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FACTORS AFFECTING TEACHING AND LEARNING OF PHYSICS IN GHANAIAN SENIOR HIGH SCHOOLS: A CASE STUDY IN GREATER-ACCRA REGION

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DECLARATION

STUDENT'S DECLARATION

I, Mumuni Musah, declare that this dissertation, except for quotations and references contained in published works that have all been identified and fully acknowledged, is entirely my original work, and it has not been submitted, either in part or whole, for another degree elsewhere.

SIGNATURE…………………………….

DATE…………………………………

SUPERVISOR'S DECLARATION

I hereby declare that the preparation and presentation of this work were supervised following the guidelines for supervision of dissertation as laid down by the University of Education, Winneba.

SUPERVISOR‟S NAME: DR. ISHMAEL K. ANDERSON

SIGNATURE………….............………

DATE…………….............………

DEDICATION

I dedicate this work to almighty Allah for guiding and giving me the strength to complete this work. I also dedicate this work to my wife and children for being there for me.

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ABBREVIATIONS

GES	GHANA EDUCATION SERVICE
GOG	GOVERNMENT OF GHANA
MOE	MINISTRY OF EDUCATION
NGOs	NON-GOVERNMENTAL ORGANIZATIONS
PTA	PARENTS TEACHERS' ASSOCIATIONS

ABSTRACT

The purpose of the study was to examine the factors affecting teaching and learning of Physics in Ghanaian Senior High Schools. Purposive and convenient sampling techniques were used to sample teachers and students respectively. The sample size for the study comprised 50 teachers and 300 students. Descriptive statistics such as percentages, means, and standard deviations were used to analyse the data. The decline in the number of students taking physics could be due to a combination of factors including the perception that physics is a difficult subject with low levels of student achievement; the perceived nature of the subject as being highly mathematical and abstract; and how the subject is taught at the high school level. The findings revealed that demonstration and discussions to illustrate concepts/ phenomena, emphasizing qualitative thinking and presentation of concepts, laying emphasis on mathematical presentation of concepts/students planning and doing their experiment, teacher demonstration of problem-solving on the whiteboard, and teaching and learning being teacher-centered are the main teaching approaches of physics in senior high schools. The main constraining factors of teaching and learning physics in senior high schools were inadequate professional physics teachers, inadequate laboratory equipment, students‟ perception of physics, inadequate number of physics teachers and students finding physics too mathematical and challenging. With regards to the way forward, it was identified from the teachers‟ responses that there should be better salaries and/or incentives for physics teachers, there should be more teacher professional development on physics practicals and training of more graduate teachers must be encouraged and supported. The responses of the students indicated that appropriate authorities should provide adequate laboratory equipment and there should be more training for physics teachers. The study concluded that due to the important nature of the subject it is important for stakeholders of education to come together to find modern ways of teaching the subject and also address critical challenges such as inadequate laboratory equipment, and professional development of teachers among others.

CHAPTER ONE

INTRODUCTION

1.1 Background to the Study

It is a globally recognised fact that the development and application of science and technology are vital for a country"s development efforts. A country"s development rests on science and its application in the world of work and industry and competent workers and citizenry need a sound understanding of science and mathematics (Anamuah-Mensah, 2004). Therefore, Science education is needed in Ghana to produce the necessary human resource and skilled labour force to manage our local industries. There can never be a better understanding of science and technology without the study of physics. This is because Physics is described as an ancient scientific discipline that studies everything from basic philosophical questions to everyday phenomena, from nature"s smallest building blocks to the most distant galaxies, from high-tech satellites to processes in the human body (Angell et al., 2004). The study of physics in schools, colleges, and universities is therefore very crucial since it is the basis of engineering, technology, and other physics-related courses. Hence Students with a physics background are expected to reason both deductively and inductively and approach new situations with a high degree of precision and accuracy. Physics hinges on mathematical concepts and logic, and learners of physics are to develop critical thinking minds.

Physics is further considered an important subject for economic, scientific, and technological development (Phys TEC., 2014). Empirical studies from the field of Physics Education Research (PER) have outlined essential suggestions about the physics curriculum which are generally accepted and believed to widen the knowledge and increase the horizon of understanding of physics by learners(Ogundokun & Adeyemo, 2010; Buabeng, Conner & Winter, 2015). Among the essential suggestions are: (1) the method of teaching physics should be guided discovery instead of the traditional lecture method used in teaching the subject. This was recommended because, learning efficiency and effectiveness take place during the explanation, experimentation, and discussion; (2) there should be an interaction between the physics teacher and the students. In this case, it is believed that if genuine and helpful interaction exists between the teacher and the students, the students will be able to inform teachers what they find difficult in physics thereby reducing the difficulties they encounter (Ogundokun & Adeyemo, 2010). These features are important because it is believed that if they are dully and critically followed and applied in any given situation and at any given time, teachers will be able to make physics easy to comprehend by learners (Buabeng, Conner & Winter, 2015).

According to Marshall, Smart, and Alston (2016), the types of high classroom interactions created by teachers and the types of questions they use to structure the teaching play an important role in the kinds of thinking skills learners employ, the range of information to be covered and the thinking skills they may learn. This suggests that teacher"s abilities to create an enabling atmosphere that allows meaningful classroom interaction with students cannot be underestimated.

In Ghana, a study by Buabeng and Ntow (2010) revealed a wide range of reasons which accounted for students" negative responses to physics. Prominent among these factors were teacher factors, poor performance, perceived difficulty nature of physics, and unknown career opportunities in the subject. Buabeng and Ntow (2010) further posited that most of the students reported that there is reduced interest in the subject at the senior high school (SHS) level because the subject was poorly taught. The question therefore is, how is physics taught to the understanding of students in the senior high school in Ghana.

According to Gibbs (2003), Researchers have suggested that the study of physics is crucial to understanding the world around us, the world inside us, and the world beyond us. According to Cutnell and Johnson (2007), physics is the most basic natural science which involves universal laws and the study of the behaviour and relationships among a wide range of important physical phenomena. They further mentioned that physics encompasses the study of the universe from the largest galaxies to the smallest subatomic particles. Moreover, it is the basis of many other sciences, for example, chemistry, oceanography, seismology, and astronomy which are all accessible within physics (American Physics Society, 2008). They are critical to understanding the physical and chemical properties of matter, particularly natural earth materials, and play a significant role in influencing changes in the world's climate, weather, earthquakes, and related phenomena, particularly the physical properties of the Earth's interior.

1.2 Statement of the Problem

In Ghana it appears the number of students pursuing physics as a course continues to dwindle with time. This situation is found at the senior high level and tertiary levels. It is recently that the free senior high school policy has brought about some increase in the number of students pursuing physics at those levels. However, their attitude toward physics appears to be ambivalent.

This assertion is also seen as global concern about the number of students pursuing physics at both secondary and tertiary levels and the number of graduates wanting to be trained as physics teachers (PhysTEC, 2014). In the USA, the National Task Force on Teacher Education reported that the need for qualified physics teachers is greater now than at any previous time in USA history (PhysTEC, 2014). The decline in the subject has led to the closure of physics departments in some universities (Blickenstaff, 2010). This decline in the numbers of students taking physics could be due to a combination of factors including the perception that physics is a difficult subject with low levels of student achievement; the perceived nature of the subject as being highly mathematical and abstract; and how the subject is taught at the high school level.

In Australia, Pockley (2013, p.10) reports the measures outlined by physicists to reverse the "worrying decline" in the number of students taking physics. It would not be unreasonable to speculate that those factors accounting for this worrying development may include teaching methodology, teacher qualifications, and teacher education programmes, instructional resources, teachers‟ and students‟ attitude towards physics, psychosocial learning environments, teaching and learning support systems among many others. According to Vannier (2012), several reports on students‟ performance and classroom practices in Ghana have identified some areas of concern including little time for science, few hands-on activities, teachers with insufficient knowledge of the subject matter, and confidence in science instruction, and students with less interest for science.

It would be intriguing, therefore, to investigate issues concerning the teaching and learning of physics as a subject. When these issues are rectified and teachers revised the way they present instructions in physics and students are helped to change the negative perception they have for physics. It may then attract the interest of the learner. Therefore this study sought to investigate the teaching and learning of physics in Ghanaian Senior High Schools.

1.3 Purpose of the Study

The purpose of this study was to examine the factors affecting teaching and learning of Physics in Senior High Schools in the Greater Accra region.

1.4 Objectives of the Study

The objectives that guided the study were :

1. to ascertain the views of teachers and students on teaching approaches to physics in Senior High Schools in Greater Accra.
2. identify teachers and students' constraining factors towards teaching and learning physics in Senior High Schools in Greater Accra.
3. identify the teachers' and students' solutions to the challenges of teaching and learning of physics in Senior High Schools in Greater Accra.

1.5 Research Questions

1. What are the views of teachers and students on teaching approaches to physics in Senior High schools in Greater Accra?
2. Are there some factors constraining teachers and students interest in the teaching and learning of physics in Senior High Schools in Greater Accra?
3. What are the solutions of teachers and students to the challenges to the teaching and learning of physics in Senior High Schools in Greater Accra?

1.6 Significance of the Study

This current study will contribute to literature and classroom practice. The teaching of science subjects including physics in Ghanaian schools is of much concern to the stakeholders in the educational setting. Therefore, this study will be among other studies in the area that contribute to knowledge by exploring the approaches, practices, perception of teachers and students, the challenges of teaching and learning physics. The planners of workshops for physics teachers may incorporate the perceptions students have towards physics. It also encourages physics teachers in the Greater Accra region to improve their teaching methods, ways of imparting knowledge of physics to reduce the abstract in learning about the subject. Physics students are likely to change to have better perceptions towards physics thereby deepening their skills in physics learning. In terms of practice, the findings of this study may help school authorities and teachers to better understand the challenges of teaching and learning physics education in Senior High Schools. It will also provide them with the necessary information as to what content, methods, and strategies to adopt in teaching and learning physics.

1.7 Limitation

Students are likely to give answers that may not reflect their actual views about the phenomena due to fear of victimization. They may give cursory responses to the questionnaire items due to the time factor. The students may feel reluctant to observe the covid-19 protocol hence they may be unwilling to participate in the study.

These therefore may dwindle the level of participation of the students and teachers thereby affecting the collection and quality of data.

1.8 Delimitation

This study only focused on approaches to teaching and learning physics, the perception of students and teachers in teaching and learning of physics, and challenges confronting teaching and learning of physics in Ghanaian Senior High Schools. The study centered on some selected senior high schools in the Greater Accra Region of Ghana along with categories A, B and C schools with one school each from this category. There are 44 public senior high schools in the Greater Accra region. The study focused on Final year physics students.

1.9 Organisation of the remainder of the Study

Chapter one has already been covered.

Chapter one was an introduction to the study which has been captured already by presenting the background of the study. Chapter two presents the systematic review of both theoretical and empirical previous works from books, scholarly journals, etc.

Chapter three discusses the research design and approach of the study as well as the research setting, population, sampling technique and sample size, data collection instruments, the procedure for data collection, method of data analysis, and ethical consideration. Chapter four displays the results and analysis of the study. Finally, chapter five presents the summary of the findings, conclusions, and recommendations of the study.

CHAPTER TWO

LITERATURE REVIEW

2.1 Introduction

The study sought to examine the teaching and learning of Physics in Ghanaian Senior High Schools. This chapter reviews theory on constructivism and cognitive development. The empirical review will also be discussed on themes such as the nature of physics classroom practices, teaching and learning physics, interactive teaching approaches in physics, preparing physics teachers for senior high schools, initial teacher education effectiveness, etc. This chapter also provides a conceptual framework depicting the hypothetical relationship between the variables under study.

2.2 Theoretical Framework

The study will be underpinned by two theories namely, constructivism and the cognitive apprenticeship model.

2.2.1 Constructivism

According to Cohen (1998), Constructivism is Constructivism is characterized by the view that knowledge is not transmitted directly from one person to another, but is actively built up by the learner. It was further argued in the study that students come to the classroom with a variety of world-views and preconceptions and such views must be acknowledged. Therefore, the constructivist classroom is one in which people are working together to learn. Cohen(1998) was also of the view that such a classroom will be a place where inquiry is conducted and discourse will be the mode by which participants engage in negotiations of meaning. Cognitive, social, and cultural differences among students will be honoured and alternative world-views respected. Similarly, Conner (2014) suggested that a constructivist classroom is a learner-centered environment that acknowledges and brings to the fore the experience of students. Conner (2014) discovered that in constructivist classrooms, learning is reflective, interactive, inductive, and collaborative, and questions are valued as a source of curiosity and focus for learning (Conner, 2014).

