. **Student T9:** When we are doing practical we work in groups. If we are given homework we do it individually. **Student from T9**: We like working in groups because we share our ideas as the saying goes two heads is better than one. We the students we can learn from each other better than the way the teacher is teaching us. For example if the teacher teaches us and I don't understand if a student comes and explain I understand it more. In fact when I understand from the teacher and my colleague students comes and explain I will understand more from him than the teacher.
Student centred orientation	Activity driven, and process, and conceptual change	ST10:1. Group work-Sharing of knowledge 2. Individual work.	**Student from T10**:So he supports us when we are given activities or other things. **Student from T10**: We usually work in groups. Sometimes independently. **Student from T10**: Because everybody wants to contribute their knowledge. **Student from T10**: We share our knowledge to each other

Student centred orientation	Activity driven, process, and conceptual change:	1.Reviewing lessons 2.Asking questions 3.Answering questions 4.Group work. 5. Work individually.	**Students from T12:** Yes. Just like a recap so that you can review and try to remember what you learn yesterday. That also help us. When he come, he ask us question we usually answer, we usually grab it in your head. If you don't understand, he explain it to you again so that you can understand. If you come back, we usually understand. **Students from T12:** He is teaching us may be if he give a group work, so that we work together. **Student from T12**: We work individually, sometimes we work in groups also. Yes sometimes he gives group work sometimes we all do it together. Sometime he give individual work after he mark it to see whether everybody has understand it. That's why usually he gives individual work. To see whether everybody has understood it.
Belief about science teaching and learning	**Best way to learn science**	**1.Explanation** **2.Reading pamphlets** **3. Use of diagram** **4.Through observation** **5.Research** **6. Through home support.** **7.Experiment** 8.Group work	**Student from T1:** Diagrams, explanation and experiments, textbooks and pamphlets (repeatedly three times).**Student from T1:** Explanations, when there is no teacher sometime when I take a pamphlets I read it and do not understand but due to the teacher explanation of the teachers, I understand better. **Student from T1:** My best way to learn is to explain. **Student from T1:** To know what I am doing, to say like the teacher when we a treating this topic the teacher brings diagram to show me that this is what we are doing that also help me to know what I am doing. By observation, research. In the internet, parents, brothers. **Babou:** Where else can you do the research? **Student from T1:** In the science lab, you can go to your teachers, ok ask your teachers. Sometime teachers explain and you do not understand but when it is group work

Belief about science teaching and learning		1.Explanation from teacher 2. Doing Practical 3.Students contact with physical materials 4.Use of internet	like this when our fellow students are also explaining you have better understanding. **Student's from T2:** The most important thing we want now is any topic that they teach let them bring along materials, like this experiment so that we can see what is actually happening instead of. Let them improve on that. Yeah, instead of teaching theoretically, just verbally like that explaining. **Student's from T2:** Yeah, well it can be the teacher himself, because if you have a good teacher who explains to you very well and you understand, yes and he is very active, he is coming to school every day and coming to school regularly on time, it will help you to learn and even to like that subject very much. So it will help you, yes. **Student's from T2:** The practical aspect, like when there is , they always conduct practical like when it comes to experiment you get more interested in the subject, the practical will help us to see exactly what he is talking about, it helps to be interested. **Student's from T2:** Is when teacher is explaining is when the teacher is explaining and at the same time bringing materials to show us exactly what he is explaining, like what we did here, this practical and sometimes when you don't understand what he explains, you can go on asking people how to make an experiment for you or you can go to the internet and research then you see the images then.
Belief about science teaching and learning		1. Doing experiment 2. Teachers motivation 3. Class effectiveness	**Student from T3**: I think it is the experiment. How he teaches and the teachers' motivation. How effective the class will be.

Belief about science teaching and learning		4.The use of internet 5. Through teachers' explanation 6.Asking questions 7.Book reading (Textbook) 8.Learning from my parents/friends : 1.Teacher makes fun 2. Group presentation 3.Concentration 4.Teachers explanation	**Student from T3**: My learning is kind of different, normally after school when I go home at night I usually browse the internet researching continuously both topic that has been taught, that has not been taught. I keep on researching to know better so that I could perform both academically and even outside school I will have the understanding for the future. So I understand mostly by researching. **Student from T3**: I learn best through the teacher explanation, when he explains it perfectly through to my own understanding and level. I understand it better than reading the books. Through his explanation I understand more than going through the notes. **Student from T3**: There are various ways in which I learn science. As a scientist, one of the qualities of a scientist is that you have to curious. I tried to be curious like if someone said something I tried to question and ask about what you have said to know more about that particular thing. Mr xxx is someone who can explain a lot. He helps me to learn science and as I said I ask a lot and my father is a literate in science so most of the time I go to him and ask him if I have doubts in many things. Last but not the list I myself I have to read my books too, reading your books also make you to understand more. **Student from T3**: Yes. **Student from T3**: I learn best whenever I go home and take my books and read them again. This is the time I understand more. **Student from T3**: For me the ways I learn is by seating with friends ask each other questions and I learn individually if I am at home. What makes you enjoy your science lessons apart from the explanation? **Students from T4**: He makes funny things. **Students from T4**: He makes funny when teaching. He gives

Belief about science teaching and learning	Best ways students learn science	5.Class participation through discussions and asking questions 6.Listening 7.Notes taking 8.Studies	us group presentation, if you present and have some difficulties of stating some word he will tell you. **Students from T4**: Concentration. When the teacher is explaining you concentrate and listen to what he is saying. Participating in class lessons through discussions, and also asking questions if you don't understand. **Student from T4**: By listening to the teacher and if you go home you study and to take notes if you don't have the pamphlets.
Belief about science teaching and learning	Best ways students learn science	1.Studies 2.Questioning 3.Reading	**Student from T5**: By studying it, by asking questions, by reading it, by learning.
	Best ways students learn science:	1.Make research 2.Teaching aids 3.Explanation	**Student from T8:** Like you go and search for examples like if you are learning about the microscopes and we do not have microscope we go and find out about microscope and bring them in class so that it can be very interesting. **Student from T8**: Teaching aids. Like this thing, when we were learning about this thing- burning and rusting. **Student from T8:** We did not have the practicals and T8 was trying for us to understand she told us that if you want the metals not to get rust you can use this thing- oil and paint to prevent them from rusting.
Belief about science teaching and learning		1.Practical/experiment aspect	**Student T9:** Yeah we enjoy a lot about science because we know different part of our body. **Student T9:** I enjoy all the aspect of science in fact the most part I enjoy is the practical part. We do experiment, this

Belief about science teaching and learning	Best ways students learn science	2.The use of materials	experiment if you do them once they will be part of your life. In the future generation for example in the exams when they bring questions your mind will be able to remember it. The apparatus you use the step you take so that is why I said that I enjoy the practical part a lot. **Student T9:** Yeah as xxx said things that can help you to learn science very quickly and understand is the practical because once you see you remember. As the proverb says things that they tell you is not factual but what you see yourself is factual. **Student T9:** Things that make us to learn a lot is these materials and the equipment. **Student T9:** Me also I believe in proofs with these materials if you hear or see them in books they might be right but if you yourself see it and you are doing it that is the best thing for me and I enjoy them a lot.
Belief about science teaching and learning	Best ways students learn science	: 1.Teacher support 2.Friends support 3.Parents support 4.Hard studies.	**Student from T10**: There are so many people that help me learn science. Before I go outside, the teacher is number one, my friends number two and parents at home number three. **Student from T10**: Study, we should study very hard and should not give chance to our books, we have to study them very hardly, very hard because if you want to success in this live you have to, you have to … follow your education, yes.
	Best ways students learn science:	1.Provision of physical materials 2.Explanation 3.When the lesson is a practical one	**Student from T11**: When we were doing part and functions of the microscope he normally bring the instrument and to show us how the microscope work and to see the small things that we cannot see with our naked eye. In that lesson the way he normally explains is the way we like to understand step by step following the teacher explaining about microscope.

Belief about science teaching and learning	Best ways students learn science:	4.When they interact with the physical materials 3.Through discussion, 4 Group work 5.Students work individually. 1.Availability of science materials. 2. Extra classes 3.Questioning 4.Explalantion 5.Use of textbooks 6.Make research/further reading 7.Lessons that involve participation 8.Availability of textbooks	**Student from T11:** It is supposed to be practicals so that you can see the instrument he is talking about and know what it means. He discusses with us in the class properly and we understand the lesson. You study hard. Through explanation, group work and discussion during practicals. **Student from T12**: When we have study classes and we have science properties. Science materials? **Student from T12 :**Yes. Oh. **Babou**: Alright okay and apart from science materials and study classes, what else actually helps you learn better? **Student from T12:** If you don't know something and you ask someone about it about science, you ask the teacher himself about it so that he explain properly. **Babou**: Okay explanation. Teacher's explanation. What else apart from that? **Student from T12:** You go and find it from somewhere. **Babou**: You go and make a research? **Student from T12:** Yea. **Babou**:Umm and what else make you learn better science? **Student from T12:** Books. Textbooks. **Student from T12:** Yes. You come here and see other books you can use it and read and search something, yes. **Student from T12:** You participate in science when the teacher is explaining, or if you see something in science and you don't understand, you can ask a teacher to explain so that you can understand it . Yea, and to have textbooks at home and read it every time. When you see word that you don't understand, you should go to the teacher ask him what is the meaning of this word.
Views of science	**Beliefs and values about science:**	**1. Knowing parts and function of the body.**	Student from T1: I have seen that science is a very good subject.

		2.Helps to improve on our hygiene **3. Science is very good subject**	Science in the school helps us a lot. Science in our school here helps us in many things about to be Hygienic. It helps us to know the things in our body. Science is an important subject. It tells us parts of our body and their functions, like the heart, lungs, kidneys and our elementary canals. It tells us so much a lot of things about ourselves and day to day activities.
Views of science	**Beliefs and values about science:**	1.Helps us to know about our health 2.Inventing of cars 3.Science is a very good subject. 4.Science is difficult	**Student's from T2:** Science is a very important subject because it helps us to know many things like it help us know the health issues of ourselves, we know so many diseases and their causes and that is a very important thing and we know how to take care of ourselves and all is because of science and it helps us to invent new materials like these cars and they are all important, so I think science is very good subject that is needed in the school, yes. **Student's from T2:** As I said earlier it is a very good subject so we want to widen our knowledge on it to know so many things. Okay. **Student's from T2**: Yes, because there are larger numbers of students offering arts because it's a simple field to do and science there is not much doctors in the Gambia, not much qualified doctors because everybody feels like it's a very complicated field, it's very difficult to tackle with. So, that's why I myself I want to oppose it.
	Beliefs and values about science:	1.Knowing about our surrounding 2.Inspirational subject	**Student from T3**: For me science is a very amusing subject and I love science since primary school. Like science have taught me many things that the world has not taught me, even

			things that my parents have not taught me. As he said it has taught us about our surroundings, our life style things that have been discovered, how to live and many things. Science have been inspirational to me and it makes me feel like I want to study science in the future and discover more things that others have not and to be an inspiration and help on to the world.
Views of science	**Beliefs and values about science:**	1.Helps to know more about the world	**Student from T4**: Science is a subject that helps you to know more about the world. **Student from T4**: Science is the study of nature. If you are studying science very well and researching, you can find out things you don't know by asking others
	Beliefs and values about science:	1.A nice subject 2. It can earn you good living	**Student from T5**: Is a nice subject. Without science you cannot have good life. Without science you cannot have good jobs. **Student from T5:** It makes human beings to know their body well.
	Beliefs and values about science:	1.Science is difficult	**Student from T6:** Science is one of the core subjects here and every student sometimes feels that science is a difficult subject but with that I don't think so. Science is not a difficult subject, is just a matter of reading and understanding. **Student from T6**: Science is easy and we have some students who said that science is difficult but it is not that, it is based on your studies and how you focus in class or how you participate in class.
Views of science	**Beliefs and values about science:**	1. Science is a natural subject.	**Student from T7**: So science in general is about our health and our environment and about the earth.

	Beliefs and values about science:	1.Very good subject 2. Helps them to learn about their body.	**Student from T8**: Science is a very good subject and it helps us to know our body parts that we have never known or seen. She explains everything to us, I understand something about the body, yeah and the various part of the body and their functions and how to take care of the body.
	Beliefs and values about science:	1.Science is important in our everyday life 2.Ease transportation 3.Provision of Medicine 4.Ease communication 5.Provision of electricity	**Student T9**: Science is a very, very important subject in our everyday life. Through science we can be able to have scientist, doctors and all other things. **Student from T9**: But now science has developed a lot you can be here and get up anytime and go somewhere else. Vehicle are available, aeroplanes, things are working. Now you can know the amount of medicine to take in and foods to eat a lot of things science have done in this world. **Student from T9**: They are very, very right without science you cannot have these aeroplanes, cars because they are all made by scientist. You have these medicine vaccines they were made by scientists. Without the help of science, we will not be able to have scientist who will help us. Even this telephones, electricity we are benefiting from today were made by scientist who sacrifice their lives for the generation.
Views of science	**Beliefs and values about science:**	1.Love for science 2.Import and interesting subject	**Student from T10**: Science is very interesting, my best subject is science and I pass it always so I like it. **Student from T10**: It is very important; I like science because with science you study many things in our lives. Science is very interesting and very

Views of science	**Beliefs and values about science:**	3.Science is about our body, lives and environment 1.Important for national development.	important. **Student from T10**: Science tells us about body, our daily lives, and about our environment around us. Science is really good. **Student from T10**: Without science you cannot be a doctor. You have to learn science before you become a doctor. **Students from T12:** Science is important for example if you are a doctor you help people when they are sick and to tell them what to do so that they cannot be sick. They will be preventing them of mosquito or some other things. Yea. And technology to help your country to go further, science also can do it help you like technology and others.
Students' view of their lessons	**Challenges/Difficulties in learning science**	**1. Experiment and procedures** **2. Inability to pronounce scientific terms** 1 Lack of simple basic science experiment. 2.Experiment is rarely done	**Student from T1:** Experiments and how to go about it; the labelling of the diagrams;**Student from T1:** Some parts have this big word that people cannot pronoun and cannot capture it. Pronunciation of the scientific terms. **Student's from T2:** Yea , like the way he teaches it is like its perfect but when it comes to practical parts like we are not that much, like we are not having that much of those materials to use for, we use for experiment so we don't see much of the practical side when it comes to like physics some of the chemicals we never saw them. So like when it comes to the explaining part that's perfect, he explains it and he is a major in it so the way he explains it is good but when it comes to the practical it is very, most of us we do not understand it because it needs like an experiment for us to understand but there are

Students' view of their lessons		3.Prioritising the Senior Secondary level 4.Explanation without concrete objects	no experiments so we are dull in those parts. **Student's from T2**: Let's say once in a year, once…very rare. Very rare…. **Student's from T2:** Aaaa for the upper basic school. .junior we are not allowed to use the Chemistry labs and other labs because it's for senior level they are the ones who have exams on it like the physics practical exam WAEC they have it, they have practical exam on it but we don't have it so we are not allowed to use it, unless if the teacher is there. Unless you are taken there by a teacher, Yes **Student's from T2:** Like when it comes to explaining and you are not seeing something in reality, like it is being explained and you are not seeing it in reality, like it brings a big obstacle. Like when they say scientist discover something and you don't see it in reality it will be very difficult to understand it. Like if they say element Helium and we don't know what Helium is whether it is a stone or what. Something like that…so you have to take your time or else it is going to be difficult for you to understand it **Student's from T2:** Yes, or pictures of it…. or an object itself. Yes, because we hear about Helium, Argon but I don't know what it is. Like also when you are explaining about the digestive system and all these systems you are explaining. Yes, and there is…. or the oesophagus is around the neck part and there is no diagram to show us that it's here…it's here so we don't understand well.
Students' view of their lessons			

	Challenge/difficulties in learning science **Positive views** Difficulties in learning science Positive views	1.Have good teachers 2. Lack of facilities/apparatus to conduct experiment 3. Have experience teachers. 4. Lack of practical in science lessons 5.Student like science	**Student from T3**: I think we have good teachers but the only problem is we don't have enough facilities. Like in grade seven giving us to the apparatus for us to do the experiment was the only thing lacking but apart from that everything has been fantastic. We have experience teachers and that is all. Tell me about your lessons. **Student from T3**: Science lessons are good and is really effective, as he said like this experiment we did should have been done long ago since in grade 7. Going to class having our lessons is very good we don't have any problem with that**. Student from T3**: I think they have said it all, like science in school A, herein my own experience it has been always fantastic. Teachers are qualified, they teach with zeal, like they always give what they have and we just feel so happy with that, and he also said it all, the only thing we are lacking is the apparatus and the experiment we are supposed to do since we were in grade 7 and 8 but thanks be to God and I belief that everything is fine with us. **Student from T3:** Only few I can remember one or two since grade 7. **Student from T3**: For the past grades we have not it is only this grade 9 that we have started doing some. Yes, our science teachers are very good teachers when they are teaching us we always understand but only thing is the apparatus since we were in grade 7 and 8 we don't use to conduct experiment only teaching but their teaching is always fantastic.
Students' view of their lessons		1.Lack of materials 2.Mathematical part of science	**Student from T3:** I think is fantastic, ever since I just love studying science. Since I was a kid I was ever curious, so out of science a lot of my problems have been solved. The experiments if I don't understand something, after doing the

	Difficulties in learning science		experiment I see the truth behind it. So I like science a lot, I think that is very good. **Students from T3:** Like we said earlier on the apparatus, most of the time is based theoretically. Theory, theory all time the teacher is explaining but there is no materials to proof to you what the teacher is explaining and at time you are kind of lost. So I think is the material side of it. **Student from T3**: It is limited, is not for our level. Most of it is based at Senior level. **Student from T3**: Most of the time also the physics and chemistry part are very tough, the calculations. **Student from T3**: Well I can see that I am not very good in mathematics and that is why I want to do commerce. Apart from that I would have love to specialise in science.
	Positive views	1.very good 2.It is enjoyable	**Student from T4**: Science lesson is very good and I enjoy it. **Student from T4**: It is very nice when you are learning it and if we are learning it makes us happy.
	Challenges /Difficulties in the learning of science:	1.Lack of explanation 2.Lack of concentration 3.Absenteeism	**Student from T5**: May be the teacher did not explain it. Lack of concentration, by absenting yourself from school, coming to school late.
Students' view of their lessons	Positive view and difficulties	1.Good teacher 2.Nice lessons	**Student from T6**: Science lessons are very nice, the lessons, especially T6 is a good teacher.

	Difficulties in learning science	1.Important 2. Interesting 3.Teacher makes efforts to do practical with students.	**Students from T7**: Our science lessons are important, we learn about our body parts. **Student from T7**: Our science lessons are very interesting. **Student from T7**: There are many things we learned that we never knew before like our digestive systems, how it works and how it takes its journey, we learn all those things. **Students from T7**: It is also important because how T7 used to teach it we used to understand it fast. He explains it step by step which help us to understand better. **Student from T7:** Normally if we do a topic and it needs practical T7 do all his effort to do practical at the end of the lessons.
Students' view of their lessons	Challenges /difficulties in learning science	1.Abstract nature of topics 2.Teacher inability to explain clearly 3.Lack of concentration in class 4.Lack of experiment 5.Lack of studies.	**Student from T7**: If you are learning science and you don't know what you are learning it's very difficult, also if the teacher is not explaining well it is very difficult to understand the subject. **Student from T7**: Also if you are doing science you need to concentrate otherwise science will be difficult to you. Also you need to study science well at home. Lack of experiment also makes it difficult to understand.
	Challenges/Difficulties in learning science:	1.Pronounciation of scientific terms 2. Lack of science equipment.	**Student from T8**:This thing the biological words. **Babou**: Yes how about them? **Student from T8**:This oxford dictionary sometimes when madam pronounces a word if you check them you cannot find them. Like the words are difficult to

			pronounce. **Student from T8**: Yeah, like this scientific instrument some of them we do heard about their names but we do not see it physically. **Student from T8**: Like the Bunsen burner me I have never seen it.
Students' view of their lessons	Positive views	1.Love for science 2.Lack of practical 3.Science is interesting	**Student from T9**: Yes, we like science and we enjoy our science lessons. The only thing we miss is the practical we just learn it in theory. **Student from T9:** Yes, science as you know is a very interesting discipline in the school here because is part of everyday life style.
	Challenges/ Difficulties in learning science	1.Lack of materials 2.Lack of practical	**Student T9:** For example, if you don't have materials in class, you cannot have your practicals so it will be very, very difficult for you to understand things.
	Challenges/ Difficulties in learning science	1.Limited practical/experiment 2.Numerous diagrams to remember in science	**Students from T10**: This is the first time we have done practical in grade 8. In grade seven we had three practicals. **Students from T10**: Remembering of the parts and functions of the numerous diagrams in science.
Students view about their lessons:	Positive views Challenges/ Difficulties in learning science	1.Important 2.They are passive listeners 3. Teacher teaches according to syllabus	**Student from T11**: Because science is important one. During the lesson we normally keep quiet, listen to the teacher what he will say is good for us so that tomorrow and not today. **Student from T11**: When we have the science lessons the teacher normally comes to class and teach us all the time. T11normally teach us syllabus according to our levels, he does not teach you syllabus above our level , he does not do that.

Students' view of their lessons	Positive views	1.Labelling of parts due to many diagrams 2.Lack of concentration 3. Failure to ask questions	**Student from T11:** Science my problem is labelling the parts; the diagrams are many. You must have to understand the topic very well. Lack of concentration and sometime students feel shy to ask question.
Students view of their science lessons	Challenges/ Difficulties in learning science	1.Interesting 2.Enjoyable 3.Good teacher 1.Lack of materials	**Students from T12:** Very interesting yea. One after the other ah. And we usually enjoy his classes he teaches us properly. You understand everything he teaches. He is a good teacher. He usually teaches us good things and we understand him yes. **Student from T12:** When you lack science materials. When the teacher explains whilst the materials are not there. It will be difficult to understand but if you have the materials, you can easy to understand.
Science topics	Student's favourite science topics	**1.Circulatory system** **2.Adaptation** 1.Reproductive system	**Student from T1:** The circulatory system, **Student from T1:** Adaptation, adaptation Student from T2: Like when it comes to reproductive system, yes, you know reproductive system you know about this thing, this thing how to call it sah. You know about your body system and the like for us girls you know about your menstrual flow and you know to tackle it yourself.

		1.Changes of state of matter.	**Student from T3**: Like changes of matter I did so many experiment based on that
		1.Energy 2.Force 3.Animal	**ST4**:He teaches us what density is, he teach us energy, he teach us matter, state of matter solid ,liquid and gas and if you do not understand he will ask you to raise your hand and he will revise the point you don't understand that is why I like it **Student from T4**: Energy; **Student from T4**: Force; Student: Me animal.
		1.Human body system Eg. Teacher uses students as teaching aids.	**Student from T5**: For me is the human body system. If she is teaching us the human body she brings some students out and mentioning the human body so that we can understand.
Science topics	Student's favourite science topics	Interesting topic: 1.Unicellular and Multi-cellular organism. 1.Students brought physical objects to class.	**Student from T8**: We learn about unicellular organisms and multi- cellular organisms. **Student from T8**: We brought housefly and cockroaches.
Science Topics	Student's favourite topics	1.Plant and animal cell	**Student from T11**: I enjoy plants and animals. When he comes to plants and animals

Science Topics	Student's favourite topics	1.Male and female reproductive system 2.This is related to their body.	**Students from T12:** Male reproductive system and female reproductive system. You may know something about them because it is on your body
Future career Future career	Students' future career Students' future careers Reason for doing science:	1.Doctor 2.Teacher 3.Scientist : 1.Medical doctors and 2.Nurses 1.To become doctor 2. Nurse 3.Scientist 4.Chemist 1.To become doctor	What do you want to become later in live? **Student from T4**: Doctor. **Student**: teacher. **Student**: Scientist **Student from T4**: Me I want to be a scientist because I enjoy science when he is teaching it. **Student from T5**: I want to be a medical doctor. **Student from T5**: The reason why I love science is because I want to be a nurse. This also because T5 knows how to teach science, I love how she teaches science that is the reason. **Student from T8**: I want to specialise in medicine and become a medical doctor. **Babou** :Any you what would you want to become?**Student from T8**: I want to become a nurse . **Babou**:Yes and you will be injecting me alright, yes? **Student from T8**:For me I want to become a doctor. **Babou:** And you? **Student from T8**; Scientist. **Students**: Hey!! Ahaahaa. I want to be a chemist. **Student T9:** Yes, I have a plan to do science when I go to the senior secondary school I want to do pure science and when i finish my senior secondary level I will go straight to the

Future career	Students' future career	1.to become medical doctors 1Doctor	university when I finish medicine for seven years I can become a doctor. **Students from T10**: When I finished my education I want to go to the university and study medicine and later become a qualified doctor. It is the same that I want to become a medical doctor. Me also medical doctor and me too. **Student from T11**: I want to study medicine. **Student from T11:** I want to be a scientist that is the reason why I want to do science at senior secondary level. **Student from T11**: I want to be a doctor that is why. **Student from T11**: Me also I want to be a medical doctor.

Appendix 10: Analysis of RQ2

RQ2. In what ways do science teachers' own perceptions of SCL influence their

Classroom practices?