Constructivism as a theory has evolved from not only learning about declarative knowledge (knowing what) but also knowing "how and when" to learn in different ways). In such classrooms, the teacher acts as a facilitator or mediator of learning rather than someone who only takes on the role of imparting knowledge. The theory is in line with the current study because the theory of constructivism talks about an interactive classroom where both teachers and students work together to achieve the desired goal. Similarly, the current study is investigating teaching and learning of physics in senior schools where the focus is to examine the policies and practices that might promote excellence in physics teaching.

2.2.2 Theories of Cognitive Development

Over the last two decades, many learning theories, including the cognitive development theories of Piaget, Vygotsky and Bruner, have been implemented in different instructional models in learning environments. Piaget indicated that social interactions create disequilibrium to encourage growth in knowledge. He emphasized that the individual learners construct their knowledge through the process of adaptation – which can be accomplished in two ways: (1) accommodation, where existing schemes are modified so that new information can fit in, and (2) assimilation, where new information is modified to fit in the existing schemes. (Eggen & Kauchak, 2013; Hoy, 2010). According to Piaget, social interactions 20 can reinforce this mechanism but it is the learners themselves who play the major role in developing their knowledge. Vygotsky, on the other hand, promoted the dominant influence of social interactions. In his well-known sociocultural learning theory. Vygotsky suggested that social interaction leads to continuous step-by-step changes in learners‟ thought and behaviour that can vary greatly from culture to culture (Hoy, 2010). This learning process involves three key elements – culture, language and "zone of proximal development". Vygotsky believed that when learners interact with peers they can actively participate in dialogues, discover how others think about their experiences and then incorporate the ways others interpret the world into their own ways of thinking. By this way, learners are able to develop their knowledge towards more complex and sophisticated structure (Eggen & Kauchak, 2013; Hoy, 2010). Bruner also suggested that instruction follows a sequence of three stages. The basic stage is called enactive stage where learners manipulate objects to learn about the world around them. The next stage is iconic stage where learners represent experiences and objects as concrete images.

The process of cognitive development is highly complex, and various scholars sought to propose their view on how this process occurs. Cognitive development is usually defined as the process when a child acquires and learns various thinking processes (Galotti, 2015). Understanding cognitive development is crucial for educators because it enables them to support children throughout this process. The present paper will discuss two key theories of cognitive development and explore the implications for teaching and learning. The first theory has been developed by Jean Piaget, and the second is attributed to Lev Vygotsky.

Piaget viewed cognitive development as a sequence of stages, including sensorimotor, preoperational, concrete operational, and formal operational. All in all, the theories view cognitive development from contrasting perspectives. However, they can still be used by educators to understand the process of cognitive development better. For example, educators could use them to understand how to best support children in overcoming specific challenges. Alternatively, educators can choose to teach beyond the theories. In order to do that, they could use a variety of proven teaching methods and tailor their approach to each individual student, thus finding what works best for them.

The cognitive apprenticeship model was propounded by Collins, Brown, and Newman (1987). The theory suggests that learners should be exposed to the teaching methods that give students the chance to observe, engage in, invent, or discover expert strategies in context. They developed six teaching methods namely, modeling, coaching, scaffolding, articulation, reflection, and exploration. These methods help students to use cognitive and metacognitive strategies for managing and discovering knowledge(Brown et al.(1987). They explained the teaching methods as follows.

Modeling: With modeling, usually teachers or mentors demonstrate a task explicitly. New students or novices build a conceptual model of the task at hand. For example, a math teacher might write out explicit steps and work through a problem aloud, demonstrating his or her heuristics and procedural knowledge.

Coaching: During coaching, the expert provides the novice with feedback and hints.

Scaffolding: It is the process of supporting students in their learning. Support structures are put in place. In some instances, the expert may have to help with aspects of the task that the student cannot do.

Articulation: McLellan (1996) describes articulation as (1) separating component knowledge and skills to learn them more effectively and (2) more common verbalizing and demonstrating knowledge and thinking processes to expose and clarify them. This process gets students to articulate their knowledge, reasoning or problem-solving process in a domain(McLellan, 1996). According to Collins et al.,(1987), this may include inquiry teaching in which teachers ask students a series of questions that allow them to refine and restate their learned knowledge and to form an explicit conceptual model.

Reflection: Reflection allows students to "compare their problem-solving processes with those of an expert, another student and ultimately, an internal cognitive model of expertise" (McLellan, 1996). A technique for reflection could be to examine the past performance of both experts and novices and to highlight similarities and differences. The goal of reflection is for students to look back and analyze their performance with a desire for understanding and improvement towards the behaviour of an expert.

Exploration: Exploration involves giving students room to solve problems solve on their own and teaching students exploration strategies.

The former requires the teacher to slowly withdraw the use of supports and scaffolds not only in problem-solving methods but problem setting methods as well. The latter requires the teacher to show students how to explore, research and develop a hypothesis. Exploration allows the student to frame interesting problems within the domain for themselves and then take the initiative to solve these problems. The ideas in these cognitive learning theories are in line with constructivism in the sense that learners construct their knowledge and/understanding on their own, rather than knowledge being transmitted by someone else. Though these theories have been used in different instructional models in learning environments, constructivist theory has been found to be more related to instructional methods, and can be used to improve teaching in certain scientific subjects taught in schools to which physics is no exception. It encourages students to use active techniques (e.g. experiments, real-world, problem solving) to create knowledge, reflect on, talk about what they doing and how their understanding is changing (Conner 2014; Keser, Ö. F., Akdeniz, A. R., & Yyu, V.-T. (2010). The constructivist theory of learning also applies to teachers" learning when learning to teach.

The cognitive apprenticeship model also presumes that learners should be exposed to the teaching methods that give students the chance to observe, engage in, invent, or discover expert strategies in context (Collins, Brown & Holum, 1991). Berryman (1991) believes that teaching approaches should be designed to encourage student curiosity and independence. Berryman emphasises that teachers only coach by "giving clues, feedback, and reminders; providing „scaffolding' (support for students as they learn to carry out tasks); and fading" (gradually passing over control of the learning process to the student). Similarly, Chandra and Watters (2012) were of the view that the learning environment should reproduce the technological, social, time, and motivational characteristics of real-world situations with varying levels of difficulty to enable students to work with their peers in finding solutions to problems as experienced in the real world. Studies show that the cognitive apprenticeship model and/or constructivist theory is an accurate description of how learning occurs and the instructional strategies can be designed into formal learning contexts with positive effects (Chandra & Watters, 2012). With these two theories (constructivist and cognitive apprenticeship) teachers acknowledge they cannot mandate what students learn. They design learning activities that are informed by what students already know and believe, and actively encourage students to reflect on and manage their own learning. Bruner also suggested that instruction follows a sequence of three stages. The basic stage is called the enactive stage where learners manipulate objects to learn about the world around them. The next stage is iconic stage where learners represent experiences and objects as concrete images. In the last stage, the symbolic stage, learners are able to think in abstract terms with symbols (Cahyadi, 2007). The principle of progressing towards a higher level of thinking process has a lot of applications. Two prominent ones are the spiral curriculum (were concepts are developed from simple forms involving concrete objects and experiences to a high level of abstraction) and discovery learning (where learners work from examples to find general principles on their own (Cahyadi, 2007).

The ideas in these cognitive learning theories are in line with constructivism in the sense that learners construct their knowledge and/understanding on their own, rather than knowledge being transmitted by someone else. Though these theories have been used in different instructional models in learning environments, constructivist theory has been found to be more related to instructional methods, and can be used to improve teaching in certain scientific subjects taught in 21 schools to which physics is no exception. It encourages students to use active techniques (e.g. experiments, real-world, problem solving) to create knowledge, reflect on, talk about what they doing and how their understanding is changing (Conner 2014b; Keser et al., 2010). The constructivist theory of learning also applies to teachers‟ learning when learning to teach.

2.3 Empirical Review of Previous Studies

In this section, the discussion was done on: Beliefs and Conceptions of Physics Teachers about Physics, nature of Physics Classroom Practices, teaching and Learning of Physics, interactive Teaching approaches in Physics, Preparing Physics Teachers for High/Secondary Schools, Initial Teacher Education Effectiveness, the Role of

Content Knowledge, Designing Professional Development for teachers, What Professional development do Physics teachers Need?

2.3.1 Beliefs and Conceptions of Physics Teachers about Physics

The New Oxford Dictionary of English defines belief as an acceptance that a statement is true or that something exists; something one accepts as true or real; a firmly held opinion or conviction (Pearsall & Hanks, 1998). An inspection of other dictionaries and entries also brings out the meaning of belief as: …. a state or habit of mind in which trust or confidence is placed in some person or thing; conviction of the truth of some statement or the reality of some being or phenomenon especially when based on examination of evidence; the feeling of being certain that something exists or is true and a strong feeling that something is right or good; an idea that you are certain is true; the feeling of certainty that something is true. In short, belief can be understood as the psychological state in which an individual holds a proposition or premise to be true (Cahyadi, 2007). The Oxford dictionary and Merriam-Webster dictionary also define conception as: a complex product of abstract or reflective thinking; the sum of a person‟s ideas and beliefs concerning something; and the originating of something in the mind (Pearsall & Hanks, 1998; Webster, 2006).

Conceptions of teaching are defined in science education research as "the set of ideas, understandings, and interpretations of experience concerning the teacher and teaching, the nature and content of science, and the learners and learning that the teachers used in making decisions about teaching, both in planning and execution" (Hewson & Kerby, 1993). Also Mulhall and Gunstone (2008) also describe conception “beliefs travel in disguise and often under an alias – attitudes, values, opinions, perceptions, conceptions, implicit theories, explicit theories, and perspectives.” have also been used to refer to teachers" conceptions, such as views, beliefs practical personal theory, orientation, and cognitive structures (Buaraphan, 2007). Even though there seem to be subtle differences in the meaning of the labels, Tsai (2002) used these labels interchangeably. In this study, conceptions, beliefs, and views are used interchangeably in the report to describe participant teachers" understanding and experiences about teaching and how these inform their teaching.

Generally, what people know and believe influence their actions and inform the choices they make in their everyday lives. Beliefs also inform how teachers engage in and go about their classroom practices (Loucks-Horsley, Stiles, Mundry, Love & Hewson, 2010). Teachers" conceptions about how science is developed may be potentially related to their beliefs about how to teach science and how students learn science, including physics. Classroom observations showed that all the teachers emphasized science as a body of knowledge, spent more time in developing terminology than on building relationships across concepts, and rarely engaged students in laboratory work. Tsai (2002) investigated science teachers" conceptions about teaching, learning science, and the nature of science. Research data were gathered through interviews with 37 secondary school science (physics and chemistry) teachers. Results from the study showed that most science teachers had „traditional" beliefs about the teaching and learning of science – science is best taught by transferring knowledge from teacher to students (e.g. transferring of knowledge, giving firm answers, providing clear definition, giving accurate explanations, presenting the scientific truths or facts.

Mistades (2009) also investigated beliefs about physics teaching held by three physics teachers (faculty members) of the De La Salle University in the Philippines and sought to determine how many of these beliefs translated into classroom strategies and practices. Findings from the study showed that teacher‟s beliefs influence their actions and practices in the classroom. The physics teachers who participated in the study viewed learning physics as primarily understanding underlying ideas and concepts rather than simply focusing on memorizing equations and formulae. The classroom observation data, obtained using the Reformed Teaching Observation Protocol (RTOP), supported this view as they (teachers) scored highest (83.3%) in the propositional content knowledge. Mistades indicated that the teachers‟ lessons highlighted fundamental concepts by giving specific examples, showing the relationship between concepts, and moving from simple to complex problems.

As part of the research on teachers‟ knowledge and thought patterns (conceptions, beliefs and views) about teaching, some studies often make conclusions about teachers‟ practice but do not support these conclusions with observational data (Tsai, 2002). However, recent studies about teachers‟ conceptions and/or beliefs that included classroom observations found a relationship between their conceptions about teaching and learning science, their epistemological beliefs, and their teaching practice (Ladachart, 2011; Mulhall & Gunstone, 2012; Tsai, 2007). Mulhall and Gunstone (2012), for example, found that the approaches used by physics teachers to teach physics were generally linked to their views about learning physics. Mulhall and Gunstone used qualitative methodology to explore views about physics held by a group of physics teachers whose teaching practice was traditional and compared them with the views held by physics teachers who used conceptual change approaches. Semi-structured interviews and observations were employed for this purpose. The authors discovered that the idea that specific physics teaching methodologies may be linked to specific physics views appeared to apply to the traditional group but not to the conceptual group(Mulhall & Gunstone, 2008). Findings from the study suggest that the two groups of teachers had distinct views about learning physics:

The traditional teachers thought of physics learning as the outcome of doing certain activities and in terms of acquisition of information about physics ideas. For the traditional teachers, physics was seen as hard because it is mathematical and abstract, and many learners do not have the special attributes necessary to learn it.