Themes	Sub- Themes	Codes	Evidence
Teachers' perception of SCL	Challenges/ constraints:	1.Limited resources 2.Large class size 3.Pressure from the school administration/High expectation from the school from the school administration 4.Difficulties in the improvisation of local materials 5.Prioritising the SSS level over the Upper basic level(T1) 1.Lack of equipment	**T1**: Ahhaa, anyway, It is challenging to teach science especially in the Gambia. One limited resources. Two number of students per class. And three what is demanded from you by the school. So looking at it is hectic, one i have to make sure that I provide material locally to make sure that the students are able achieved exactly what they need to achieve. **T1**: In term of education we will, people will say that they are not separated, but to me they are separated. When we look at material bought, materials are bought for the SSS students classes, at the end of the day we who are having the junior school, we only have to use limited materials so that we would not exhaust the materials. So when we have experiment, we have to use a little of that to make sure that we do the experiment with the student because if we exhaust them at the end of the day, the SSS will not have T2: I want the Gambian system like the upper basic system to be equipped with like conventional scientific apparatus because it is really becoming difficult for science teachers

	Challenges / constraints	2. The expensive nature of science materials(T2)	nowadays for them to have the conventional science apparatus. I think one of the issues of not making these materials to schools is because they are expensive and some of them are not within the country you have to export them and bring them here and there
	Challenge/Constraints	1.Lack of materials 2.Rush to complete the syllabus 3.Lack of time 4.Pressure from the school administration(T3)	T3: We use more of theory that is the fact because materials are not available and also we run to meet the time so that we can be done with the syllabus for their final exams, yes. The reason why we do that is, we normally run… like I said we try to cover the syllabus on time before their final exams. Because if you don't cover a lot and then they happen to have their exams if they do not perform the blame comes back to you from the administration. That is why at most cases we teach the student theoretically rather than giving them practicals in the labs. We have three labs here but I think based on the time frame we were give the grade 9 students we don't normally engaged them in activity in the school lab
	Challenge/ Constraints	1.Large class size 2.Lack of time 3.Lack of room to conduct practical	**T4**: The main factor is the large class size. Large class sizes does not allow us to have that enough time and to have that enough room to conduct a successful science practical. That is one, the second one is I have to be very honest is we the science teachers especially in the school we need more training on many of the practicals. We can do some we only know by the book, how to do the other one we do not practicalised it so we need to do them

		4.Lack of training to conduct practical (T4)	ourselves first successfully before engaging the students. So that will improve our confidence.
	Challenges/ Constraints:	1.Inadequate materials 2.Large class size 3.The mentality that science is difficult 4.Lack of practical science (T5)	T5: Obviously, there are little materials in the lab because the lab is not situated for, like they are not considering these grade eight to be using the lab. So the lab is for the science students so they are fifteen to nineteen in number. So when you compare 15 to 19 in number with some classes that are 84, 69 and 67 to take all of them in the lab becomes a big problem hahaa accessing the materials and then so, yeah is not easy. **T5**: Yeah most of them don't continue in science because they have the mentality that science is difficult. They will only know that it is not difficult that is only a teacher can make them know that it is not difficult. They will consider it difficult if the practicals are not being done.
	Challenge/ Constraints:	1.Students weakness in mathematics 2.Inadequate materials 3.Teacher's lack of practical knowledge in the chemistry area (T7)	**T7**: Like for the Physics aspect for the maths that's the problem am facing when it comes to mathematics most of them are very dull and Physics is a subject whereby it entails mathematics calculations. For the chemistry the problem is the practical aspect, during the first term when we started the Electrolysis of acidified water so I explained the topic everything but still now some of them did not understand so I decided to improvised because at now there is no Hoffman's voltmeter here we don't have the material so **I** decide to improvise because we don't have the materials but even with that it was a problem because it was leaking so that was the reason why we don't do it. T7... and also for the chemistry

			aspect for me as a teacher there are some materials whereby am I was not exposed to them when I was going to school. **T7**: Yes, I specialised in science but I was from the provinces whereby materials are very limited
	Challenges / constraints in teaching and learning of science:	1.Students' difficulties in pronouncing biological words 2. The absence of life object makes it difficult for students to learn. 3.Lack of scientific apparatus(T8)	T8: If you go to class without the life objects, especially in science and biology gives some of the students a lot of problems. They find it difficult to pronounce the biological words. Some of the words sound funny to them and like I said before they found it challenging to pronounce biological words. **T8**: Like I said before, my main problem is the scientific apparatus. If we can have plenty of them they will help a lot. Apparatus are our main problem here
		1.The lack of science materials(T9)	T9: Some of them were coming to me and I ask them to improvise because we don't have filter papers T9: If the materials are available I believe that will go a long way in supporting and delivering our lessons as expected.
	Challenges /constraints	1.Lack of materials 2.Lack of funding(T10)	**T10**: Additional information, well, well, well, the only thing I want to say to be honest at times materials are lacking from the side of the school. In the meantime, is difficult financing those resource materials, teaching and learning is normally a problem with us.

	Challenge/Constraints: Challenge/Constraints Challenge/ constraints	1.Students phobia in science 2.Students weakness in mathematics 3.Problem of speaking English language(T11) 1.Schools are inadequately equipped(T12)	**T11**: That for sure I can say no. Art and commercial classes are more than the science classes. Many of them fear science because of the mathematics involved. You need to see problems and solve and come to conclusion. For them mathematically, they are poor and all the topics in science deal with Mathematics. When you look at their grades in mathematics during the final exams they hardly have a credit. T11: The common problem is that they don't understand the language. Many of them don't speak English, they speak their own dialect. That's one of the challenges we are facing. **T12**: Now here science teaching in most Gambian schools is abstract. Because in most Gambian schools because most of the schools are ill equipped when it comes to science labs so this is why most of the time you learn things you don't even know, if they are presented before you, you don't even know them.
Teacher Perception of SCL	Teacher's understanding of SCL:	1.Students working together in groups	T1: Students might get something out of it when they work together.

		2.Group discussion 3. Group presentation 4.Teacher explains and summaries the main points 5.Teacher guides(T1)	**T1**: Ok first of all, the teacher needs to give the student group work, whether two students sitting together discussing, or 5 or 10, depending on how the teacher wants to do it, but at least, a number of students must come together, sit up and to discuss on what you need them to discuss on. Like the topic at hand, after discussion, one or two must present the activity they have done which enable them to at least bring the different ideas they have to showcase the main points which means the topic at hand, at least, after that presentation, the teacher explains or summarises for better understanding of the students. **T1**: Must be guiding the students, let students discuss and present their work. T1: So you allowing them to go home, study it and come back, most time they will have the idea and will have that confidence to talk.
Teacher Perception of SCL	Teacher's understanding of SCL:	1.Students participation 2.Students interaction 3.Students involvement 4.Teacher's role is to guide and not to impose. 5.Students are able to learn from each other effectively. 6.Students are allow to ask questions(T2)	**T2:** When we talk about student centered learning, it means the student should participate, interact and get involved in the learning process. As a teacher you are there to guide, you not there to impose, so you have to tap from their minds and then guide to the right and appropriate information of what you want them to know. T2: That's why I said that the student centered approach is most appropriate because when they learn from each other and help each other it is more effective. **T2**: Yes, that is real, they do both. They ask their fellow colleagues to make things simpler for them and also they pose questions generally to the teacher during lesson deliberations

	Perception of SCL	1.With SCL students learn by themselves 2.SCL is the best approach 3.Students come with new ideas 4.It is time consuming-disadvantage(T3)	**T3**: The child centred approach is the best because students learn by themselves. Sometimes they come with ideas which even you don't know. Yes, but it has a disadvantage because it doesn't safe time. **T3**: Yes, is time consuming because you have to allow the students to interact.
	Teachers' understanding of SCL:	1.Guidance from the teacher 2.Allow students to get involved 3.Interact with materials(T3)	**T3**: My understanding is that you give more room to the students to interact with materials, see the materials, or learning materials or try to …eehh, give their own conclusions T3: Yes it doesn't mean that the teacher have to come to class and do all what not in the class without involving the students but you allow the students to learn or do certain things to be able to achieve something on their own with the guidance of the teacher.
	Teacher's understanding of SCL:	1.Not every SCL involve practical 2.Every practical should be SCL 3Teaching students	T4: According to my understanding not every student centred learning involves practical but every practical should be student centred or must be student centred just like this one here. **T4**: Student centred learning as the name implies teaching students but it will be ammm teaching students but giving

		4.Allowing students to express themselves 5.Teacher guiding students 6.Students learning on their own 7.It takes place in groupings 8.It allow students' discussion(T4)	chance to students themselves to express themselves more, to conduct, you conduct the lesson. You the teacher you will not be like the teacher giving direct information. You will only be guiding the students like if you want to do practicals. For me that is student centred students themselves doing the work, doing more work, doing more of the talking than the teacher, that is my understanding students learning on their own with the help of few points from the teacher But in the learner centred method they do more not only asking the teacher they will do the write ups, they will do the discussions among themselves; have a general conclusion within groups themselves. The idea of learner centred mostly takes place in groupings, in groupings.
	Teacher's understanding of SCL:	1.Students do the work on their own 2. Teacher has a syllabus to follow 3. Teaching the topic according their linkages(T5)	**T5**: For me student centred method is whereby students do the work on their own. The job is being done by the student more than the teacher. **T5**: Yeah here the teacher has a syllabus, you have what to cover in a month; you have what to cover in a term and what to cover in an academic year. You have a syllabus so now you know what to bring in here after one topic the next on how they are related.

	Teacher's understanding of SCL:	1.Students are not rigidly seated 2.Students are in control and takes charge of the class 3.Students have access to resources 4.Students are engaged into discussion 5.Teacher is a guide 6.Group work is encouraged(T6)	**T6**: Student centre learning is a kind of a learning centre which is very conducive for students where students are not seated rigidly at one place throughout the entire class but students take control of the class, they take charge of the class, have access to resources, have that atmosphere of discussing together where the teacher come and guide them too but it is not a situation where everything all explanation from A to Z is being master mined by the teacher, no. Much room is given to students for students to work together as a group harmoniously.
	Teacher's understanding of SCL:	1.Guiding students 2.Finding out students background knowledge about a particular subject matter. 3. Involving students(T7)	T7:I prefer guiding them than for me doing the whole work and anything that we are doing I brain storm them to see if they have an idea about that particular area but I realised that they tend to understand better if they are involve than you doing everything
	Teacher's perception of SCL:	1.Student learn through what they see and do on their own.	T7: I believe that the child centered method is the best because students they learn through what they see and what they do on their own.

	Teacher's understanding of SCL:	1.Seek for students' consent 2.Teacher should talk less 3.Listen to students' explanations and conclusions made. 4.Students understand better when they do things on their own. (T8)	**T8**: What I understand by student centered learning is that the teacher should always seek the consent of the students on whatever topic one is teaching, like if I go to class, I should not do all the talking. I should listen to their understanding of the topic and from there we explain together and come to conclusion. That is what I understand from the term student centred learning. **T8**: Yes, from my own understanding, the student centered learning is the best method of learning because whatever one tries on their own I think that one is best understood by that person than you just come and giving the person everything and at the end of the day you go
	Teacher understanding of SCL:	1.Review of previous lesson taught 2.Brain storming 3.Finding out student prior understanding 4.Activities are conducted and get students involved 5.Improvising materials (T9)	**T9**: Yes, it is student centred learning, normally in any lesson that I normally start with I have to review any previous lesson that I treated with them and try to connect it to the recent one that we are currently treating. In that we do brain storming session. When we brain storm we sometimes even enquire from the students their prior understanding on some of the things we do in class. Then we do the activities, some small scale experiment and we improvise materials. Sometimes I do explain and demonstrations in most case as well. Those are some of the teaching methods I do in the school here. Most of the students are involved that is why I say I used the student centred approach.
	Teacher's understanding of SCL	1.Students are allowed to take the lead 2.Teacher guides	**T10:** For child centred normally students are allowed to take the lead while the teacher guides. So because of that lesson always involve activity and you know children they

		3. The Lessons involve activity 4.Students like interacting with materials 5.They are excited and happy during such lessons 6.If students discover for themselves, they retain that longer than what is being told. 7. Child centred is the best 8. The teacher gives guidelines for the conduct of activities(T10)	like activities, they are always very excited, happy, you will see them smiling. You will realise that the euphoria in the classroom is very positive actually when you are conducting practical classes so the children like interacting with materials. Child centred method is the best, it actually helps children very well. Is like a child is discovering for himself, what you are discovering for yourself is normally maintain in your memory for a very long time rather than somebody discover something and tells you that this and this is what happened. Is better you conduct the activity and discover for yourself. So actually that is what we are employing in our class, we are deploying child centred learning. **T10**: Well according to my understanding in child centred learning the teacher only serve as a guide and you can probably give the children the instructions or the guidelines as to how things are supposed to be done and the children will carry out the activities on their own while the teacher observed. Where they are about to deviate from in terms of instructions if instructions are given, if the children are about to deviate you can put them back on track that no this is not the way to go or take this other way as it should be done and then you allow them to carry out the activities. **T10**: The term student centred learning is a learning process in which the child takes the lead in being involve in the activity rather than the teacher taking the lead in the conduct of the activity in a class. That is my understating of the term student centred learning. T11: Now when you talk about student centred learning according to my own ideology. If you look at percentage you should be in class, introduce the topic, allow the

	Teacher's understanding of SCL:	1.Students to do more of the talking 2. Students to do more of the writing 3.Students to do activities 4.Support from the teacher 5.Students understand better(T11)	students to do the work on their own. For example if I decided to look at floatation which talks about liquid and substance that floats in water. So you can introduce the topic and let them do the talking. You the teacher should not do everything, do the talking, writing and other activities. Involving the students themselves, you should just help them to simplify things so that they can understand them. They understand better with the student centered than the teacher centered.
	Teacher's understanding of student centred learning:	1.SCL is about student participation 2.Developing student thinking ability 3.Not spoon feeding the students 4.Students should participate in class discussions 5.SCL practiced goes with a teaching syllabus provided by the Ministry of Education. 6.Students have no choice(T12)	**T12**:Well what I understand is that where students will participate. They will not be spoon fed where they participate. To develop their ability of thinking and so where by the teacher will not be giving them… they will not be spoon fed. They have to take part and participate in the discussion or what so ever in class. Because some of those kids, they know something which the teachers themselves don't even know. So when you involve them, that's the time you realize that. You learn from them also. **T12**: There is a specific syllabus that we follow like for grade 7, there is a syllabus that is to be covered 1st term, 2nd tern 3rd term. Grade 8, 9 the same thing and that is the syllabus that we strictly follow. **T12**: The syllabus is from the ministry and that is what we follow strictly. **T12**: No, no they don't have the choice, you just follow strictly the syllabus

Teacher perception of Teacher centred	Understanding of Teacher centred	1.Few or no activities 2.Teacher does it all 3.Students are listeners(T1)	**T1**: Teacher centre approach is far worse than child centre learning **T1**: Because teacher centre approach you will realise that there is less activity you want to do with students or even no activity you want to do with students. The teacher does it all, he introduces the topic, explains the topic, he explains his diagram or present his diagrams, at the end of the day he concludes his lesson while or Students are just there listening.
Teacher perception of Teacher centred	Understanding of Teacher centred :	1.Teacher does it all(T2)	**T2:** With the teacher centered approach it means all the brainstorming, interaction, all the lesson presentation and demonstration is strictly done by the teacher. So you can see it's like when it comes to the teacher centered approach, it is all based on the teacher, the whole is delivered by the teacher not the students
	Teacher's understanding of TCM:	1.Teacher does more of the talking 2.Students listening and writing 3.Students are allow to answer or ask question at the end of the lesson. (T4)	T4: Teacher centred as you know is where the teacher will do more of the work, more of talking, more of giving to the students directly from him **T4**: How does students participate in teacher centred learning apart from writing and listening and may be giving chance later on to ask questions and answer questions finish.
		1. Teacher does all the activities.	**T5**: Yeah, here if you said like teacher centred learning it is the teacher doing all the activities.

	Teacher's understanding of TCM Teacher's understanding of TCM:	1.All work done by teacher 2.Too much time spent on giving instructions to students 3.Students are rigidly seated 4.Inadequate materials 5.Teachers focus on students understanding and not their application (T6)	**T6**: Yeah teacher centred approach is a situation in class is like all the work is done by the teacher. The teacher spends a lot of time giving instructions. Students are rigidly seated at one place. They do not have freedom to work together, perhaps materials are not enough also enough for the topic or materials are not just given like that and then everything is dominated by the teacher and the teacher will always be counting for understanding not necessarily the application that the students can do.
		1.Teacher explains all(T7)	**T7**: Yaa, it is quite different because a lesson whereby you just come to the class explain everything on your own.
	Teacher understanding of TCM:	1.Use a lot of energy 2.Students are bored and sleepy(T9)	T9: I feel the pressure that is like I have spent a lot of energy. Normally the students will be bored some of them will start sleeping on the table. So I feel like I am going to more of teacher centred so I must try to do something that will engage them
	Teacher's view of teacher centred:	1.Teacher talk and tell students 2.Students are expected to memories or copy.	T10: …teacher centred where the teacher stand and just talk to the children tell them everything for them to just memorise or try to copy, that is not actually not a good way of teaching.

	Understanding of Teacher Centred Method:	3.Students are not involve in the lesson 4.Students are passive recipients of information 5.Students are passive listeners 6.Student -material interaction is lacking(T10)	T10: But in the other side were you have teacher centred is like the children are not actively involved, they are passive recipients of the information that the teacher is giving. The children will just seat possibly quietly and listen to the teacher as he elaborates and if it involves an activity the children will still be standing watching the teacher carrying out the activity while the children don't have a personal contact with the material.
Student centred orientation: Student centred orientation	Activity driven and Process Activity driven, project based, and conceptual change:	1.Obtaining materials locally 2.Use of diagrams(T1) 1.Involving students 2. Encourage participation 3.Induce students' interest 4.Teacher acts as a guide 5.Project work(T2)	T1: There are some topics in the science, locally you can get materials so it depends with the topic that you have, so if the topic enables you to get materials within the surrounding then you might be able to get the materials. That is why I did say, you realise that in most of our classes we use diagrams because you teaching the science you realise that you will not have the materials. T2: So I always make sure that they are involved, making the lesson learner centered not teacher centered. When it is teacher centered, it means all the suggestions, answers and manifestations come from the teacher but if they are involved in the lesson administration, it makes them belong, it makes them partake and it makes them interested in the lesson. The teacher is just there to guide and put them through but not to subject them to the lesson. T2:I gave each and every group a different topic and they

			go out to research and bring all the stuff and then we had a presentation. To me that was a project which they went to research about write notes, get teaching aids and all what they require to do and then they came to class we sit together and then group by group did their presentation on different topics
Teacher centred and Student centred orientation:	Conceptual change and discovery orientation:	1.Teacher ask questions 2.Students response to questions 3.Teacher guides 4.Allow students to seat in groups(T3)	**T3**: What we do we ask students questions and then they respond, yes. At most case we ask them to discuss within themselves, try to find some kind of responses when they acquire those responses we give them the floor to express themselves. So when they express themselves I guide them on their mistakes or errors. Okay, that is how we normally teach them in the class based on child centred approach. And also more importantly we normally keep them or allow them to seat in groups. So if you go to the class you find out that the table are packed in such a way that the students seat in groups that makes it easy for us to teach them, yes based on child centred approach. **T3**: Generally, like I said, you know let me be specific to the junior secondary school area it is more of theory like I said before. You can take the students to the lab for them to interact with materials but at most cases are very rare.
	Didactic	1.Theoretical 2.Explanation 3.Giving notes 1.Talk and chalk method 2.Conduct few practicals(T3)	
Student centred orientation:		1.Use of materials 2.Discussion 3.Asking questions(T4)	**T4**: Since my science lesson is not much based on practicals, is much based on theory I teach science using materials I have mentioned before. That is my mobile phone that is internet, other textbooks, the pamphlets, which is of course guided by the curriculum or the syllabus to a particular grade. So preparing scheme of work and lesson plan, do that, then go into the class and teach them

Student centred orientation:	Activity driven, project based	Conducted project work on periscope(T4)	those objectives I have in mind which are also directly connect to the syllabus and to the curriculum. This is how I teach science in the school here. Discussions, asking questions, giving notes, explanations finish. This is the normal way of me teaching science **T4**: Solar system even their teacher talking to you right now can't do that. May be let's say periscope using mirrors, yes I have done that.
Student centred orientation:	Activity driven, Conceptual change Knowledge of students understanding:	1.Use of the instruction sheet 2.Discussion 3.Correcting students' errors(T5)	**T5**: For me what I do is this, I will write information, I will write it on my instruction sheet do this and they follow the steps. They are the one to discuss on their own and know what to do. That is they are the one cracking their understanding and agreeing on one thing unless they failed or miss the point you rectify them. Which means you rectify their work, that is student centred learning.
Student centred orientation:	Activity driven, process and project based orientation:	1.Students are involved and engaged in activities 2.Students working together 3.Solar project work carried by students(T6)	**T6**: I make sure they involve and engage in the activities. Interact with the activities; they have a taste with the activities by touching it, feeling it, and working together as peers T6: In our science lab we have solar kits where we have different electric gadgets like a bell, like a stand fan, like small radio. So normally we do the theoretical part in class were they are exposed to parallel and the like then know that this the voltage, this the ammeter, this is the resistors. These are the cells so after doing the theoretical part of it in the classroom they come to the lab take the materials

			outside and they develop their own solar system and they feel very happy when they see the results out of it that is done here many times.
Student centred orientation	Activity driven,process and conceptual change orientation	1.Provision of materials 2. Use of appropriate teaching method. 3.In SCL teacher is a guide where students do most of the things(T7)	T7: Normally I go over the topic and see the materials that are needed I provide them from there I see which methods I should use to teach this particular topic to them **T7**: Yaa because most of the things are done by them am just there to guide.
Student centred orientation:	Activity-driven, process, Inquiry orientation.	1.Putting students into groups 2.Provide teaching aids 3.Allow students to make observation and draw conclusion. 4.Students to do practical at home(T8)	**T8**: Yes, like this group working, sometimes not all the topics but in most of the topics I put them in groups. Like for examples this plants, flowering and non-flowering plants, I will bring some specimens sometimes if we are to treat the topic tomorrow I will ask them to bring this and that plants in the next class. So if they come with the plants the monocot and the dicot I will group them, then give them the specimens to study and then after that I will ask them to give their observation. So from that we will look at it together and then discuss and come to conclusion. **T8**: Yes, there are many topics like the topic we were treating the last time is burning and rusting and there is this experiment which I even asked them to do it at home.

Student centred orientation:	Activity-driven, conceptual change and project based	1.Brain storming 2.Discussions 3. Explanation 4.Demonstration 5.Use of visual aid 6.Use of teaching aids in the form of van guard or charts 7.Project work (T9)	**T9**: Normally we do a brain storming session and when I brainstorm them, we have a discussion on some of the responses. I will further explain and if I explain I will demonstrate. I also show them some audio visual aid. I have some of these videos that I downloaded from GAMTEL. So most of the topics that we find difficult to do practical on after teaching them, I also show them the videos. I use my personal laptop which I mount on a table right in front of the class and the students will be watching. **T9**: I use teaching aids ,van guards, sometimes I draw on van guards, sometimes I have wall charts that I use were as we don't have that I normally use van guard. T9:One of the projects was to prepare Neem cream
Student centred orientation:	Process, Activity driven:	1.Students are allowed to take the lead 2.Teacher guides 3. The Lessons involve activity 4.Students conducting practicals 5.lack of project work at UBS level(T10)	. **T10:** For child centred normally students are allowed to take the lead while the teacher guides. So because of that lesson always involve activity and you know children they like activities, they are always very excited, happy, you will see them smiling. You will realise that the euphoria in the classroom is very positive actually when you are conducting practical classes so the children like interacting with materials. **T10**: Normally we do so but to be honest that one has to deal with the senior school. We normally involve the senior school more on project work. Normally project takes longer time; it can be weeks, months and whatever. So we normally involve the senior students and not the junior students

Student centred orientation:	Activity-driven, conceptual change, process orientation:	1.Teacher guides 2.Allow student to interact 3. Students allow to do things on their own(T11)	**T11**: Yes, I do, most of the time; I go to class, introduce the topic and leave them to do the work. I be a guide and let them interact among themselves. When you talk about child centered, they should be at the centre. They should be allowed to do things by themselves and you the teacher just guide them.
Student centred orientation	Activity-driven, process, conceptual change	1.Students working in groups 2.Students are allow to discuss on the topic assigned to them 3.Allow group presentations(T12)	**T12**: Alright normally what I would do is I would go to the class ask them to divide themselves in to groups of five-five people and then I will give them topics each group specific topics then I will give them time to discuss on the topics. Sometimes if it's a double period, I'll give them the whole period for them to discuss as a group then after that discussion, each group will come and present to the rest, the topic that is given to them. And I'll just be there listening to them.

Appendix 11: Analysis of RQ3

3.In what ways do science teachers' own pedagogical orientations influence their classroom practices?