The conceptual teachers thought that learning involves cognitive activity by the learner and that individuals construct their understanding in terms of their frameworks. For the conceptual teachers, the ideas of physics were considered to be counter-intuitive and troublesome in terms of learning. They saw discussion as being important for learners as it helps tease out and develop understandings of physics ideas (Mulhall & Gunstone, 2012). In discussing the implications of the data collected, the authors indicated that traditional approaches to teaching physics, which often fail to promote adequate student understanding of physics ideas, persist. The challenge then, reported by the authors, is to find ways of promoting teacher change, of helping physics teachers understand and implement ways of teaching that lead to better student learning.

Research on teachers‟ conceptions about teaching is framed within the constructivist perspective on teachers learning (Hashweh, 1996; Hewson & Kerby, 1993; Koballa, Glynn, & Upson, 2005; Ladachart, 2011). According to this perspective, it is believed that teachers process information and build cognitive structures about teaching based upon their prior experience which they have gained since their days as a student

(Hashweh, 1996; Hewson & Kerby, 1993) and such cognitive structures can act as a point of reference for their current teaching practice (Koballa et al., 2005). Hewson and Kerby (1993) noted that teachers are likely to choose instructional approaches which are align with their conceptions about teaching so that they can achieve their teaching goals. Thus, 26 teachers‟ conceptions about teaching have a direct relationship with their teaching practice. Koballa et al. (2005) therefore contended that understanding of teachers‟ conceptions about teaching can be used as point of reference to understand their teaching practice. Even though such conceptions about teaching are often resistant to change (Buaraphan, 2007), Koballa et al. (2005) and Ladachart (2011) observed that, teachers are most often, likely to compromise their ideal and aspirational conceptions about teaching due to contextual constraints causing them to "keep working or backup ideas on teaching"(Ladachart, 2011, p. 177). Given that teachers have their conceptions about teaching and these beliefs are likely to influence their instructional decision-making, this study, in part, explored the conceptions held by some physics teachers and examined them in the context of constructivist epistemology.

2.3.3 Teaching and learning of physics

Research into students‟ understanding and learning of physics is prominent in the literature. Interest and motivation have been reported as essential factors for student learning and academic achievement (Nolen, 2003). Science classrooms that focused on understanding and qualitative thinking were found to positively predict students‟ satisfaction with learning (Nolen, 2003). In physics education, in particular, the motivation, active knowledge, and participation of the students are of paramount importance. Passive, unmotivated students and minimal creativity in learning have a limited future in contemporary education (Ulen & Gerlic, 2012). At the heart of physics education research is a shift in physics instruction from "What are we teaching and how can we deliver it?" to "What are the students learning and how do we make sense of what they do?" (Redish & Steinberg, 1999, p. 2). Over the years, physics education researchers have used a variety of tools in trying to find out what students" real difficulties are and how to improve their achievement in the subject.

The connection between physics and mathematics, for instance, has been found as a major weakness to physics understanding (Angell et al., 2004). To make this shift achievable, Redish and Steinberg (1999) stress that teachers of physics need to listen to the students and find ways to learn what they (students) are thinking. By doing this, teachers then begin to make sense of how students learn physics in a way that helps them improve their courses to be more meaningful to students. In their paper, "Teaching Physics: Figuring out What Works", Redish and Steinberg (1999) described one of such tools, to find out students" real difficulties, as "determining the state space" (p. 2). This approach, according to the authors, involves an interview with several students, letting them describe what they think about a particular situation or having them work through a problem. Thus, the students are encouraged to "think aloud" and to explain their reasoning. Ideally, the goal is not to help the students come up with the correct answer but rather to understand their thinking. The writers argue that interviews often reveal new insights into the way students think about physics that are surprising even to the most skilled and experienced instructors.

In addition, McDermott and Shaffer (2000) extol that the focus of physics teaching must be on the students as learners. She underscores that close contact with students provides the opportunity to observe the intellectual struggles of students as they try to understand important concepts and principles. "Day-to-day interaction in the classroom has enabled us to explore in detail the nature of specific difficulties, to experiment with different instructional strategies, and to monitor their effect on student learning" (McDermott & Shaffer, 2000, p. 1128), reported by McDermott and Shaffer and their research team (Physics Education Group).

Research findings have indicated that the conceptual learning of physics often uses models, animations, and simulations for problem-solving approaches. For example, in teaching electric circuits, one model that has been proven effective is *Physics by Inquiry* (PBI), developed by McDermott and her physics education group (see e.g. Afra, Osta, & Zoubeir, 2009). The PbI is a module with carefully structured experiments, exercises, and questions that are intended to engage students actively in the construction of important concepts and their application to the physical world. As the students work through the module, they are guided in constructing a qualitative model for a simple circuit. In the process, specific difficulties identified through research are addressed (McDermott & Shaffer, 2000).

Their experience was eloquently described: Students work with partners and in larger groups. Guided by the questions and exercises, they conduct open-ended explorations, perform simple experiments, discuss their findings, compare their interpretations, and collaborate in constructing qualitative models that can help them account for observations and make predictions. Great stress is placed on explanations of reasoning, both orally and in writing. The instructor does not lecture but poses questions that motivate students to think critically about the material. The appropriate response to most questions by students is not a direct answer but a question to help them arrive at their answers. (McDermott & Shaffer, 2000).

The Project for Enhancing Effective Learning (PEEL) in Melbourne, Australia is another example of a movement in education that directly responded to teachers‟ concerns about students learning, especially in the sciences. Though it was developed as part of a consequence of traditional teaching, PEEL teachers view teaching as problematic and have become experts in developing procedures that are the direct opposite of transmissive teaching (Loughran et al., 2012). The Project for Enhancing Effective Learning (PEEL) in Melbourne, Australia is another example of a movement in education that directly responded to teachers‟ concerns about students learning, especially in the sciences. Though it was developed as part of a consequence of traditional teaching, PEEL teachers view teaching as problematic and have become experts in developing procedures that are the direct opposite of transmissive teaching (Loughran et al., 2012). One experienced PEEL teacher, Rosemary Dusting of Wesley College – Glen Waverley in 32 Melbourne, Australia, offers an extensive report of her efforts to move from teaching as telling to teaching for understanding. She indicated: … my teaching had shifted from me doing all the work for the students to the students now working out part of the content for themselves.

They had been provided with meaningful opportunities to think and I had not taught by telling… My understanding of what it meant to teach students to be active learners was being developed and I valued what was happening. (Dusting, 2002, pp. 177-180) PEEL is a project which focuses on the teaching and learning practices in secondary school classrooms (Erickson, Brandes, Mitchell, & Mitchell, 2005). This project supports the "creation of classroom learning environments, which are more productive and enjoyable places for students and teachers alike in comparison to more conventional classrooms" (Erickson et al., 2005, p. 793). As stated by Lumb and

Mitchell (2009), PEEL operates as a network of autonomous and voluntary groups of teachers who take on the role of interdependent innovators. The teachers agree to meet regularly to reflect on their practice and to provide mutual support and stimulation for the processes of teacher and student change. Thus, coherence is provided by the shared concerns about passive, dependent learning by the dissemination of information about the project and by structures that allow teachers to learn from and share new wisdom with teachers in other schools as well as a few academic friends. PEEL"s achievements include the development of a repertoire of teaching procedures designed to promote effective learning; findings of the nature of student change, and teacher change; and findings of the nature of collaborative professional development in schools and between the school and tertiary sectors (Lumb & Mitchell, 2009). Having been founded in one secondary school in 1985, PEEL has since then spread to schools throughout Australia and many other countries including the U.K., Canada, Sweden and Iceland (Erickson et al., 2005). PEEL"s large collection of ideas, strategies, procedures, support and resources, developed over a 33 long period, for science teachers have helped to improve upon their classroom practices, such as group work and assessment (Lumb & Mitchell, 2009).

2.3.2 Nature of Physics Classroom Practices

For students to have an expert understanding of scientific concepts, Vosniadou (2007) argues that students must undergo profound conceptual change. She recommends that instruction must address both the need for individuals to construct their understanding and the socio-cultural factors that are present in school settings (Vosniadou , 2007). Even though many empirical studies have demonstrated that carefully planned, interactive instruction can be effective in promoting conceptual change and enhance performance (Cahyadi, 2007; Vosniadou, 2007), findings from a study show that many physics teachers continue to teach using the same old, ineffective, traditional, teacher-centered instructional approach (Angell, Guttersrud, Henriksen, & Isnes, 2004; Gallagher, 1991; Rennie, Goodrum, & Hackling, 2001; Vosniadou, 2007). For instance, in the late 1980"s in Perth Australia, Tobin and Gallagher (1987) found that the most common instructional mode in high school science classes was whole-class interactive – when the teacher dealt with the class as a whole and interacted with one student at a time while 27 the others listened; and whole class non-interactive – comprised lecture presentations followed by individual seatwork and small group activities. More than a decade later, Rennie et al. (2001) found that the teacher-centered instructional approach was still prevalent in many of the secondary schools in Australia.

For many secondary students, the teaching-learning process is teacher-directed and lessons are of two main types: practical activities where students follow the directions of the teacher to complete an experiment, and the chalk and talk lesson in which learning is centered on teacher explanation, copying notes and working from an expository text (Rennie et al., 2001). The extent of teacher-centeredness was revealed by 61% of secondary students who indicated that they copy notes from the teacher nearly every lesson and 59% also indicated that the teacher never allows students to choose their topics to investigate. A similar situation was described in high schools in Norway. Angell et al. (2004) administered questionnaires to 2192 students taking physics and 342 physics teachers in high schools in Norway and followed up with focus group interviews. They found that about physics, proportionally a greater part of classroom time (about 60%), was spent with the teacher presenting new material on the blackboard/whiteboard. Physics classrooms were found to be dominated by "chalk and talk instruction" (p. 701). Though students in the study perceived physics as interesting and describing the world and everyday phenomena, they also perceived the subject as difficult/demanding, formalistic, and more mathematical as it uses the language of mathematics to express physical processes and phenomena. The majority of the students wanted a stronger emphasis on context and connectedness as well as qualitative/conceptual approaches that are student-centered. Based on the findings, the authors suggested that: "…secondary physics education preparing students for tomorrow"s society should be characterized by variety, both within and among courses, integration of mathematics in the physics courses, more pupil-centered instruction, and a stronger emphasis on knowledge in context. (p. 703).

It has also been shown that teacher interactions affect learners' attitudes towards learning and their participation in-class activities (Masika, 2011). Masika indicated that teacher interaction behaviours were an important aspect of the learning environment and are strongly related to high school student outcomes. It was further identified that, in Kenya, physics teachers were autocratic and dominated their classrooms by talking only and sometimes talking with illustrations. The study recommended that an initiative involving teachers of physics in action research in the area of classroom interaction would go a long way in helping the teachers improve their teaching behaviour. Recently, using a mixed-method approach, physics instruction in Alabama State was reported generally as teacher-oriented with lectures forming a significant part of the lesson (Sunal, 2015).

The authors indicated that the classroom observation data did not support teachers" references, during interviews, to their common use of hands-on instruction. One can infer from the above studies that teacher-centered instruction continues to be a widely used instructional strategy in secondary school physics classrooms. Moreover, students have expressed a desire for more interactive environments. In a teacher-centred approach, there is little opportunity, if any, for students to articulate their thinking, hear what others are thinking and examine those ideas (Crowe, 2007). At best, questions posed by instructors to individual students may be the limit of interaction in most physics classrooms. Remaining members of the class are not required to subject their ideas to the type of scrutiny that might reveal any incoherence in their minds. The practical challenge consists of finding instructional methods that would help students to understand, accept and use current scientific views.

Teaching and Learning of Physics – Conceptual Change and Problem Solving Dealing with Conceptual Change and Problem Solving Research into students" understanding and learning of physics is prominent in the literature. Interest and motivation have been reported as essential factors for student learning and academic achievement (Hidi & Harackiewicz, 2000; Nolen, 2003). Science classrooms that focused on understanding and qualitative thinking were found to positively predict students" satisfaction with learning (Nolen, 2003). In physics education in particular, the motivation, active knowledge and participation of the students is of paramount importance. Passive, unmotivated students and minimal creativity in learning have a limited future in contemporary education (Ülen & Gerlič, 2012). At the heart of physics education research is a shift in physics instruction from "What are we teaching and how can we deliver it?" to "What are the students learning and how do we make sense of what they do?" (Redish & Steinberg, 1999, p. 2). Over the years, physics education 30 researchers have used a variety of tools in trying to find out what students‟ real difficulties are and how to improve their achievement in the subject. The connection between physics and mathematics for instance, has been found as a major weakness to physics understanding (Angell et al., 2004; De Lozano & Cardenas, 2002; Gill, 1999; Orton & Roper, 2000).

In order to make this shift achievable, Redish and Steinberg stress that teachers of physics need to listen to the students and find ways to learn what they (students) are thinking. By doing this, teachers then begin to make sense of how students learn physics in a way that helps them improve their courses to be more meaningful to students. In their paper, "Teaching Physics: Figuring out What Works", Redish and Steinberg (1999) described one of such tools, to find out students‟ real difficulties, as "determining the state space" (p. 2). This approach, according to the authors, involves an interview with a number of students, letting them describe what they think about a particular situation or having them work through a problem. Thus, the students are encouraged to "think aloud" and to explain their reasoning. Ideally, the goal is not to help the students come up with the correct answer but rather to understand their thinking. The writers argument is that interviews often reveal new insights into the way students think about physics that are surprising even to the most skilled and experienced instructors.

Adding to this, McDermott (2001) extols that the focus of physics teaching must be on the students as learners. She underscores that close contact with students provides the opportunity to observe the intellectual struggles of students as they try to understand important concepts and principles. "Day-to-day interaction in the classroom has enabled us to explore in detail the nature of specific difficulties, to experiment with different instructional strategies, and to monitor their effect on student learning" (McDermott, 2001, p. 1128), reported by McDermott and her research team (Physics Education Group). 31 Research findings have indicated that the conceptual learning of physics often uses models, animations and simulations for problem solving approaches. For example, in teaching electric circuits, one model that has been proven effective is Physics by Inquiry (PbI), developed by McDermoth and her physics education group (see e.g. Afra, Osta, & Zoubeir, 2009; Akerson, Hanson, & Cullen, 2007; Breslyn & McGinnis, 2012; Campbell, Danhui, & Neilson, 2011).

The PbI is a module with carefully structured experiments, exercises, and questions that are intended to engage students actively in the construction of important concepts and in their application to the physical world. As the students work through the module, they are guided in constructing a qualitative model for a simple circuit. In the process, specific difficulties identified through research are addressed (McDermott, 2001). She eloquently describes their experience: Students work with partners and in larger groups. Guided by the questions and exercises, they conduct open-ended explorations, perform simple experiments, discuss their findings, compare their interpretations, and collaborate in constructing qualitative models that can help them account for observations and make predictions. Great stress is placed on explanations of reasoning, both orally and in writing. The instructor does not lecture but poses questions that motivate students to think critically about the material. The appropriate response to most questions by students is not a direct answer but a question to help them arrive at their own answers. (McDermott, 2001, p. 1129) the Project for Enhancing Effective Learning (PEEL) in Melbourne, Australia is another example of a movement in education that directly responded to teachers‟ concerns about students learning, especially in the sciences. Though, it was developed as partly a consequence of traditional teaching, PEEL teachers view teaching as problematic and have become experts in developing procedures that are the direct opposite of transmissive teaching (Loughran et al., 2012). One experienced PEEL teacher, Rosemary Dusting of Wesley College – Glen Waverley in 32 Melbourne, Australia, offered an extensive report of her efforts to move from teaching as telling to teaching for understanding. She indicated: … my teaching had shifted from me doing all the work for the students to the students now working out part of the content for themselves.

They had been provided with meaningful opportunities to think and I had not taught by telling… My understanding of what it meant to teach students to be active learners was being developed and I valued what was happening. (Dusting, 2002, pp. 177-180) PEEL is a project which focuses on the teaching and learning practices in secondary school classrooms (Erickson, Brandes, Mitchell, & Mitchell, 2005). This project supports the "creation of classroom learning environments, which are more productive and enjoyable places for students and teachers alike in comparison to more conventional classrooms" (Erickson et al., 2005, p. 793). As stated by Lumb and Mitchell (2009), PEEL operates as a network of autonomous and voluntary groups of teachers who take on a role of interdependent innovators. The teachers agree to meet regularly to reflect on their practice, and to provide mutual support and stimulation for the processes of teacher and student change. Thus, coherence is provided by the shared concerns about passive, dependent learning and by the dissemination of information about the project and by structures that allow teachers to learn from and share new wisdom with teachers in other schools as well as a few academic friends. PEEL"s achievements include the development of a repertoire of teaching procedures designed to promote effective learning; findings about the nature of student change, and teacher change; and findings about the nature of collaborative professional development in schools and between the school and tertiary sectors (Lumb & Mitchell, 2009). Having been founded in one secondary school in 1985, PEEL has since then spread to schools throughout Australia and to many other countries including the U.K., Canada, Sweden and Iceland (Erickson et al., 2005). PEEL"s large collection of ideas, strategies, procedures, support and resources, developed over a 33 long period of time, for science teachers have helped to improve upon their classroom practices, such as group work and assessment (Lumb & Mitchell, 2009). These collections are available online and both physics teachers and teacher educators can access them to inform better physics teaching practices and learning.

2.3.4 Interactive Teaching Approaches in Physics

In last three decades various interactive methods have become very popular. Their use brings about much better results than the use of traditional methods. One of these methods is modern approach which was developed at the Institute of Physics at the University of Dortmund. The essentials of this approach are that a better education of physics teachers must put more emphasis on: the teaching of educational philosophy as well as individual preconceptions in the minds of pupils, avoiding and overcoming misconceptions, the deliberate use of mental processes such as assimilation and accommodation, the cognitive conflict as a trigger for changes of thought structures, more simple and qualitative experiments done by learners, exercises to improve comprehension, the making explicit of the connection between formalism and the real world, and the recognition of the role of the affective domain in the physics teaching-learning process. These elements concern several components of the teaching-learning process: didactic principles and educational findings, pedagogical strategies and understanding of subject matter, department and interdisciplinary orientation, teacher"s self-concept and student"s motivation, intellectual growth and emotional development. All these components are interconnected and their integration leads to a better education for future physics teachers (Nachtigall, 1990).

Some of other these methods are PI (Peer Instruction), ILD (Interactive Lecture Demonstration), JiTT method (Just-in-time-teaching), etc. (Mazur, 1997, Crouch and Mazur, 2001). These methods emerge mainly from the interaction between the lecturer and students, whereas students are actively involved into individual stages of the teaching and learning process and actively participate in solving of the dealt problems what gives an immediate feedback to the lecturer and he/she can immediately respond to incorrectly understood concepts, or misconceptions (Sokoloff and Thornton, 1997, McDermott, 2001). The meaning of the word “to know” has changed from “be able to remember” to “be able to find information and use it” (Simon, 2006, Stebila, 2010). Research into the area of Physics methodology among other things has shown that an increased focus on experimenting during the teaching and learning process and the use of qualitative (problem) tasks encourages students to solve problems and look for new procedures in discovering information (Hockicko, 2010, Holbrook, 2009, Žáčok, 2010). The use of creative experiments in the teaching process increases the level of understanding and attention of students and at the same time the theory of physics is becoming interconnected with everyday life (Bussei, 2003, Dykstra, 1992, Zelenický, 1999). The use of qualitative tasks from Physics supports the fixation of knowledge and at the same time these tasks enable to test the knowledge and practical skills. Such tasks influence also increased interests of students in the subject and support active understanding and application of Interactive Methods of Teaching Physics at Technical Universities 53 curriculum within the teaching process. While solving a qualitative task students must dive into the issue or phenomenon. In the process they often realise that they do not understand the phenomenon as well as they thought they did (misconceptions). A great advantage of qualitative tasks is the practical application of theoretical knowledge. While solving qualitative tasks students learn to analyse the phenomena, develop logical thinking, sense and creativity (Němec, 2008, Hockicko, 2011).

The innovation of teaching Physics started to be dealt with at the Department of Physics, Electrical Engineering and Applied Mechanics, Faculty of Wood Sciences and Technology, Technical University in Zvolen in 2006. The reasons for trying to implement modern interactive methods into the teaching process in the conditions of higher education in the Slovak Republic were various. The first reason was the below mentioned insufficiencies of the current education programme and also the possibilities of:

- Using the world-wide experience of the creators of the given methods, which are based on the newest theories from pedagogy and psychology as well as the experience of physics teachers, who have been using these methods successfully for years and their results are published in scientific magazines. Another reason was to try to acquire the ways of introducing these methods into practice.
- Trying these methods at universities with a technical focus in Slovakia and this way gain the experience for creation of modern interactive method for teaching Physics at universities with technical focus in Slovakia.

- Comparing and evaluating the effectiveness of teaching Physics via modern interactive methods, which are not traditionally used at universities with technical focus in Slovakia. Further reasons, which influenced our decision to do a research into the implementation of interactive methods in the teaching process of Physics in the conditions of Slovak higher education:
- The Slovak Republic has experienced a reform of higher education recently; one of the results was a transition to a system of higher education consisting of three cycles. Implemented changes caused several system changes to be made within individual study programmes, whereas it affected mainly physic subjects within the bachelor cycle of study. These subjects represent a form of basic tool for the understanding of most technical subjects, which later build on the knowledge obtained in physic subjects (Krišťák and Němec, 2011).
- Slovakia has experiences also a reform of regional education recently. It was aimed at a transition to a creative and humanistic education focused on the pupil (Koubek and Lapitková, 2011).

The use of interactive teaching methods in the teaching and learning of physics is a significant change in teaching methodology. One notable feature of these approaches is providing an environment where students are motivated to construct knowledge by themselves, rather than the knowledge being transmitted to them by their instructor as in the traditional approach (Hake, 1998). These methods have various labels such as interactive engagement, active learning and guided inquiry, and the constructivist theory of learning informs the philosophy behind the methods (Hake, 1998). According to Hake (1998), the term interactive teaching approach refers to those "methods designed at least in part to promote conceptually understanding through the interactive engagement of students in heads-on (always) and hands-on (usually) activities that yield immediate feedback through discussion with peers and/or instructors".

This section discusses four of these interactive approaches: peer instruction (Mazur, 1997); interactive lecture demonstration (Sokoloff et al., 2007; Sokoloff & Thornton, 1997), photonics explorer (Prasad et al., 2012), and visual interactive computer software programs (applets, PhET and augmented reality) (Dünser, Walker, Horner, & Bentall, 2012; Ülen & Gerlič, 2012; Wieman et al., 2008). Physics teaching should include more student interactive approaches than the way it is now, and when physics is taught in this way, the subject would be made more accessible to all students (Wieman et al., 2008), especially those at secondary schools, thereby improving upon the number of students involved and possibly teachers as well. 34 Peer instruction. Peer Instruction (PI) is a widely used pedagogy in which lectures are interspersed with short conceptual questions, usually, multiple-choice questions, called ConcepTests (Fagen, Crouch, & Mazur, 2002; Lasry, Mazur, & Watkins, 2008; Mazur, 1997).

The PI engages students during class through activities that require each student to apply the core concepts being presented, and then to explain those concepts to their fellow students. Unlike the common practice of asking informal questions during a lecture, which typically engages only a few highly motivated students, the more structured questioning process of PI involves every student in the class. It modifies the traditional lecture format to include questions designed to engage students and uncover difficulties with the material (Crouch & Mazur, 2001; Mazur, 1997). Results from ten years of teaching with PI, through true experimental-based research – where subjects are assigned randomly to intervention and control groups, (Crouch & Mazur,

2001) indicate an increased mastery of both conceptual reasoning and quantitative problem-solving. Fagen et al. (2002) focused on assessing the effectiveness of PI via a web survey. The researchers polled PI users (teachers) to learn about their implementation of and experience with PI. The survey collected data about how instructors learned about PI, courses in which PI was used, implementation details, course assessment, effectiveness, and instructor evaluation. Out of the 700 instructors that completed the survey, 384 were identified as using the PI. The PI survey results indicated that most of the assessed PI courses produced learning gains matched with interactive engagement pedagogies, and "more than 300 instructors (greater than 80%) consider their implementation of PI to be successful" (p. 208). Also, the majority (over 90%) of those using the method plan to continue or expand their use of PI. Lasry et al. (2008) measured students" conceptual understanding of Newtonian mechanics using the Force Concept Inventory (FCI) in both PI and traditional courses at John Abbott College (a two-year college) and Harvard University.