Themes	Sub - Themes	Codes	Evidence
Goals and purposes of science teaching	Rationale for teaching science:	1.Teacher like science and love science 2. To impact knowledge(T1) :	**T1**: Anyway choosing to teach science I like it, I love it I can say it is my hobby and to me it seems I am naturally built to like nature, that why today I find myself teaching science. **T1**: My goal is the students Mr. Joof, because my goal is that I have to impact knowledge in to the students.
Goals and purposes of science teaching	Rationale for teaching science:	1.Science as part of him. (T2) 2.Student to know the importance of science(T2)	**T2:** For me it's not a matter of choosing to teach science, science is just in me. I am part of science, so if the science in me is out then there is no science **T2:** My main goal in teaching science is to put the message across to students that science is not a subject that relates to past and present events; it relates to human development, socio-economic development and the well-being of people itself.
Goals and purpose for teaching science:	Rationale for teaching science:	1.Change student's life and perception 2.Pass information that will change students' life and perception(T3)	**T3**: My goal when I teach science, my ultimate objective is to pass an idea to be able to change the life or change the life and perception of my students based on a particular area. Students have to see science as a real thing. So that is my job when I teach science my ultimate objective is to pass the information that will change the life of students and their perception. That is why if you

			go to the classes I teach most of the students would say I want to do science when I go to senior level. So it all boils down to making things clear to students on what science is all about in real life.
Goals and purpose for teaching science:	Rationale for teaching science:		
Goals and purpose of teaching science:	Rationale for teaching science	1.To inspire students 2.To achieve good results(T4)	**T4**: My number one goal when i teach science to my students is to inspire them. **T4:** No we have never achieved our goals in terms of science but we have achieved our goals in terms of results because that is what the administration need. This people have aggregate 6, aggregate 7, this people have credit in science that is finished.
Goals and purpose of teaching science:	Rationale for teaching science:	1.Teacher like science 2.Like conducting experiment 3.Making observation 4. Talking about the environment 5.Students to understand what is being taught. (T5)	**T5**: I choose to teach science because it was the subject I like when it comes to in terms of experiment, I like doing it, talking about environment, made a lot of observation T5: When the students understand what I taught them having in the mind-set that they will practicalised or they can answer it anywhere they see it
Goal and purpose of teaching science	Rationale for teaching science:	1.Like science 2.I get fun from teaching science 3.Building students capacities(T6)	**T6**: I like science because science is actually something that you can really link to real life situation. By studying sciences, it means that you are studying yourself and nature in general. So I really, really like it. As I said earlier on I always find fun in science. I don't want to study a particular field that gives me stress but science is something that I always get fun out of whenever I teach it. **T6:** My goal to teach science is to ensure that capacities of students are built in different, different areas.

Goals and purpose of science teaching: :	Reason for teaching science:	1Teacher enjoy teaching science 2.Teachers goal is for students to understand better 3.Change student negative concepts that science is difficult.(T7)	**T7**: Yaa, is also a particular area that I also enjoy and I enjoy teaching it yaa. So I like it, I majored science and English. **T7**: Ok, like one of my goals could be like at least let the student understands better. I want to remove the concept of it is a very difficult area yaa
Goals and purpose of science teaching	Reason for teaching science:	1.Teacher like science during school days 2.Teacher's goal is to prepare the students and inspire them to opt for science.(T8)	**T8**:I like science since I went to school **T8:** My goal to teach science is to make sure that i teach and prepare students who are the future leaders. I want them to be inspired by me to study science.
Goals and purpose for teaching science:	Rationale for teaching science:	1.Motivated in science 2.Better in science 3.Improve students in the area 4.Improve myself as teacher 5.Students to pass their exams(T9)	**T9**: That was the area I was motivated when I was going to school. That was the area I excel well it has ever been my ambition because I was well motivated in the area of science **T9**: When I teach science is two folds: One is to help student to improve in the area and two is to improve myself in the area.T9.. make sure that they perform well in the external exams but in the process I also learn a lot.

Goals and purpose of science teaching:	Rationale for teaching science:	1.Understood science more than other subjects due to the activities conducted during the lessons. 2.Build students' knowledge 3.Build students confidence 4.Encourage them to opt for science(T9)	**T10**: Well the choice of science is emanated a very long time when I was a student. When I was a student I realise that I understand science subjects more than any other areas and at the same time as I said students normally enjoy lessons that are activity centred. To help children build the knowledge as I said, have the spirit of investigation and also have confidence in themselves in a bit to encouraging them to choose science as a career.
Goals and purpose of science teaching	Rationale for teaching science:	1.Curious 2.To innovate(T11)	T11: I was so curious to know about science. **T11**: I teach to innovate
Goals and purpose of science teaching	Rationale for teaching science:	1.Teach science to have an impact on students(T12)	**T12**: Well when I teach science, I teach science for it to have an impact on the student.
Goals and purpose of science teaching	Activities designed to achieve the goals	1.Use of science materials(T1) 1.Class Discussions	**T1**: Ok, the only thing I will say is that, in teaching science to achieve the goal, is necessary for the teachers and students to get the right materials, it helps to gain or achieve desired goals. In the absence of teaching materials, the teacher finds it difficult to impact the knowledge and students in turn to achieve these goals, and in fact the teacher will not even learn from the students neither will the students learn from the teacher. T3: One I sometimes kind of teach students based on my own eeeh let's say I kind of do most of the activity to be able to pass the

Goals and purpose of science teaching	Activities designed to achieve the goals	2.Guidance from the teacher(T3)	information. Secondly I sometimes give the floor to student to be able to speak their mind and then discussions come in the class and there is argument here and there but in the end we agree on a particular thing based on my guidance.
Goals and purpose of science teaching	Activities designed to achieve the goals	1.Through the available resources 2. Through student interaction(T6)	**T6**: Primarily, I make sure that the goals or objectives that are set in teaching science are achievable that I can do with the support of the readily available resources and interaction with students as well. I do not enjoy teaching in the abstract.
Goals and purpose of science teaching	Activities designed to achieve the goals	: 1.Group work 2.Science exhibition 3.Science excursion(T7)	**T7**: We do group work is one of the activities we do sometimes also we have exhibition. T7: ..also exploration we do go out a times to see certain things
Goals and purpose of science teaching	Activities designed to achieve the goals:	1.Discussion 2.Explanation 3.Demonstration 4.Practical activity 5. Problem solving(T9)	**T9**: In implementation we have class discussion, we have explanation going with demonstrations, practical activity and even problem solving.
		1.Investigative lesson(T10)	T10: So I try to involve them more on the lesson in an investigative manner so that I can build their confidence in the area of science.
Goals and purpose of science teaching	Learning activities designed to achieve the goals:		**T11**: When you talk about science it has to be practical

Goals and purpose of science teaching Goals and purpose of science teaching	Designed events to achieve the goals: Learning activities designed to achieve the goals:	1.Practical(T11) 1.Involving the students in practical activities(T12)	**T12**: Right amm by involving the students because once you involve them, they build interest. **T12**: Alright like when I go to the class, I come up with things that will make them interested by involving in practical.
Teacher's views of science: Teacher's view of science: Teacher's view of science	Belief about science Belief and values about science Belief about science	1.Science is a more difficult area for students 2.The brighter students tend to relax with time and this lead to underperformance(T1) 1.Students like science 2. Students want to specialise in science to become doctors(T2) : 1.Science is life 2.Science is interesting 3.To understand the innovation taking place(T3) :	T1…we belief that especially I believe that Science is far more difficult for students than mathematics. **T1**: One in my understanding I believe those who believe that they have it in them tends to relax a lot and those that believe they did not have still need to pursue more or struggle to get what they need and those are the one we believe they couldn't do it and in them they believe that they have the potential to struggle and make it a life. T2: Students like it and are seeing what the benefits of science are doing in the world at large and they are also encountering it their daily lives. Of course yes, they are continuing with science and some of them want to take it as a career in the near future, some of them want to become doctors, architects and the like. **T3**: First of all after doing science at Senior School, College level, I decided to stick with it due to the fact that science is life. Yes because everything you do in life is equal to science. That is why science is very interesting and I stick my life to it so that I can be able to understand how the changes in the world are taking place, like innovation even in real life.

Teacher's view of science	Belief about science	1.Students view science as difficult(T6)	**T6**: Well I just want to challenge my colleagues, my counter parts who are teaching science anywhere let them try to bring fun in the teaching of science because many at times students see science as subject that is very, very difficult, a subject that cause trouble to many, many candidates.
Teacher's view of science:	Belief about science	Belief about science 1.Science is broad(T7)	**T7**: Yes, like if you look at science it's a very broad area and the area that am teaching consist of three main components which is the Biology aspect, Physics aspect and the Chemistry aspect
Teacher's view of science:	Belief about science:	1.Students have the phobia of science(T10)	**T10:** As you are aware normally in our school system, children tend to fear science they think science is difficult because of that we the science teachers are also very careful.
Teacher's view of science:	Beliefs about science	1.Science is broad 2.Science is difficult	**T11**: Well science itself is very broad. I say for science it is a little bit difficult. We face some obstacles especially in delivering our lessons according to our plan.
Teacher's view of science:	Belief about science:	1.Most students dislike science subject	**T12**: Now what I normally do, because what is happening like most students do not like science subjects. They don't like science subjects.

Belief about science teaching and learning Belief about science teaching and learning: Belief about science teaching and learning:	Role of the teacher Role of teacher Role of teacher	1.Teacher should be well prepared(T3) : 1.Serves as a guide 1.Teacher's role is to teach the lesson.	T3: You prepare yourself meaning you do your lesson plans from there you also prepare based on your topic, based on the materials you want to teach in class. You prepare yourself very well go to class you deliver **T10**: The teacher serves as a guide T11:The role of the teacher is to teach the lesson and the role of the students played with their lessons
Belief about science teaching and learning Belief about science teaching and learning	Role of the student Role of the student	1.Students are excited and eager to know what occurs 2.Students to pay attention to the work given 3. Students are able to explain what they have done practically. (T5) 1.Investigative(T10)	T5: Yeah they like the science lesson because like when you do the practical with them. They are excited, they are eager to know what is happening there. So obviously they will pay attention when you give them work they will pay attention like what I did with them when you go and ask they will explain but if you ask them to explain the note what and what they will not be able to explain. T10: So the students' role here is investigative
Belief about teaching and learning science	How students learn science	1.Provide them with martials(T1)	**T1**: Ammm, if you want your students to really be engulf with the subject you have to give them what they need. That is still the materials you are talking about, let them see the materials, let them touch, let them feel, and possible let them play with it if they are unbreakable

Belief about teaching and learning science:	How students learn science:	1.Introducing the topic 2.Allow student interaction 3. Rectifying students' errors 4. Linking what is learned to real life situation(T2)	T2: But it is very important you introduce the topic, and brainstorm into the topic with them by allowing them to interact and then rectify their mistakes as you go along the interaction and then make facts and relate them to real life issues
Belief about science teaching and learning	How students learn science:	1.Asking questions 2.Giving class exercise 3.Group activity(T3)	**T3**: That is normally done in various ways. Sometimes when you are introducing your topic you can ask questions related to the previous discussions and then ask students what they have learnt the previous day in order to help them at least remember some of the things that you have done in the past. You give them class exercise and sometimes assignments will help to enable them remember what they have learnt before, you understand. Also like I said group activity or group work so they will be able to work on a particular area and be able to remember what they have done before.
Belief about science teaching and learning:	How students learn science:	1.Explains the topic 2.Improvised materials for students to use(T5) 1.Providing students with materials 2.Allowing students to do their own work. (T5)	T5:You explain the topic to them then allow them the next lesson like what I did today you tell them we will be doing the practical today so that they can bring their materials because I used cup with them, spoons with them which you can use as beaker and spatulas but you have bring the materials to avoid the breakage, you see how the number is large they can easily break those materials. . It is a tin of milk they open it so that we can have an evaporating dish. So we improvise the materials and they work with them. **T5**: By giving them materials and then they work on their own.

Belief about science teaching and learning	How students learn science:	1.Methods used 2. Motivating students by making science a fun. 3. Making lessons interesting by giving them hands on activity. 4. Increase students interest in science 5.Making lessons activity based(T6)	**T6:** To be very frank with you some of them when they are starting with me at the upper basic sector they come with a kind of very, very low interest in science but before they graduate from the Upper Basic all of them would always yearn to specialise in science in the Senior Secondary School. That is very real here, yes. **T6**: Virtually, one way is perhaps may be the methodology that I am taking and also I do motivate them by bringing fun in the teaching of science. They are not very much stressful or feel bored in class because they always have what we call hands on activity
Belief about science teaching and learning:	How students learn science:	1.Through assessment 2.Conduct of practical 3.Peer tutoring among students(T6)	**T6**: Yeah once in a while I do assess them. Once in a while they come together conduct their own practical even in my absent, you know. There is also this thing happening here were you have peer tutoring where in the absence of the teacher students help one another make sure the knowledge learnt is retain.
Belief about science teaching and learning:	How students learn science:	1.Students are allowed to explain certain concepts to colleagues(T7)	**T7**: Yes, it do happen, at times I will be teaching somebody will ask a question then instead of me somebody will prefer ok yes T7 ok let me also handle that particular question.
Belief about science teaching and learning:	How students learn science:	1.When students do most of the work in class 2.When students are involved 3. The lesson is child centred	**T7**: They always learn it well, if they do most of the work on their own yaa for me that is what I believe. If they're involve they'll learn it better then you doing everything for them. Let it be just purely child centered lesson, always try to avoid the class being so boring.