The results showed that PI-taught students demonstrated better conceptual learning and similar problem-solving abilities than traditionally 35 taught students. They also found that, by engaging students on the course, PI reduces the number of students who drop the course. The researchers concluded that PI is an effective instructional approach not only at a top-tier university but also at a two-year college. In both settings, PI increases conceptual learning and traditional problem-solving skills. Interactive lecture demonstration. The Interactive Lecture Demonstration (ILD) is designed to engage students in the learning process by converting the usually passive-student lecture and recipe lab environment to a more active one (Sokoloff et al., 2007; Sokoloff & Thornton, 1997). With the ILD, the instructor initially describes a demonstration to the class. Students record their predictions on a prediction sheet and engage in small-group discussions. Afterward, they record their final predictions and hand in the prediction sheets to the instructor. The instructor elicits common students‟ predictions from the whole class. The instructor then carries out the demonstration, with measurement tools suitably displayed. A few students may be asked to describe and discuss the results in the context of the demonstration. The instructor may proceed with presenting analogous physical situation(s) with different "surface" features based on the same concepts (Sokoloff & Thornton, 1997, p. 340). Through a pre-test and post-test experimental study, supplemented with questionnaires, Cahyadi (2007) conducted two case studies to investigate the effectiveness of the PI, and ILD approaches on students understanding of Newtonian concepts. The first case study took place at the University of Surobaya, Indonesia and the second study was conducted at the University of Canterbury, New Zealand. In the areas that she assessed (conceptual change and problem solving), the results showed that the experimental classes achieved significantly greater improvement in conceptual change compared to the control classes.

Students in the experimental classes also performed significantly better in problem-solving than those in the control classes. Results from the second case study also produced a marked improvement in students‟ comprehension of learning materials as all the students welcomed the application of "new 36 elements of the instruction" (Cahyadi, 2007, p. 82). Even though the sample sizes for Cahyadi‟s studies were large (341 for the first study and 198 for the second study) for an experimental study, the results were obtained with non-randomization of the subjects to the treatment conditions, indicating that the gains might have resulted from pre-existing differences between the groups. Galvan (2006) emphasized that in the school settings students are not normally assigned to the classes hence there may be “important pre-existing differences between the two groups, which may confound the interpretation of the results of such an experiment” (p. 45).

Photonics explorer. To solve the declining interest of students in science subjects, particularly physics, in Europe the European Union has initiated various projects to foster science education at the European high school level. One of these projects is the Photonics Explorer Kit (PEK) which focuses on the development of an educational kit for light, optics and photonics (Cords, Fischer, Euler, & Prasad, 2012; Fischer, 2011; Prasad et al., 2012). The PEK is specifically designed to cover the topics that are in the curriculum to help the teacher and students to achieve educational targets – yet with the use of hands-on experiments in an inquiry-based learning context (Cords et al., 2012). The photonics explorer project offers well-prepared resources that can be integrated into the existing European curricula and which can also be easily integrated into other curricula. It does not take away teaching time but rather helps the teacher to make the best use of the time already designated for light and optics in their curriculum to ensure that educational targets are easily achieved (Cords et al., 2012).

The experimental equipment in the kit has been specifically designed to support inquiry-based teaching and learning. The kit equips teachers with class sets of experimental materials related to optics and photonics within a supporting didactic framework consisting of worksheets, factsheets, teacher guides and multimedia material (videos, photos etc.) (Prasad et al., 2012). The kit consists of eight modules, four for lower secondary (12-14 yrs) and four for upper secondary (16-18 yrs). Each kit includes a class-set of experimental materials such 37 that a class of about 25 to 30 students can work together in small groups of three and four. It contains not only the components, worksheets and factsheets for conducting hands-on experiments but also a guide for the teacher with a suggested outline for the use of each module, and these save the teacher valuable lesson preparation time (Prasad et al., 2012). From a pilot study in six school classes in Germany and five school classes in Belgium, the authors report that the approach has been very well received by both teachers and students.

Many students are reported to have said that they appreciate the "additional freedom due to the „simplicity" of the components to develop their experimental setups far away from the regular step-by-step programme" (Cords et al., 2012, p. 72). The photonics explorer program aims at equipping science teachers in European secondary schools free-of-charge with up-to-date educational resources to engage, excite and educate students about the fascination of working with light (Fischer, 2011). A teacher receives the kit free of charge once he/she attends a teacher training course on how to implement it in their classrooms. This is mainly to introduce teachers to the concepts of guided inquiry-based learning and the importance of students doing the hands-on experiments themselves (Prasad et al., 2012).

Visual interactive computer software programs. The advances in computer hardware and software programs have provided new platforms for physics teaching and learning. One such program is applets, which have been running on the World Wide Web for the past decade. When an applet is oriented on a small, specific domain of physics, we talk about physlets (Ülen & Gerlič, 2012). Physlets are interactive materials, where processes happen at certain intervals and there is an interaction between the model and the student. Students have the opportunity of changing the conditions and immediately observe the impact.

In addition, when dealing with new physical phenomena, students can change relevant parameters and immediately see the consequences of their actions. This can help students to understand the main concepts of the phenomenon. Ülen and Gerlič stress that due to the phases of physlets (illustration, exploration and problems), "they 38 can be used as an element of almost any curriculum with almost any teaching approach, so they could also play an important role in the conceptual learning of physics" (p141). A similar model, which has been developed, tried and tested, to help develop students‟ conceptual understanding of complex ideas with problem-solving is Physics Education Technology (PhET) (Wieman et al., 2008). PhET is a collection of web-based interactive simulations for teaching and learning physics and other sciences as well.

It was developed with three primary goals: "increased student engagement, improved learning", thereby improving performance and "improved beliefs about and approach toward learning" (p. 394). These goals have been the critical areas for physics education research over the years (McDermott, 2001; Redish & Steinberg, 1999). The majority of the PhET simulations are physics-related and cover a range of topics from introductory material in mechanics and electricity and magnetism to advanced topics such as quantum mechanics, lasers, and magnetic resonance imaging (Wieman et al., 2008). The key features of PhET simulations, that is, visualization, interactivity, context, and effective use of computations are particularly effective for helping students understand the abstract concepts in physics (McKagan et al., 2008).

Another form of technology development for increasing student interaction has been augmented reality (AR). The AR technology has emerged as one of the interactive engagement approaches which provide visual and interactive experiences that allow in-depth understanding of abstract phenomena (Dünser et al., 2012). It provides physics educators with an exciting interactive environment to engage learners and enhance their understanding of key concepts. What is different with regards to AR is that it provides the platform for both teachers and students to think about how to use technology to represent complex concepts. Thus, the learning materials (AR books) are developed by teachers and students themselves which in turn enhances greater understanding of the content (Dünser et al., 2012). 39 Using the software application BuildAR (HIT Lab NZ) as an educational tool for constructing AR scenes (Buabeng, Conner, Walker & Winter, 2013) interacted with a small group of pre-service secondary school physics teachers with constructed AR sequences. The aspiring physics teachers visualising the magnetic field about an inductor were able to fully immerse themselves in the three-dimensional projection of the field, thereby actively interacting with the physical phenomena in virtual space.

The aspiring physics teachers were convinced that using AR as a teaching tool would facilitate an improved conceptual understanding of the underlying physics concepts. All the interactive approaches mentioned above aim to encourage student interaction in physics classrooms and to focus students" attention on fundamental concepts. Involving students actively in the lesson, through these interactive teaching methods is likely to improve their conceptual understanding of physics concepts (Cahyadi, 2007; Lasry et al., 2008; Mazur & Hilborn, 1997; McDermott, 2001; McKagan et al., 2008). As observed by Brekke (2009), high school physics can be a great experience for students if some changes are made in the way the subject is taught. Brekke advises physics teachers to remember that most students gain knowledge when the subject matter is tangible or real, therefore physics instruction should generally proceed from the concrete to the abstract, rather than the other way around which is prevalent in many physics classrooms education reform depends on.

2.3.5 Preparing Physics Teachers for High/Secondary Schools

High-school teachers are one of the most important factors in developing the science and technology workforce of the future. Institutions of higher learning in the US will need to dramatically increase the number of high-school physics teachers they educate if every high-school student who wants to take a physics course is to have access to a highly qualified teacher. The responsibility for that teacher preparation cannot be left solely to education departments or schools of education; we physicists must work with our colleagues in education to address the significant shortage of qualified physics teachers.

Education research indicates that the success of science education reform depends on the preparation of teachers (Etkina, 2010; McDermott & Shaffer, 2000). Since the teacher mediates the science culture in the classroom, thereby setting environmental conditions that might enhance student learning and interest (Juuti, Lavonen, Uitto, Byman & Meisalo, 2010), the preparation of physics teachers has been a purposeful intellectual endeavor in many countries, institutions, and universities. Hodapp, Hehn, and Hein (2009) argue that high-school physics teachers are one of the most important factors in developing the science and technology workforce of the future. Therefore, they suggest, institutions of higher learning will need to dramatically increase the numbers of high-school physics teachers they educate. The authors indicate that the responsibility for that preparation cannot be left solely to education departments or schools of education.

According to them, physicists must work with colleagues in education to address the significant shortage of qualified physics teachers. In 1999, the American Physical Society (APS), the American Institute of Physics (AIP), and the American Association of Physics Teachers (AAPT) jointly established the Physics Teacher Education Coalition (PhysTEC) (2014) to improve and promote the education of future physics teachers (www.phystec.org). Since then, PhysTEC has been working in collaboration with colleges and universities to identify and disseminate effective practical and innovative methods and to advocate for an enhanced role of physics departments in the education of future teachers (Hodapp et al., 2009). According to the authors, successful teacher education programs span a continuum of effort – from student recruitment to the post-graduation mentoring of those who eventually enter classrooms. Teachers, like other professionals, are not produced in a single act or even a single semester, they are rather developed over time and must be supported during the process. More importantly, the key to attracting and retaining students in a teacher education program is personal interaction.

The American Association for Employment in Education (AAEE) reports that physics teacher positions are the most difficult to fill in high schools (McLeskey, Tyler, & Flippin, 2004). Many universities have been encouraged to institute more proactive programs to train more physics teachers for high schools in the USA (Etkina, 2010). For example, the University of Arkansas is reported to have an exemplary program for physics teacher preparation that incorporates many of the above features. The university‟s graduates are reported to be the main source of high-school physics teachers for the region (Hodapp et al., 2009). The Physics Teacher Education Coalition (PhysTEC) (2014) program at Arkansas develops student interest in physics with inquiry-based introductory courses, guides potential teachers through the licensure process, and mentors them during the early years of their professional lives. Arkansas also has a Learning Assistants program that has played a significant role in the recruitment and retention of new teachers.

2.3.6 Initial Teacher Education Effectiveness

Researchers over the years have assessed initial teacher education (ITE) programs through the impact of both primary and secondary school teachers' (most often pre-service teachers) subject matter and pedagogical knowledge on classroom practice. ITE (also called pre-service education) has been a major concern of many physics education researchers. The National Research Council (1996) recommended that teachers of science and mathematics should have a strong knowledge of science and mathematics concepts to enable them to guide students to explore these concepts. Research findings, however, show that it is difficult to measure the extent to which a large national sample of teachers understand the concepts they are teaching, hence proxy measures such as „major" or „number of courses taken in one"s field are usually used (Weiss, Banilower, McMahon, & Smith, 2001). Teachers who have acquired sufficient academic preparation – usually subject matter content and pedagogical skills are generally regarded as effective in classrooms (Hendriks, Luyten, Scheerens, Sleegers, & Steen, 2010).

2.3.7 The Role of Content Knowledge

Initial teacher education plays a key role in supporting the development of effective teachers. Lederman and Gess-Newsome (2001) found that despite the fairly high level of confidence preservice teachers have in their subject matter knowledge and the attainment of a bachelor"s degree in the academic area, most do not understand the content that they are to teach in a conceptually rich or accurate manner. In discussing how the nature of science content affects learning and teaching, Fensham, Gunstone, and White (1994) indicated that content, learning, and teaching are interrelated. According to them, the extent to which teachers will go about a particular task in the classroom is greatly influenced by the subject matter content they know. Advancing on this, Gunstone (1994) suggested that content knowledge is important for "metacognition purposes" (p. 145). It was further argued that understanding the science subject matter content, for physics, in particular, is most important for pre-service teachers, in the sense that it promotes self-reflection amongst them about their learning and how and what others have learned. Conner and Gunstone (2004) noted that learning outcomes are maximised when content knowledge is promoted together with strategic learning approaches. All these have implications for ITE in that ITE programmes need to model how to identify and learn content knowledge for pre-service teachers so they will gain confidence to teach the fundamental aspects of physics. ITE providers are responsible for the training and development of effective teachers.

Commenting on the role that science teachers can play in facilitating high school students" learning, Wellington and Osborne (2001) indicated that "as teachers of science, our primary skills lie not in our ability to do science, but in our ability to interpret and convey a complex and fascinating subject" (p. 138). This statement indicates the importance of subject matter content knowledge (Fensham, Gunstone & White, 1994) and how beginning teachers might be enabled to interpret and connect ideas and make these explicit in their teaching. McDermott and Shaffer (2000) found that in the USA, a science degree programme majoring in physics does not provide adequate preparation for teaching in high schools. McDermott and Shaffer (2000) emphasized that the scope of topics and the laboratory courses offered by most physics departments rarely address the needs of student teachers. Likewise, Mohd Zaki (2008) found that in Malaysia pre-service teachers had a weak conceptual understanding of Newtonian concepts, and had difficulty understanding kinematics graphs. Similar observations have been made by other researchers (Darling-Hammond & Baratz-Snowden, 2005; Korthagen, Loughran, & Russell, 2006). This has led to various attempts to reorganise teacher education programs. Korthagen et al. (2006) for example, after analysing effective features of teacher education programs in Australia, Canada, and the Netherlands, outlined how to guide the development of teacher education programs that are responsive to the expectations, needs, and practices of student teachers. Also, Fensham, Gunstone, and White (1994) argued that in developing appropriate pedagogies, the problematic nature of the content itself should not be ignored. This means that when educating physics teachers, we need approaches that are specific to the content domain of physics (Mohd Zaki, 2008).

The Shortfalls – Figuring Out What Works and What Doesn‟t Work McDermott and Shaffer (2000) argued that a well-prepared teacher of physics or physical science should have, in addition to a strong command of the subject matter, knowledge of the difficulties it presents to students. The authors, through a series of classroom observations and interviews with pre-service and in-service teachers, found that traditional courses in physics do not provide the kind of preparation that teachers need to teach physics at secondary school level. They indicated that teachers tend to teach as they were taught – “if they were taught through lectures, they are likely to lecture, even if this type of instruction is inappropriate for their students” (p. 72). They

(McDermott & Shaffer, 2000) argued further that, although the content of the high school physics curriculum is closely matched to the introductory university course, the latter does not provide adequate preparation for teaching the same material in high schools. The authors emphasize that the breadth of topics covered and the laboratory courses offered by most physics departments also do not address the needs of students, in that most of the time the equipment used in universities is/are not available in high schools, and no provision is made for showing teachers how to plan laboratory experiences that utilize simple apparatus. In discussing the implications of the study, the authors noted that separation of instruction in science (which takes place in science courses) from instruction in methodology (which takes place in education courses) decreases the value of both for teachers.

They emphasized that effective use of a particular instructional strategy is often content specific, hence if teaching methods are not studied in the context in which they are to be implemented, teachers may be unable to identify the elements that are critical. Thus they may not be able to adapt an instructional strategy that has been presented in general terms to specific subject matter or to new situations. Among many other things, McDermott and Shaffer (2000) recommended that teachers should study each topic in a way that is consistent with how they are expected to teach that material. In 46 addition, they stressed, teachers also need to be given the opportunity to confront and resolve their conceptual and reasoning difficulties, not only to improve their own learning but to become aware of the difficulties that their students might have. Through a survey of about 3000 beginning teachers (from both teacher education programmes and alternative teacher preparation programmes), Darling-Hammond et al. (2002) examined the teachers" perceptions of their preparedness and their sense of teaching efficacy. These variables are found to correlate with student"s achievement (Darling-Hammond, 2000; Darling-Hammond, Berry, & Thoreson, 2001). Findings from the study showed that teachers" overall preparedness to teach related significantly to their sense of efficacy about whether they are able to make a difference in student learning. The results indicated that teachers who felt better prepared were significantly more likely to believe they could reach all of their students, handle problems in the classroom, teach all students to high levels, and make a difference in the lives of their students. And those who felt underprepared were significantly more likely to feel uncertain about how to teach some of their students and more likely to believe that "students" peers and home environments influence learning more than teachers do" (Darling-Hammond et al., 2002, p. 294). In discussing the findings, the authors noted that the teachers" feeling of preparedness was also significantly related to their confidence about their ability to achieve teaching goals.

They concluded that measures must be put in place to improve teacher education programmes. They cited quality control standards by the National Council for Accreditation of Teacher Education (NCATE) as one of those measures that can be used to improve initial teacher education programmes. The professional learning of student teachers has been attributed to three major sources of influence, namely pre-training education experiences, teacher education coursework and fieldwork in the teacher education programme (Cheng, Cheng, & Tang, 2010; Kagan, 1992; Levin 47 & He, 2008). These authors assert that the practicum experience and the variability of this experience influence teaching preparation. In New Zealand, most secondary teachers complete a one-year graduate diploma, which includes supervised practicum experience in local high schools. Most of these teachers complete their first degree in their respective subject specialisms. The subject specific degree is deemed to provide most of the content knowledge required for at least one specialist-teaching area. Thus, the ITE physics course is primarily about acquiring pedagogical content knowledge (PCK). Findings from the Teaching and Learning International Survey (TALIS) 2013 results indicate that teachers whose initial education included content, pedagogy and practice elements specifically for the subjects they teach reported feeling better prepared for their work than their colleagues without this kind of training (OECD, 2014). Though the New Zealand education system has been reported to be attending well to developing understandings of the teaching and learning processes, teacher educators continue to have divided opinions over the subject matter knowledge that should be included in teacher education qualifications (McGee et al., 2010).

There is an opportunity to review what subject matter content knowledge is included in ITE programmes as New Zealand explores shifting its entry qualification to be at Masters level. Recent international studies about effective approaches to teaching and learning, such as findings from the OECD Innovative Learning Environments (ILE) Project (OECD, 2013) mean that adjustments to initial teacher education are required to accommodate the needs of current day learners and what we know makes a difference to learning. Recently, Conner and Sliwka (2014) indicated the implications of the ILE work for initial teacher education. The authors argued that initial teacher education should adhere to the "seven transversal learning principles" (pp. 165-166) if prospective teachers are to be effective in their learning environments in which they will be expected to teach. Thus, significant changes are imminent in the initial teacher education programmes in New Zealand.

2.3.8 Elements of teacher professional development

Professional learning opportunities for teachers are seen as improving instruction and students‟ achievement. Using the multiple conceptual and situative perspective approaches, Borko (2004) identified three phases of research on teacher PD that can have a positive impact on teacher learning. She explains that Phase 1 research focuses on a single professional development program at a single site which seeks to understand the relationships between the teachers‟ participation in the professional development program and their learning. In Phase 2, a single PD program enacted by multiple facilitators is studied to seek insight into the relationships among facilitators, the professional development program, and the teachers as learners. Different PD programs, situated at multiple sites are studied and compared in Phase 3. In conclusion, Borko noted that the majority of today‟s professional development studies are all Phase 1 research. She revealed that Phases 2 50 and 3 helps to study and compare the relationships among all four elements of a professional development system: facilitator; professional development program; teachers as learners; and context.

To inform professional development policies and practices, she suggested that more attention be given to Phases 2 and 3. Reporting on what makes PD effective, Garet, Porter, Desimone, Birman, and Yoon (2001) contended that PD activities that focus on mathematics and science content areas have an important positive influence on changes to teaching practice. Similarly, professional development programs that focus on "subject-matter knowledge and on student learning in that subject area are more likely to have an impact on student learning than those that focus on more generic topics" (Banilower et al., 2007, p. 377). The authors also stated that providing teachers with opportunities to deepen their content and pedagogical knowledge in the context of high-quality instructional materials would improve their classroom instruction, which would in turn lead to higher student achievement. Other researchers, for example Darling-Hammond and Richardson (2009), and Hill (2009) have also stressed that professional development that focuses on developing the pedagogical skills of teachers to teach specific kinds of content has a strong positive influence on practice and student learning and achievement. In a review of 25 PD programs across states in the USA for science and mathematics teachers, Blank et al. (2007) found that 22 of the programs focused on content knowledge. Most of the programs were also positively rated for providing pedagogical content knowledge for the teachers. As outlined above, PD is seen as one of those strategies for improving teachers" competencies and students" achievement.

Bucher (2009) emphasized that a good student academic achievement and better educated nation and society is the ultimate goal of education and to be able to achieve this, teachers" competencies in the content areas they teach should be of paramount interest to all educators.

Thus, the need for an increase in teacher content knowledge and pedagogical skills 51 should be not be disregarded. Bucher uses the figure below to explain how education is reformed through the gains from PD. Figure 2. How professional development yields reform In their first report on research study of professional learning opportunities in the USA and abroad, Darling-Hammond, Wei, Andree, Richardson, and Orphanos (2009) found that opportunities for sustained, collegial professional development which changes in teaching practice and student achievement were more prevalent in most of the high-achieving nations than USA. In a similar report, teachers in high-achieving Organization for Economic and Co-operative Development (OECD) nations are reported as having more time in their regular work schedules for cooperative work with colleagues (Wei, Darling-Hammond, & Adamson, 2010). The authors noted however, that, progress has been made as many states in the USA now provide induction support to beginning teachers and professional development for science and mathematics teachers on content and pedagogical skills for the subjects they teach.

2.3.9 Designing professional development for teachers

Evidence from research shows that effective professional development programmes (PD) designed for teachers correlate positively with student learning and achievement. Mizell (2010) describes effective PD as those that focus on the information and skills teachers need to address students" learning difficulties. PD should therefore cause teachers to improve their instruction. As pointed Professional development Increase teacher knowledge and improve teaching skills and students" achievement Reform: Better educated nation and society previously carried out PD that focuses on teacher subject-matter knowledge and pedagogical skills that has a positive impact on student learning and achievement (Darling-Hammond & Richardson, 2009).

Even though PD is usually used to mean a formal process such as a conference, seminar, workshop, or collaborative learning among members of a work team, it can also take place in informal contexts, such as discussions among colleagues, independent reading and research, observations of a colleague"s work, and/or other learning from a peer (Mizell, 2010). Thoughtful planning and implementation are required for any PD approach to be effective. Research has shown that the amount of PD teachers receive has a positive impact on their learning and student outcomes

(Yoon, Duncan, Lee, Scarloss, & Shapley, 2007). The short-term workshops tend not to cause as great a change in teacher practice and student achievement (Wei, Cherry, Glomrod & Zhan, 2014). The researchers found that PD activities that span a longer period with a greater number of contact hours (an average of 8-14), and that require ongoing reflection are more likely to bring a positive change. Given this, Darling-Hammond and Richardson (2009) advise that schools should make PD a coherent part of their activities rather than the "traditional one-shot workshop" (p. 48). They further indicated that disparities sometimes exist between what teachers learn in professional development work and what they can, put into practice in their classrooms, so to avoid this situation, professional learning opportunities must be linked with the curriculum, assessment, and standards.

Several important factors and/or inputs underpin the design and implementation of any effective professional development. Loucks-Horsley et al. (2010) identified four key factors into the professional development design process that could help professional developers to make an informed decision. These are knowledge and beliefs, context, critical issues, and strategies.

Physics is one of the subjects in which students have to master complex skills and reasoning processes that are essential for scientific literacy. For this vision to be realised, Loucks-Horsley et al. (2010) emphasized that teachers need to have the strong content knowledge and pedagogical skills for their subject. Thus, teachers need to have quality education and feel competent to create appropriate learning environments for their students. For teachers to be able to do this, the authors insist that teachers need opportunities for ongoing professional development, especially one in which they (teachers) can learn what they need to know and how they can work with their students to achieve that goal. Timperley (2011) observes that teacher professional development, which is quite often seen as a solution for improving schools and raising achievement, rarely lives up to expectations. Timperley, therefore, calls for a shift from professional development to professional learning which is capable of promoting teacher and student engagement, learning, and well-being. This type of professional learning is inquiry in nature and teachers take control of their professional learning through the reflection of their teaching practices (Timperley, 2011).