		4.Keep the lesson interesting(T7).	
Belief about science teaching and learning:	: How students learn science:	1.Provision of materials to students 2.Students feel happy in class and do the work on their own. (T8)	T8: When I went to the class, I took the materials to them. They were so happy and they told me that we are going to do everything on our own. You will not do any teaching. Yes, as you can see in class most of the parts were named by them and at the end of the day they were able to state the function of them.
Belief about science teaching and learning:	How students learn science:	1.Use practical activities for students to remember and understand what they have learned. (T9)	T9: Doing it is like forming an indelible image in their mind, in their brain, and with that they will go a long way in getting that information. That is why we go more in for practical activities where what they do they can easily remember and they understand.
Belief about science teaching and learning:	How students learn science:	1.When they are engaged into activities. (T9)	T9: When we involve we may involve by only talking to them but if we allow them to do the activity on their own I think with that approach we are ensuring that they are getting what we want them to have.
Belief about science teaching and learning			
Belief about science teaching and learning:	How student learn science:	1.Students learn best when you allow them to see, feel and touch during practical activities(T11)	T11: When you allow them to see after you did it once that the best way they can learn. If they feel it and touch it you can see how the students feel about it. They see it themselves and feel it. If they practicalising it then they learn better and can do it themselves. It makes them to learn faster.

	How students learn science:	1.Give assignment and attached marks to it 2.Asking questions(T12)	T12:So what I would do is, I would give them a lot of assignments, and then at the end of the day, the assignments, I would have to mark and then and is part of the assessment termly assessment. So that would force them to read and then also every day, in the morning when I come to the class, I used to ask them each a question if I entered the class because today I didn't do but normal days that's what I would do
: Belief about teaching and learning science Beliefs about teaching and learning of science	How science can be taught : How science can be taught:	1. Science cannot be taught without experiment. 2.Abstract if taught by talking only(T2) The benefit of experiments: 1.Experients cuts down time 2.Enable students understanding 3.Allows students – material interaction 4. Encourage student participation 5.Inject love for science among students(T2) 1.Relate topic to real life 2.Taking students out of the classroom such as hospitals 3.Students easily remember if what they	**T2**: I personally believe that one cannot teach science in the absence of experiments and also in the absence of exposing them to the real nature of what you are teaching, so it is rather abstract when you just talk and talk without doing, they go together. When you conduct an experiment it cuts down time, makes to understand easily, makes them to interact with the materials, they get to love the subject more and participate rather than you talking throughout without any based practical lesson. **T2:** As I said, the learning activities which I embarked on to achieve my goal in teaching science is; I always make sure that any topic that I teach I relate it to real life issues and show them people that survive on those real life issues. I took my students to the hospital, I covered a topic on malnutrition that is deficiencies due to lack of vitamins and I took them to the hospital and they saw people lacking those vitamins and how they ended up and how are those things treated. They saw the difference that on the whole this is important, because they were taking it as something just to know but on the whole this is happening. When I took them to the hospital I took them to the surgeon, there was somebody who had a goiter and was being operated, they saw it and from there they knew that lack of iodine causes goiter and that iodine is found in our local foods. From there they realised that it was very good that I eat snails, oysters and other sources of iodine to avoid the iodine deficiency. You can see that subject was connected and you are helping them to have an insight of what happens around when it

		learn is connected to their daily lives.(T2)	comes to your teaching, your teaching should not only be a teaching but it should be connected to real life issues. But if they don't see it in any way connected to the lives of people they will only learn theoretically and forget about it.
Belief about teaching and learning science:	How science is taught:	1.Use both teacher and student centred method 2.Student materials interaction 3.Guide students 4. Ask questions and obtain responses 5. Rectifies and clarifies students misunderstanding and errors. (T3)	T3: Sometimes we do more of teacher centred learning in most cases and in few cases were applicable or needed we use student centred learning approach were by we expose students to different materials and then interact with the materials and then come up with their own ideas or their own conclusions. But we normally guide them even in class, even if we are discussing in class, the teacher comes there as a guide, you understand and then show them what to do. If I ask questions they respond. If there is any need for rectifications and clarification, I make that and then we move on.
	How science is taught: Practical work or experiment:	1.Aim 2.Materials 3.Procedure 4.Observation 5.Conclusion (T3)	**T3**: When you teach a science topic which involve practical work. First of all you must have the aim or objective. If you have your aim or objective, you try to gather some materials. Those materials are sometimes are locally available or sometimes they are available in the school lab there. So you set your procedures, that is the step you are going to take to carry out that particular activity and then from there you have your observation of the activity, what students are doing and then from there you have your general conclusion. These are the ways we teach practical topics.
Belief about teaching and learning science:	How science can taught .	1.Availability of material would enhance the teaching of science. (T3).	**T3**: I think with the teaching of science it can be enhance more if we have the required teaching materials you will be able to teach science I think we are lucky to have labs but some schools they have no material and teachers teach in the abstract.

Belief about teaching and learning science:	How science can be taught	1.The use of textbooks 2.The use of examination papers 3.The use of internet(T4).	**T4**: I teach science in a classroom using materials like textbooks, examination past papers, the internet, especially the internet is a huge tool for me when it comes to teach science.
Belief about teaching and learning of science:	How science can be taught	: 1.Need adequate materials 2.Students working in groups 3.Offer experiment procedures to students 4.Give some guidance(T4)	T4: I need adequate separating funnel minimum of six in each group. I will write for each group on a paper the steps or procedures in a clear language on what the students are expected to do during the experiment. As soon as I give them that and discuss a little bit of some guidelines on labs and how to take care of the materials then will give them each group 20minutes to do the experiment using the manual that is provided to them.
Belief about teaching and learning of science:		1.Equipment labs 2.Teachers need Knowledge and skills(T4)	T4: Science needs to be improved. Improvement in science hugely also includes on making the teachers that also the teacher teaching science to be well equipped, very much equipped, with the knowledge, with the skills and with the tools. These are the three main components. The knowledge, they have to have more knowledge, they have to have better skills and those skills cannot be performed without the tools.
Belief about science teaching and learning:	How science can be taught: How science is taught	1.Group work 2.Use of diagrams 3.Few practicals 4.Conduct demonstrations(T5)	**T5**: I teach science here because most of the time as I said before group work, I do group work but it is difficult and it consumes time and they go and join the other groups come here and there. So for me how I teach I tried to do group work at times then most of the times I draw, paste it on the board, and they learn from it. That is, i use van guard and then group work. When it comes to doing practical too is not very frequent because is not easy to do practical inside the class and taking them to the lab the number too, they cannot contained them in the lab so we do practical but not always,

Belief about teaching and learning science:	How science can be taught:	1.Give instruction to students 2.Give students procedures 3.Provide students with materials(T5)	not always. **T5**: I teach science by using diagram and materials through demonstrations to the students. **T5**: We have to get the materials for them. Write instruction for them and then the procedure in which they will carry out because they already have the knowledge about what those are all about but they don't know how to do it. So you write steps for them that is the procedure. First step do this, second step do this, third step, unless if they do not know any they can ask, at least they should be able to read on their own and able to analyse and then go ahead with the practicals. Since they have the procedure they can do it because the materials are all available, they are all labelled and then they can go ahead and do the practicals.
Belief about teaching and learning Science	How science can be taught:	1.Fun 2. Practical 3.Real(T6) 1.Teachers should make science a fun 2.Teachers to make science a practical subject 3.Teachers to motivate student(T6)	**T6**: Any way ahh science is something very, very, practical and me I always derive fun from science when am teaching science. Practical in the sense that all what you are teaching in class you see the reality outside, you see the reality outside. Like the cases of rusting that I taught is practical life topics that exist in every day of our activities. Like sometimes you can be working and you see a rusted nail compared to a brown new nail you see that there are some differences. That happens because of the chemical substances that has reacted or come into contact with some of those objects. T6: So teaching science is fun, teaching science is practical and teaching science is real students to learn science, yes. T6: So I am trying to challenge them let them make science very practical, let them bring fun in science and then motivate
Belief about science teaching and learning:		1.Plan 2.Procedure	**T6**: How I teach it is like I always ensure that I have a plan and on that plan since it is a topic that is experimentally centred I make sure that I have a procedure of how that experiment is to be conducted. All students will be involved in that experiment besides I will also have a work sheet where after the experiment students

	How science can be taught:	3. Student involvement 4.Work sheet to students(T6)	can read their comprehension in the topic by answering that answer sheet.
Belief about teaching and learning science:	How science can be taught	1.Linking topics taught to students' daily activities 2.Making sure that topic involving calculations are done after the treating similar areas in maths lessons(T7)	T7: …normally whatever topic that am teaching I relate it to some of their daily activities just to avoid being so abstract to them so that's one of the methods that I used. Certain topics in Physics is related to mathematics and for the Chemistry aspect there's is a particular area that has some mathematics like the solubility curve so I always make sure that before I discuss that with them they have already treated graphs with the maths teacher so that by the time we talk about it they already treated graph.
Belief about science teaching and learning:	How science can be taught:	1.Going over the topic 2.Making a list of materials 3. Providing the materials required for students 4.Stating the aim and objective of the practical 5.Discussion of the procedures with students 6.Putting students into groups 7.Allowing groups to explain(T7)	**T7**: I will just go over the topic and list down some of the materials am going to need for that particular experiment before the day of the class that this is what I need in other to teach this topic. I will make sure that everything is available. From there if I go to the class I will write the topic it is going to be a pure practical whereby I will tell them the aims and objective of the practical that this is what we are going to do and this is what we want to achieve at the end of the experiment. So already they have an idea of what we are about to do and I also give them a little bit of the abstract of the experiment. We first discuss the procedures together before I will give them any materials so if they are ok with that I divide them into groups so each group somebody will come and collect the materials and next I give them the substances then they'll do the setup on their own. As they are carrying it out I will go round to see what they are doing anything that is not correctly done I will explain. Later groups will come out and explain how the experiments were carried out from there I will come in and explain the whole process that is at the end of the practical. Where I feel like I should throw more light on a particular area, then I buttress more on that particular area.

Belief about teaching and learning of science Belief about teaching and learning science: Belief about science teaching and learning	: How science ca be taught: How science can be taught:	1. In the absence of real objects, use van guard to draw diagram or word cards. 2.Allow students to explain 3. Allow students to share their ideas(T8) 1.Improvisation(T8)	**T8**: In our level it is combined together both physics, chemistry and biology and we call it general science. Like for example sometimes if I am going to class If we don't have teaching aids like the real objects I will use a van guard were by I will draw diagrams. If there is no diagram I do what we called word cards like some of the words you write them on the card and when we go to the class I place it on the resource table if I am explaining I will called on a student to come voluntarily and pick one of the card and explain the word. If they answer it then I call the next one but if they don't I call the next person. But I always allow them first to share their ideas together and then if they have mistakes in their definitions we make the corrections together and we forge together. **T8**: We can use distillation. How can we use this distillation? How can we use it like the mixture of sand and salt? Let's say we have evaporating dish, if we don't have evaporating dish we can also improvise by using tomato tin. Not distillation rather you can use evaporation, evaporation, we can use tomato tin and we can have our charcoal pot or whatever. The mixture of the salt and sand we can mix it with water and when it is mixed with water we can set the fire and put the tomato tin and leave it to start boiling. As it is boiling the water is evaporating. As it evaporates we can set our clock and see how long it will take for the water to evaporate then we will see the salt that will be remaining in the evaporating dish or the tomato tin. **T9**: Teaching science I normally consider the student centred approach or the learner centred approach. That is what I always do. In most cases, I teach students by involving them in activities; usually that is what I do.

Belief about teaching and learning of science:	How science can be taught:	1.Use of student centred approach 2.Involve students into activities(T9)	T9: I group students, distribute materials. **T9**: Yes, I will make sure that they have a worksheet, each group have a secretary where they will be working in groups, whatever they do they will take note of. Like what I did today I will put the activity title and I will also put the materials involve, they will have to jot down the materials they will use and the procedures involve in the experiment.
	How science can be taught:	Teaching a practical lesson: 1.Grouping students 2.Distribute materials 3.Provide work sheet 4.Students have to write the procedures used(T9).	
Belief about science teaching and learning of science:	How science can be taught:	1.Use of appropriate methodology and teaching learning resources 2.Use of child centred method 3.Teacher guides 4.Students conduct activities 5.Student involvement and participation is encouraged 6.Students are allow to discover for themselves. (T10)	T10 We always deploy methodology that will help the children understand and actually make them discard the fear of science. Actually the teaching of science cannot be successful and effective without the right methodology and the right equipment or what we called teaching and learning resources. In a sense teaching science we focus more on child centred as you may be aware a teacher is meant to be a guide to the students and the students are allow to carry on with the real activities. So in short the teaching of science as I said I focus more on children involvement let them participate actively in the lesson. Be it a practical lesson or a theoretical lesson we normally guide the children with questions during the lesson for them to discover for themselves whatever we might want them to learn or discover.
Belief about science teaching and learning:			T10: If the lesson involves some teaching aids or learning materials they must be provided and normally this is what we do. We go to class with teaching materials alongside the lesson plan and then the lesson notes. T10: … teaching aids will be displayed accordingly in order to promote student understanding.

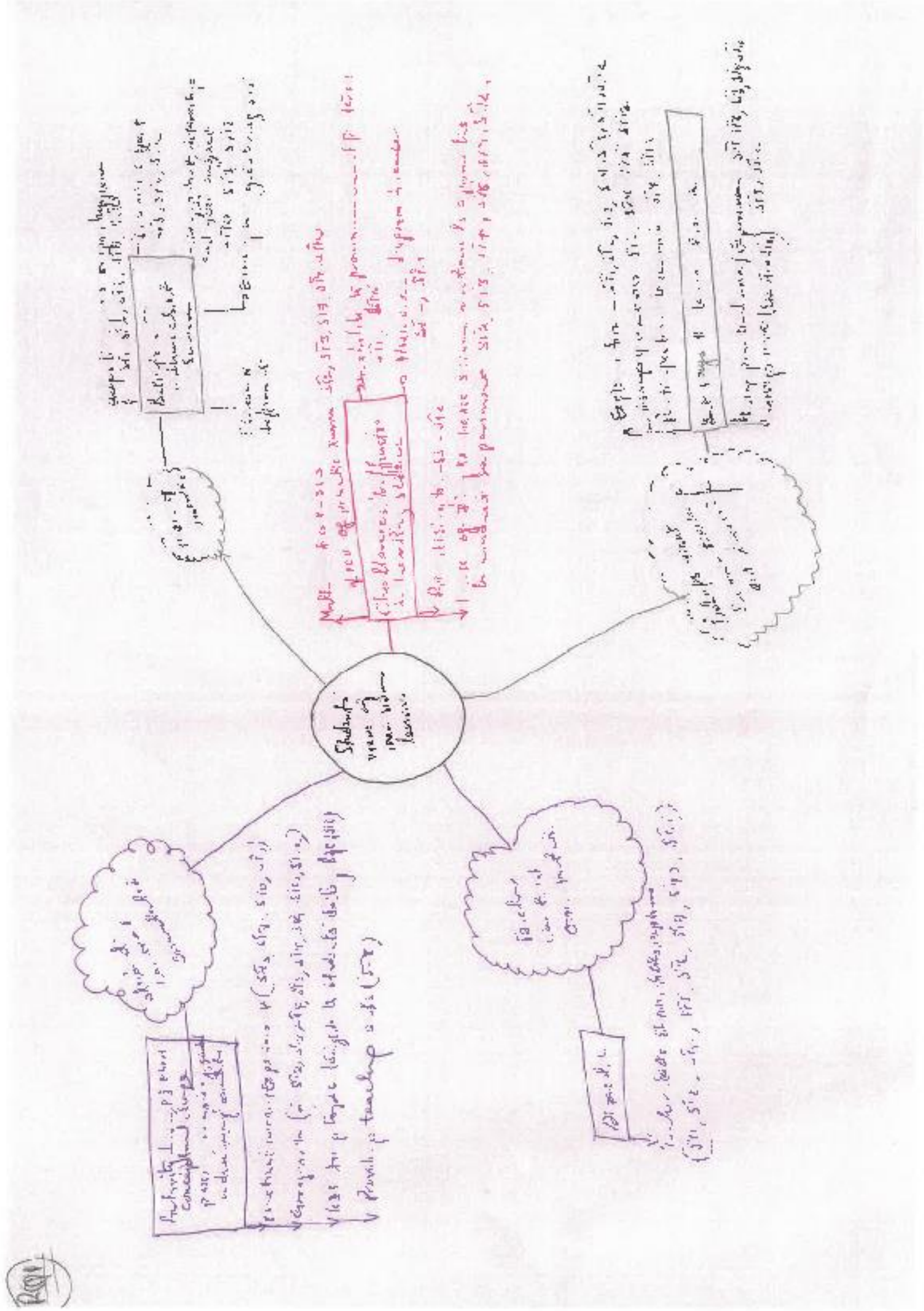
Belief about science teaching and learning:	How science is taught:	1.Provision of teaching learning materials/teaching aids 2.Lesson plan and lesson notes are drawn(T10)	T10: So that is where I will begin I will go to class deliver the theoretical aspect until I know children understand what the lesson is all about until I know that my aims and objective of the lesson are been achieved. Then I will move on to conduct the practical. Normally when I am conducting the practical with the children, the aim, the materials, the procedure, and all those things are normally written and then handed over to the children. Now is the children that will normally set up the apparatus or practicals based on the instruction or the method that is being handed to them to that is being written on the chalk board.
Belief about science teaching and learning:	How science can be taught:	Teaching a practical subject involve: 1.Having to teach the theoretical aspect first 2.Provide instruction to students 3.Allow students to set up the apparatus(T10)	**T10**: A normal science lesson will have to involve some form of practical that is how I see a science lesson, because a science lesson needs to be activity wise, something that will involve activity.
Belief about science teaching and learning:	How science can be taught:	1.Normal science lesson should be practical and activity based(T10)	T10: You can't just start teaching a topic blindly without knowing the level of understating of the children as far as other particular topic is concern. You can simply do that in the introduction; during the introduction you can actually find out the level of understanding of the children or the child's knowledge as far as the topic is concern and eventually in the development you will know where to begin based on the feedback you get during the introduction. T10:At the end of the lesson you normally try to recapitulate or revisit the key points of the lesson either verbally or orally or through oral questions and answers from the children T10: …giving them the notes in relation to the topic that you are teaching. All those notes will serve as a reminder to the child, to be remembering what is being taught.
Belief about science teaching and learning:	How science can be taught:	1.Use introduction stage of the lesson to check for students' level of understanding. 2.Recapitulation or revisiting main points of the lesson	**T10**: To ensure that students learn science very well I do employ the most suitable methods of teaching science, because

Belief about science teaching and learning:		3.Giving notes to students(T10 1.Use of a suitable methodology (T10)	methodology is one of the thing, once you don't used the right methodology it is going to be difficult for children to learn.
Belief about teaching and learning of science:	How science can be taught:	1.Practical related topic are done in science lab while non-practical related topic are done in the classroom.	**T12**:Yes, in School F here we teach both theory and practical amm because we are lucky that we have a lab yes we have a well-equipped science lab here. Okay so normally what I do is topics that has to do with practicals, I go to the lab. Topics that do not have to do with practicals, I teach it in the class.
Belief about science teaching and learning	How science can be taught:	1.Provision of materials 2. Putting students into groups 3.Explanation 4.Allow students to conduct the experiment themselves(T12)	**T12**: Amm we go to the lab, I collect the materials that are the materials concern sometimes I'll group the students, right, distribute the materials then I will teach, do the explanation everything till they understand, now I assign them now do it yourself, then they will also do it. That's what I do mostly.
	How science can be taught:	1.Introduction of the topic 2.Asking questions to find out students' prior knowledge of the topic 3.Give explanations 4.Questions and discussions	**T12**: Now I will come to the class, introduce the topic, briefly, then I will ask them to know about their basic knowledge on the topic to have at least, because not all of most of them have at least because learning is all repetition because some of these topics they have treated in the primary schools. So I will ask them questions to know their basic knowledge on the topic before I explain the topic in detail. Then after the explanation, I will throw

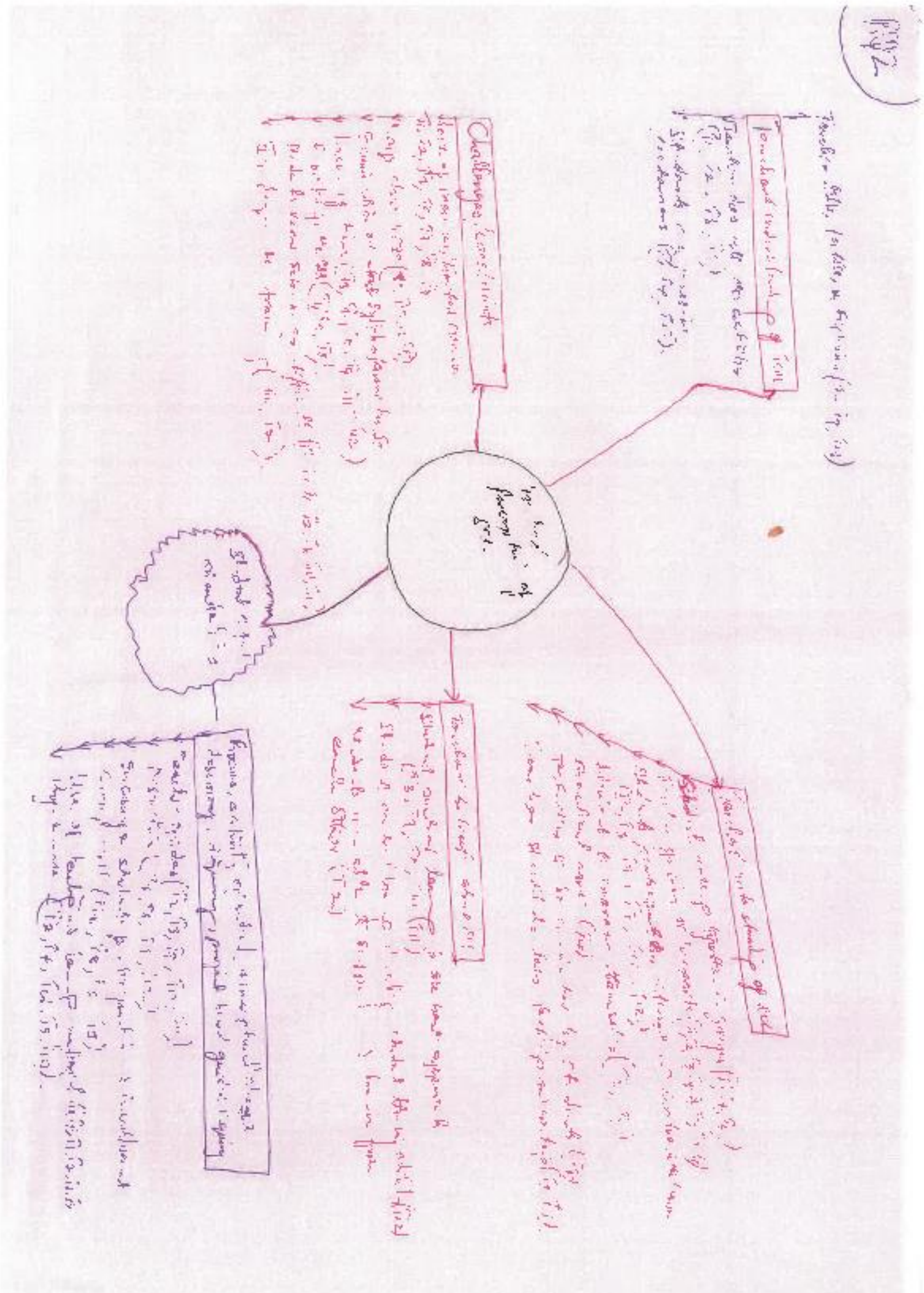
Belief about teaching and learning of science:	How science can be taught:	5.Give a summary of notes(T12)	questions to them, then we discuss. Class discussion. I will ask questions before giving them notes. Because before I give them notes, I have to summarise what I explain ask them questions to clear all their doubts and then notes. Normally, I don't give them bulky notes. I summarise notes. I do more of discussion and explanation and then give them notes which I just summarise.
		1.Teacher put prior knowledge into account. 2.Pose questions to students 3.Take students responses to see if they have an idea related to topic. (T12)	**T12**: If I write the topic on the board, I would ask them what they know about that topic Amm may be I would give them 2-3 minutes… okay, and then see their response. Then I would know how I would discuss about the topic. If there is no response, then I will know that they didn't have any idea about the topic. **T12**: They are always able to because when I group them, then during their group discussions, presentations, there are very good students who can present very well
	How science can be taught:	4.Students are able to explain concepts to their colleagues or teacher: 5.During group discussion and presentation(T12)	
Knowledge of students understanding of science	Student prior knowledge is put into account:	1.Review of the previous topic 2.Brainstorming	T2: Beginning a new topic when the previous one was not digested makes the new topic difficult and boring for learners, by bringing a reflection of the previous topic before introducing a new one you are giving your students a gentle reminder that every topic is connected to the other. **T2:** Yes, that's why you can see even before I embarked into the practical I made a brainstorm of the lesson to see what their prior skills and knowledge is based on the lesson of the day