2.3.10 What Professional Development do Physics Teachers Need?

The primary goal of teacher education is to support future teachers in developing professional knowledge and skills to meet the challenges of their profession. Common models treat professional knowledge as a key component of professional competence, whereas competence can be described as „the latent cognitive and affective-motivational underpinning of domain-specific performance in varying situations" (Blömeke et al. 2015, p. 3). Therefore, a great amount of teacher education programs focus on the development of such knowledge, especially in the German teacher education system. In Germany, teacher education consists of three consecutive phases necessary to become a teacher (Cortina and Thames 2013). In the first phase, future teachers enroll in a teacher education study program at a university, including a three-year bachelor"s degree followed by a two-year master"s degree. The second phase consists of a 12 to 24 months in-school induction program. While the first phase focuses on the acquisition and development of theoretical knowledge, the second phase emphasizes practical teacher training. The third phase aims at the further professional development of in-service teachers. The underlying model of these phases can be described as a functional chain (Diez 2010). During their university studies, future teachers are meant to acquire knowledge, which they have to apply in their teacher training course afterwards. In this perspective, it is assumed that teachers use their professional knowledge as a resource to perform their daily tasks. This model poses some challenges for teacher educators creating teacher education programs. They have to ensure that prospective teachers acquire knowledge, which is relevant for teaching. It has to be part of the knowledge base for teaching (van Driel et al. 2001), which allows teachers to develop skills to carry out high-quality instruction. To meet this challenge, most federal states in Germany implemented a one-semester internship at a school as part of their master"s degree programs for teachers (practical semester). It is meant to enable the use of theoretical knowledge and to gather first teaching experiences already before the second phase. During their one-semester internship, in addition to teacher training by expert teachers at school, all participating students also attend supporting courses at the university.

Professional development is viewed in this study from the point of view of Scheerens (2009) as the body of systematic activities to prepare teachers for their job, including initial training, induction courses, in-service training, and continuous professional development within the school settings. The most frequently used analytical variables when attempting to explain why some teachers are more effective than others are mastery of subject matter and pedagogical knowledge.

Additional components sometimes included in the concept are knowledge of the appropriate use of teaching materials and media, as well as strategic knowledge about the application of teaching strategies (Krauss, 2008; Scheerens, 2009). Krauss, Brunner, Kunter, Baumert, Blum, Neubrand, and Jordan (2008) define three main components of pedagogical content knowledge: knowledge of tasks, knowledge of students" prior knowledge, and knowledge of instructional methods. These authors measured pedagogical content knowledge using an assessment center type of approach, in which teachers rated real-life teaching scenarios in mathematics classes. Their results gave a basis for the hypothesis that teachers with more pedagogical content knowledge display a broader repertoire of teaching strategies for creating cognitively stimulating learning situations. Another interesting outcome was that pedagogical content knowledge was highly correlated with subject matter mastery, thus suggesting that deep knowledge of the subject matter is indeed the critical precondition for pedagogical content knowledge. Even though the study was conducted in mathematics, the findings are by no means limited to mathematics alone. Physics teachers also need to have good pedagogical content knowledge and mastery of their subject matter.

It has also been stated that physics teachers should participate in a variety of professional activities within the school context to stimulate both their professional development and the development of the school (Scheerens, 2009). Acknowledging this raises the important questions of which professional activities can improve teachers" participation in school practice and which type of teacher learning needs should be promoted.

Based on the available literature and research, the following professional learning activities, which are crucial for enabling teachers to deal with the rapid changes they face can be distinguished: keeping up to date (collecting new knowledge and information), experimentation, reflective practice (giving and asking for feedback), knowledge sharing and innovation (Krauss, 2008; Scheerens, 2009). Research findings have also shown that teacher collaboration aimed at improving instruction and education is also quite relevant (Meirink, Meijer & Verloop, 2007).

Co-operative and friendly collegial relationships, open communication, and the free exchange of ideas may also be sources of emotional and psychological support for teachers of physics in promoting their professional development (Toole & Louis, 2002).

Furthermore, research has shown that teachers" participation in decision making, which supports an „organic" form of school organization, has positive effects on teachers" motivation and commitment to change (Jongmans, Sleegers, Biemans, & De Jong, 2004).

Learning is maximized if school staff, and teachers, in particular, are provided with information on important school issues such as developments in student performance or the extent of parental participation. (Earl & Katz, 2006; Leithwood, Aitken, & Jantzi, 2006). Even though there are indications that schools with these characteristics do indeed promote educational change and enhance student learning, it is necessary to find more thorough and strong evidence for the claim that continuous professional development in schools can sustain teacher improvement and development and thereby enhance student learning. The Teaching and Learning International Survey (TALIS) 2013 results highlight that teachers" roles today have changed and their current knowledge and skills may not match new needs and expectations (OECD, 2014). The OECD (2014) stressed that teachers provide the most important influence on student learning, yet, teachers are often not developing the practices and skills necessary to meet the diverse needs of today"s learners.

The TALIS results emphasize the importance of collaborative professional learning between teachers since those teachers who participate in collaborative professional learning activities reported being significantly more confident in their abilities (OECD, 2014). The OECD (2014) report added that if teachers are now expected to prepare students to become lifelong learners, they need to learn and develop throughout their careers.

Purposes and Practices of Assessment in Teaching and Learning Formative and Summative Assessments Assessment in education is the process of measuring a student‟s mastery of knowledge and skills to make an informed decision about the student (Black & Wiliam, 1998). Teaching, learning and assessment are completely inextricable (Shepardson & Britsch, 2001) in the classroom and they ought to be understood as interactive and cyclical (Darling-Hammond & Baratz-Snowden, 2005). Even though the general purpose of teaching is to enable learning, assessment has several purposes, including monitoring students‟ progress; diagnosing students understanding, abilities and difficulties; informing teaching; reporting to parents on their children‟s achievement; providing constructive feedback to learners; informing pedagogy and thereby improving the 56 quality of teaching and subsequent learning (Atkin, Black, & Coffey, 2001; Darling-Hammond & Baratz-Snowden, 2005; Moreland & Jones, 2000; Shepardson & Britsch, 2001). The purposes of assessment may also fall into three broad areas. These are those concerned with "support of learning, reporting the achievement of individuals and satisfying demands of public accountability" (Black, 1998, p. 24). Therefore, one has to choose, with care, the methods of assessment that will match the intended purposes (Hackling et al., 2001). Assessment in the classroom may be formative, or summative. Formative assessment is diagnostic in nature (Black, 1998) since it is intended to provide the teacher and learner with feedback about teaching and learning processes. The results from formative assessment inform the teacher about students‟ performance abilities in the teaching and learning process and the teacher uses the information to reform his/her teaching (Atkin et al., 2001; Conner, 2013; Shepardson & Britsch, 2001). The practice of formative assessment must therefore be integrated into teaching and learning since it is essential to quality teaching (Black, 1998; Darling-Hammond & Baratz-Snowden, 2005) Summative assessment, on the other hand, refers to the cumulative type of assessment which normally occurs in large-scale testing (Atkin et al., 2001) to make a judgement about students‟ achievement at specific points in time. Specifically, summative types of assessment provide information for certification, qualifications, placement promotion and accountability purposes (Atkin et al., 2001; Black, 1998; Black & Wiliam, 1998). Whereas formative assessment involves participation and a close relationship between teacher and learners (Hackling et al., 2001) the primary role and responsibilities with respect to summative assessment fall on the teacher and the external tests (Atkin et al., 2001).

Purposes, Roles and Responsibilities of Assessment Type Purpose Roles and responsibilities Formative Identify students difficulties and capabilities Improve learning Inform instruction Student and teacher Summative Certification Placement Promotion Accountability Teachers and external tests Approaches to Classroom Assessment Essential to classroom assessment is the need for the assessment to reflect the nature of the teaching and learning activities. Research on classroom assessment has shown that regular and high-quality assessment can impact positively on students‟ achievement (Atkin et al., 2001). Darling-Hammond and Baratz-Snowden (2005) argue that formative assessment can be a "powerful tool in targeting instruction so as to move learning forward, therefore, beginning teachers must be knowledgeable about formative assessment so that it is carried out during instructional processes for the purpose of improving teaching or learning" (p. 23). Classroom assessment practices most often requires the use of multiple assessment sources (Shepardson & Britsch, 2001) so teachers ought to be skillful at using various strategies and tools. The types of assessment tools used in the classroom may include practical tasks, written test/work, quizzes and oral reports (Hackling et al., 2001; Shepardson & Britsch, 2001). Observations of students‟ performance, student interviews, discussions and responses on tests are other assessment strategies that can be employed in the classroom (Atkin et al., 2001; DarlingHammond & Baratz-Snowden, 2005). These approaches are capable of generating information that can be used to provide feedback to the teacher and/or the students on teaching and learning processes.

The information can provide effective assessment to improve learning and teaching. 58 The NZC emphasizes that the primary purpose of assessment is to improve students‟ learning and tasks schools with keeping assessment to levels that are manageable and reasonable for both students and teachers. In order to achieve this goal, the NZC has categorically stated that "not all aspects of the curriculum should be formally assessed, and excessive high-stakes assessment in years 11-13 is to be avoided" (Ministry of Education, 2007, p. 41). Summary This review explored both theoretical and empirical perspectives of the literature related to the research topic. The theoretical perspectives covered two areas namely; constructivism theory and the cognitive apprenticeship model. These two provide teachers with an understanding of how learning occurs and therefore involve their students in the teaching and learning processes, and students are able to solve their own problems. Research has shown that for physics education in particular, the motivation, active knowledge and participation of the students is of paramount importance. Passive, unmotivated students, a template of pattern solving principles and minimal creativity learning have little future in contemporary education (Ülen & Gerlič, 2012). At the heart of physics education research is exploring how a shift in physics instruction from concentrating on teaching to focussing on students‟ learning improves outcomes. In order to make this shift achievable, Redish and Steinberg (1999) stressed that teachers of physics need to listen to students about what they (students) are thinking helps them to learn. By doing this, teachers begin to make sense of how students learn physics in a way that helps them to meaningfully improve their courses.

The advances in computer hardware and software have provided new platforms for instigating conceptual change and problem solving. Applets have been running on the World Wide Web for the past decade. A similar model, which has been developed, tried and tested, to help develop students‟ conceptual understanding and problem solving is Physics Education Technology (PhET) (Wieman et al., 2008). PhET simulations are web-based interactive tools for teaching and learning physics. Greater use of such software in teacher preparation programmes might assist new teachers 59 to become familiar with and actively incorporate digital objects for demonstrations and for students to use to gain understanding and to solve physics problems. The use of interactive engagement methods, in teaching and learning of physics, is another significant change in the teaching methodology. Examples of interactive engagement methods that have been discussed in this review are peer instruction (Mazur, 1997), interactive lecture demonstration (Sokoloff et al., 2007; Sokoloff & Thornton, 1997), photonics explorer (Prasad et al., 2012), and augmented reality (Dünser, Walker, Horner, & Bentall, 2012) Over the years preparation of physics teachers has been a purposeful intellectual endeavour by many countries, institutions and universities. The report by the American Association for Employment in Education (AAEE) indicates that physics teaching positions are the most difficult to fill in high schools (McLeskey et al., 2004). It also encourages universities to initiate proactive programs to train more physics teachers for high schools (Etkina, 2010). For effective physics education to occur, students have to actively work to make sense of the concepts for themselves.

The information cannot simply be transferred from the teacher to the students. To better understand what could be done to improve physics education in New Zealand specifically, there is the need to undertake not only an attitudinal study, as a great deal of work has already been done with survey research (Blickenstaff, 2010), but also more in-depth study through observations, interviews and documentary analysis to examine students‟ encounters with physics in different high school settings. This diversity of settings will enable the researcher to examine and identify issues of commonalities which may in turn improve practice and inform policy decisions.

CHAPTER THREE

METHODOLOGY

3.1 Introduction

Chapter three presents the methodological issues of the research. It identifies the research design and the study area, the study"s population, sample and sample technique, primary sources of data, data collection procedure as well as the method of data analysis.

3.2 Study Area

The study covers the Greater Accra Region of Ghana. This region was selected because several senior high schools are located in this region. The study targeted Senior High Schools in the Greater Accra Region, specifically, physics teachers and physics students. Therefore, targeting Senior High Schools in Greater Accra Region means that more physics teachers and students are likely to participate in the study.

3.3 Research Design

The study employed a cross-sectional survey design, which ensures the researcher collects data from the participants at one particular point in time (Sedgwick, 2014). It also permits the researcher to collect more data and information regarding respondents. There are three core types of research approach or methodology. These are the qualitative, quantitative, and mixed methods approach. A quantitative approach was adopted for this study. According to Creswell and Creswell (2017), a quantitative method allows the researcher to quantify and generalise the findings of research to an entire population if appropriately sampled.

3.4 The Study Population

According to Hair, Black, Babin, Anderson, and Tatham (2006), the target population is said to be a specified group of people or objects for which questions can be asked or observed to develop required data structures and information. The accessible population was selected based on categories. The categories are A, B, and C schools. Each school was selected from the category A, B, and C schools respectively. Therefore, the target population for the research focused on all physics teachers and final year physics students in Frafraha Community Senior High School(Category C), Ghanata Senior High School(Category B), and Accra Girls Senior High School (Category A).

3.5 Sample and Sample Technique

The study employed a purposive sampling technique for the selection of teachers for this study. According to Babbie (2008), purposive sampling is a type of non-probability sampling in which the units to be observed are selected based on the researcher"s judgment about which ones will be the most useful or representative. The study purposively sampled one school from each of the categories. It was based on well highly endowed schools to less endowed schools. In all the sampling schools, final year students were used as participants. Therefore, it helped in the selection of teachers who were useful for the study. A convenience sampling technique was used to select students for the study. Since the researcher resides in greater Accra the sample size of participating students was weighted on the number of final year students of a particular school. Schools with a higher population will have more students participating.

The sample description specifies the characteristics of the participants in the study (Creswell, 2009). With regards to this study, 300 students and 50 teachers were selected from the three schools (Frafraha Community Senior High School, Ghanata Senior High School, and Accra Girls Senior High School) to participate in the study.

The data was collected for this study through the administration of a semi-structured questionnaire to the respondents to provide the necessary information for analysis.

3.6 Instrumentation

Both closed-ended and open-ended survey questionnaires were used to collect quantitative data from the respondents. The survey questionnaire method has been identified as one of the suitable ways of gathering data from a large number of respondents in a relatively short period. Two sets of questionnaires were designed, One set for teachers and the other for students. These two separate questionnaires consisted of four sections. The first section consisted of the demographic characteristics of respondents. The second section comprised the teaching approaches of teachers. The third consists of constraining factors of teaching and learning physics. The fourth part consisted of the way forward for teaching and learning physics. There was also classroom teaching and learning observation to capture areas that were not captured in the questionnaire.

3.7 Data Collection Procedure

For the exercise to be convenient for the respondents, copies of the questionnaire were personally delivered to the respondents (teachers and students). Before the administration of the questionnaire, the researcher met with the management of the schools to deliver an introductory letter asking for permission to undertake the study in their schools. During the meeting, management was made aware of the importance of the impending study. Also, respondents (teachers and students) were informed that the purpose of the study was to assess their views and opinions on factors affecting teaching and learning of physics in Senior High Schools. Participants were also notified of the benefits that will be accrued at the end of the study and not ply with their private lives. Respondents were also assured of anonymity.

3.8 Data Analysis

Descriptive statistics such as percentages, means, and standard deviations were used to analyse the data.

3.9 Ethical Consideration

Ethics in research refers to the norms for the conduct that distinguish between acceptable and unacceptable behaviour (Makhoul, Chehab, Shaito & Sibai, 2018). Letters explaining the purpose of the study were sent to the selected Senior High Schools explaining the purpose of the study. The anonymity and confidentiality of participants were also assured. It was also explained to them that the data and information they will provide will be for only academic purposes.

CHAPTER FOUR

RESULTS AND DISCUSSIONS

4.1 Introduction

This chapter of the study presents the research results. The chapter presents results on the demographic profile of the research participants. The survey questionnaires which sought to enquire into the factors affecting teaching and learning of physics in Ghanaian Senior High Schools are presented with the research questions that were formulated to serve as a guide to this study. The analysis is in two parts. Specifically, the responses of teachers, as well as students, were analysed.

4.2 Teachers' Demographic Characteristics

Demographic data can help a researcher better grasp an audience's background characteristics, such as age, race, ethnicity, income, job situation and marital status. Teachers" demographic characteristics are presented in this section including their gender, age, the highest level of educational attainment, and years of experience in teaching. Their responses to the items of the questionnaire which are based on classroom practices, constraining factors to the teaching and learning of physics and the way forward were analysed. The teachers' demographic characteristics are presented in Table 4.1.

The majority of the respondents (teachers) were males (84%) as against their female counterparts representing 16%. With regards to age, Eight respondents representing 16% fell between 21 and 30 years old, 24 of the respondents representing 48% had their ages between 31 and 40 years old, 13 of the respondents represented 26% were between 41 and 50 years old and five respondents represented 10% were 51 years old and above(Table 4.1). In terms of qualification, a lot of the respondents (52%) had postgraduate qualifications (PhD/M.Sc./M.Ed), 19 respondents had first-degree qualification (BSc/BA) representing 24%, Eight respondents representing 16% had first-degree in Education (B.Ed) and four represented 8% had Post Graduate Diploma(Table 4.1). With regards to years of experience, 44% of the respondents had between 6 and 10 years of teaching experience, this is followed by six respondents representing 12% of the respondents had between 3 and 5 years experience in teaching, 12 respondents representing 24% had teaching experience for about 11 to 15 years teaching experience, Two respondents representing 4% had 1 to 2 years of teaching experience and Eight respondents representing 16% had 15 years teaching experience(Table 4.1). The data shows teacher quality and length of experience are reasonable, and this may imply that students are likely to be well taught in lessons in physics which may increase better understanding and performance.

Table 4.1: Characteristics of Physics Teachers (N = 50)

Characteristic	Frequency	Percentage
Gender		
Male	42	84.0
Female	8	16.0
Age		
21 – 30	8	16.0
31 – 40	24	48.0
41- 50	13	26.0
51yrs and above	5	10.0
Qualification		
PHD/M.Sc./M.Ed	26	52.0
1st Degree (BSc/BA)	12	24.0
1st Degree (Ed.)	8	16.0
Post Graduate Diploma	4	8.0
Diploma	0	0
Years of Experience		
<1year	0	0
1 – 2	2	4.0
3 – 5	6	12.0
6 – 10	22	44.0
11 – 15	12	24.0
Above 15 years	8	16.0

Source: Field Survey (February ,2022)

4.3 Students' Survey Questionnaire

The majority of the respondents were males (67.0%) whilst 33.0% were females (Table 4.2).

In terms of age, it is shown that the majority of the respondents were between 15 and 19 years old (85%). 24 respondents representing 8.0% fall between 20 and 24 years old. 18 respondents representing 6.0% are between 10 and 14 years old and Two respondents representing 1.0% were 25 years and above(Table 4.2). The data shows that male interest in studying science-related disciplined visa via physics is increasingly high. It is therefore important to note that problems solving approach should have a gender dimension given the male dominance. Again, there are a lot of adolescents in senior high schools than adults. It, therefore, implies that physics students are teens still under development from adolescence to adulthood and for that matter, interventions should focus on their mental capacity.

Table 4.2: Bio-data of Students Respondents (N = 300)

Characteristic	**Frequency**	**Percentage**
Gender		
Male	202	67.0
Female	98	33.0
Age		
10 – 14	18	6.0
15 – 19	256	85.0
20- 24	24	8.0
25yrs and above	2	1.0

Source: Field Data (February, 2022)

4.4 Teaching Approaches

Table 4.3 presents the results teaching approaches. The majority of teachers in the sample employed demonstration and discussions to illustrate concepts/phenomena more often in their teaching techniques to physics, according to the data in the table. This is represented with a mean score of 3.86. Also, majority of teachers adopted student-centered in teaching (3.80). A lot of teachers lay emphasis on mathematical presentation of concepts/students planning and doing their experiment (3.80) (Table 4.3). Again most of the teachers in the study laid emphasis on qualitative thinking and presentation of concepts (3.76) (Table 4.3). A lot of teachers sometimes assist students to work with physics problems individually (3.74); some teachers give students the opportunity to explain their own ideas (3.74) students are assisted to follow instructions from the teacher (3.70) (Table 4.3). The data also revealed that a lot of teachers sometimes makes teaching and learning being teacher-centered (3.70) and most teachers presents new materials on a whiteboard/demonstrating problem-solving on a whiteboard (3.68). A greater number of teachers assist students to work with physics problems in groups (3.68); and the majority of teachers engages students in context-based activities (3.62) (Table 4.3). From the data, it appears that teachers uses best practices in presenting their lessons with regard to their teaching approaches.

Table 4.3: Teaching Approaches to Physics

Statement on Teaching Approaches	**Percentage Responses**				**Mean**	**Std. dev**
	N	**R**	**S**	**A**		
1. How often do you use teaching and learning materials	0	12.0	22.0	66.0	3.54	0.70
2. I demonstrate problem-solving on the whiteboard	0	6.0	20.0	74.0	3.68	0.58
3. I emphasize the mathematical presentation of concepts	0	14.0	18.0	68.0	3.54	0.73
4. I emphasize qualitative thinking and presentation of concepts	0	6.0	12.0	82.0	3.76	0.55
5. I use demonstrations and discussions to illustrate concepts/ phenomena	0	4.0	6.0	90.0	3.86	0.58
6. Teaching and learning are teacher-centered	0	8.0	14.0	78.0	3.70	0.61
7. Teaching and learning are students' centered	0	8.0	4.0	88.0	3.80	0.57
8. I engage students in context based-activities	0	4.0	30.0	66.0	3.62	0.56
9. Students work with physics problems individually	0	6.0	14.0	80.0	3.74	0.56
10. Students work with physics problems in groups	0	10.0	12.0	78.0	3.68	0.65
11. Students have the opportunity to explain their ideas	0	6.0	14.0	80.0	3.74	0.56
12. Students experiment by following instructions from the teacher	0	6.0	18.0	76.0	3.70	0.45
13. Students plan and do their experiment	0	8.0	14.0	88.0	3.80	0.57

Source: Field Survey (February, 2022)

4.5 Students' Perspectives on Teaching Approaches

Table 4.4 shows the percentages, mean scores and standard deviations of students" responses to teaching factors such as quality teaching and learning of physics. Percentage responses are coded 1 for never (N), 2 for rarely (R), 3 for sometimes (S) and 4 for always (A).

Students were assisted to work with physics problems individually (3.72) and a lot of students to plan and do their experiments (3.72). Some students could explain their ideas (2.67) (Table 4.4); some students sees teaching and learning as teacher-centered (2.66) and the Teacher presenting new materials on a whiteboard with a mean score (2.66) as the most important teaching approaches. Students in the sample prefer doing experiments by following instructions from their teacher (with a mean score of 2.66); most students sometimes like teachers using a demonstration of problem-solving on the whiteboard (3.64). Sometimes teachers makes teaching and learning more student-centered (2.61). students were guided by their teachers to choose their topics to investigate (2.59); Teachers uses demonstrations and discussions to illustrate concepts/phenomena (2.50). Students wants to see the teacher emphasising an understanding of new concepts/teacher engaging students in context based-activities (2.40); and the teacher using students' suggestions and ideas in teaching (2.40) (Table 4.4).

The data further revealed that students worked on physics problems in groups (2.29); It appear students in the sample rarely understands the teaching approaches used by physics teachers in teaching.

Table 4.4: Students' Perspective on Teaching Approaches

Statements on teaching	Percentage Responses(300)					
	N	R	S	A	Mean	Std . dev.
1. Teacher presents new materials on the whiteboard	0.0	11.0	43.0	46.0	2.66	0.67
2. Teacher demonstrating problem-solving on the whiteboard (e.g. solving examples of physics problems)	0.0	12.0	12.0	76.0	3.64	0.69
3. Teacher emphasizes on the mathematical problem solving of new concepts	0.0	2.0	43.0	55.0	2.59	0.55
4. Teacher emphasizes on the understanding of new concepts (qualitative thinking)	1.0	48.0	51.0	0.0	2.50	0.52
5. Teacher use demonstrations and discussions to illustrate concepts/phenomena	4.0	41.0	55.0	0.0	2.50	0.56
6. Teaching and learning being teacher-centered	0.0	11.0	43.0	46.0	2.66	0.67
7. Teaching and learning being student-centered	0.0	7.0	47.0	46.0	2.61	0.62
8. Teachers using students‟ suggestions and ideas in teaching	8.0	45.0	47.0	0.0	2.40	0.63
9. Teacher engaging students in context based-activities	13.0	36.0	51.0	0.0	2.40	0.70
10. Teacher guide students to work with physics problems individually	0.0	6.0	16.0	78.0	3.72	0.57
11. Teacher assist students to work with physics problems in groups	0.0	15.0	39.0	43.0	2.29	0.74
12. Teacher give students the opportunity to explain theirs own ideas	0.0	8.0	41.0	51.0	2.67	0.61
13. Teacher assist students to choose their own topics to investigate	0.0	2.0	43.0	55.0	2.59	0.55
14. Doing experiments by following instructions from the teacher	0.0	11.0	43.0	46.0	2.66	0.67
15.Teachers guide student to Plan and do their own experiments	0.0	6.0	16.0	78.0	3.72	0.57

Source: Field Data (February, 2022)

4.6 Teachers constraining Factors

Table 4.5 shows the percentages, mean scores and standard deviations of teachers responses to items of constraining factors to quality teaching and learning of physics. Teachers responses of the items were coded as 1 for never (N), 2 for rarely(R), 3 for sometimes(S) and 4 for always(A).

A lot