Teacher knowledge of student understanding of science and Teacher knowledge of curriculum:	1.Putting student prior knowledge into account:	1.Checking students previous knowledge(T3) 2.Making sure the topics are connected (T3)	**T3**: Yes I do relate to the former topics taught to make sure that at least students know something from a particular topic before moving to another and also they have to be connected. Yes that is very important and we do that always. You have to make sure that students have some idea previously before they are exposed to a particular lesson, yes we do that
Teacher knowledge of students understanding of science and teacher knowledge of curriculum	Student pre-requisite knowledge and skills:	1.Brain storming 2. Revisiting previous topics learnt. 3. Linkages of topics(T6)	**T6**: I always ensure that there is a linkage between the previous topics and the next topic, alright. So were in the topics are tailored together I always make sure that we have a quick brainstorming or a recall of the previous topic and then try to link it with topic at hand.
Teacher knowledge of curriculum:	Taking student prior knowledge into account:	Knowing the linkages of topics	T7: Like if am treating a particular topic whereby I feel it has a link with the other so I also make sure that before I teach this topic then it's necessary for me to teach this particular topic for better understanding. When am also drawing my syllabus we consider that were we seat together as department and discuss that this is what we are going to teach this term, so when we are doing that we use to be very conscious to make sure that the topics are in chronological order. **T7**: They most know the electron number of each element because the electron number determines the valence of that particular elements and you have to know the atomic number of each element then from there also the periodic table I will make sure that elements of each group it belongs to you know

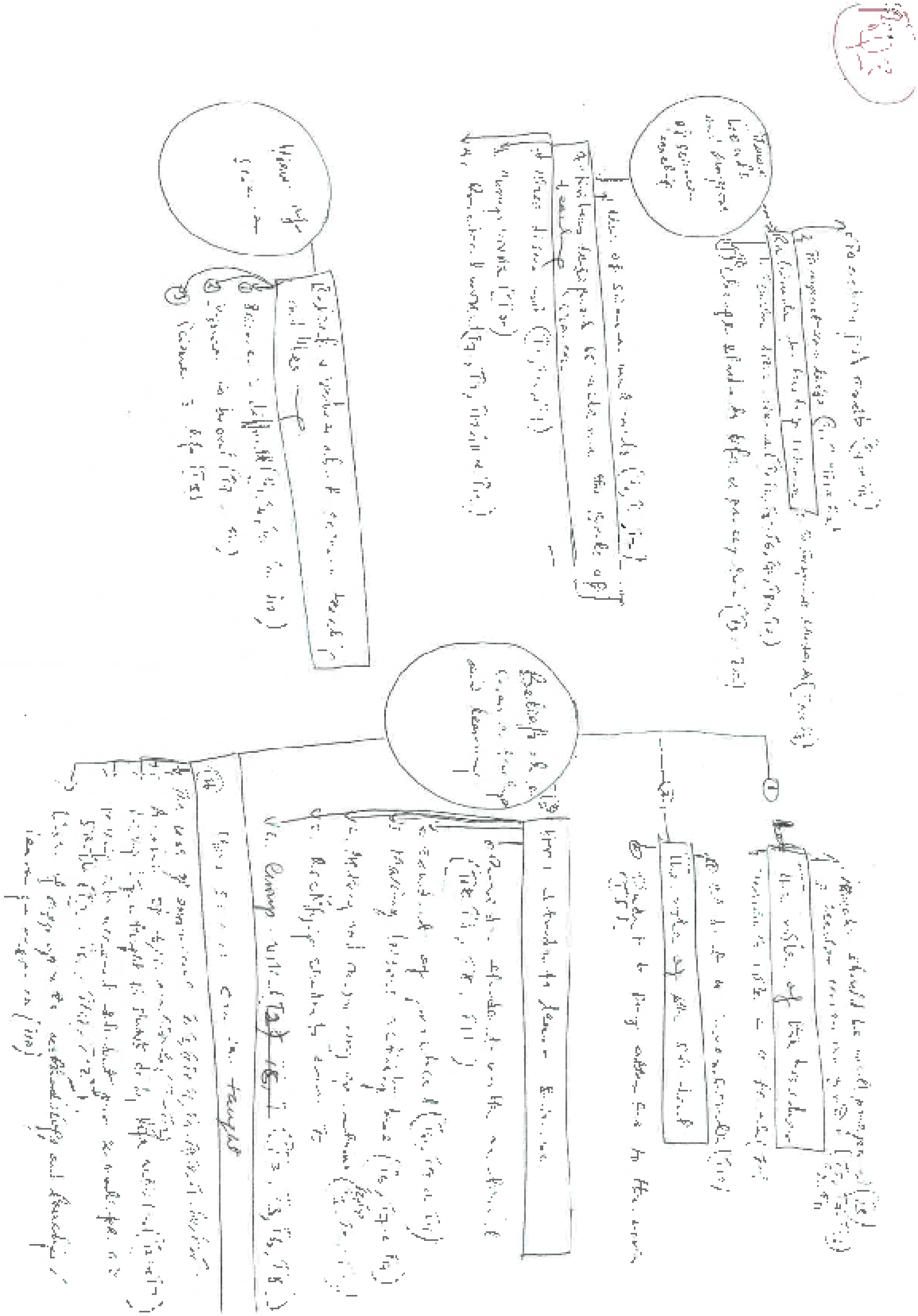
Appendix 12: Mapping of RQ1

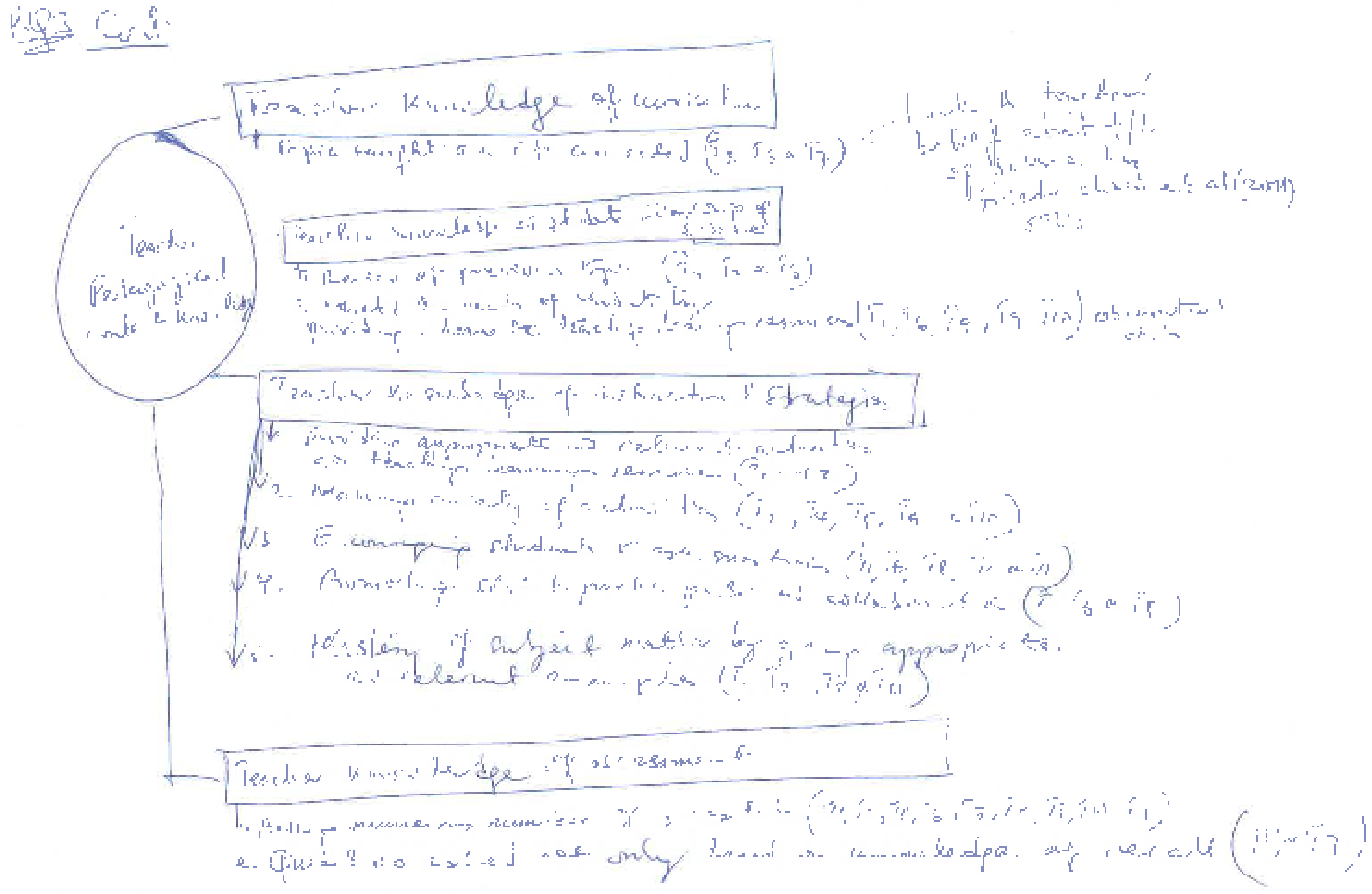


Appendix 13: Mapping of RQ2



Appendix 14: Mapping of RQ3




Teacher Pedagogical content knowledge
Teacher knowledge of curriculum
Teacher knowledge of instruction strategies
Teacher knowledge of assessment

Appendix 15: Research Consent Form

University of Huddersfield

School of Education and Professional Development

Researcher Consent Form (E5)

Title of Research Study: An examination of science teachers' pedagogical perceptions and orientations in relation to student centred learning in science education in Gambian Upper Basic Schools

Name of Researcher: Babou Joof

School:

The study focuses on science teachers' perceptions and orientations in relation to student centred learning. The study adopts Magnusson et al. (1999) model of Pedagogical Content Knowledge (PCK) and Friedrichsen et al. (2011) science teaching orientations (STOs) as its lens for data analysis. The tools to be used for the collection of data are interviews, lesson observation with teachers and focus group interview with students. Participants will therefore constitute of qualified science teachers and students.

☐ I confirm that I give permission for this research to be carried out and that permission from all participants will be gained in line within my school's policy.

Name and position of senior manager:

……………………………………………………………………………………

Signature of senior manager:…………………………………………………

Date: ………………………

Name of Researcher: …………………………………………………………

Signature of Researcher: …………………………………………………………

Date: …………………….

Appendix 16: Participant information Sheet

University of Huddersfield
School of Education and Professional Development

Participant Information Sheet (E3)

Research Project Title: An examination of science teachers' pedagogical perceptions and orientations in relation to student centred learning in science education in Gambian Upper Basic Schools

You are being invited to take part in a research project. Before you decide it is important for you to understand why this research is being done and what it will involve. Please take time to read the following information and discuss it with others if you wish. Ask if there is anything that is not clear or if you would like more information. May I take this opportunity to thank you for taking time to read this.

What is the purpose of the project?
The research project is intended to provide the research focus for a Dissertation on PhD in Education. The study focuses on science teachers' perceptions of Student Centred Learning and how these perceptions are related to their classroom practices.

Why have I been chosen?
You have been selected to take participate in this study because you are a qualified science teacher (HTC) and have at least taught for a minimum of 2 years.

Do I have to take part?
Participation on this study is entirely voluntary, so please do not feel obliged to take part. Refusal will involve no penalty whatsoever and you may withdraw from the study at any stage without giving an explanation to the researcher.

What do I have to do?
You will be invited to take part in **interview and lesson observation if you are a teacher and focus group interview if student**. This should take no more than 2hours of your time.

Are there any disadvantages to taking part?
There should be no foreseeable disadvantages to your participation. If you are unhappy or have further questions at any stage in the process, please address your concerns initially to the researcher if this is appropriate. Alternatively, please contact the research supervisor Dr. Martyn Walker**-** School of Education & Professional Development, University of Huddersfield.

Will all my details be kept confidential?

All information which is collected will be strictly confidential and anonymised before the data is presented in the Dissertation, in compliance with the Data Protection Act and ethical research guidelines and principles BERA (2011).

What will happen to the results of the research study?
The results of this research will help to improve science teachers practice in the classroom. If you would like a copy please contact the researcher.

Who has reviewed and approved the study, and who can be contacted for Further information?
The research supervisor is Dr. Martyn Walker. He can be contacted at following address: School of Education and Professional Development, University of Huddersfield, Queens gate, Huddersfield, HD1 3DH.Telephone number: 01484478225.Email: m.a.walker@hud.ac.uk.

Name & Contact Details of Researcher: Babou Joof, School of Education and Professional Development, University of Huddersfield ,Queens gate ,Huddersfield, HD1 3DH. Tel: 07490555776. Email: baboujoof@hud.ac.uk.

Appendix 17: Participant Consent Form

University of Huddersfield

School of Education and Professional Development

Participant Consent Form (E4)

Title of Research Study: An examination of science teachers' pedagogical perceptions and orientations in relation to student centred learning in science education in Gambian Upper Basic Schools

Name of Researcher: Babou Joof

Participant Identifier Number:

☐ I confirm that I have read and understood the participant Information sheet related to this research, and have had the opportunity to ask questions.

☐ I understand that my participation is voluntary and that I am free to withdraw at any time without giving any reason.

☐ I understand that all my responses will be anonymised.

☐ I give permission for members of the research team to have access to my anonymised responses.

☐ I agree to take part in the above study

Name of Participant: ……………………………………………………………

Signature of Participant: ………………………………………………………

Date: …………………………

Name of Researcher: Babou Joof

Signature of Researcher:

Date: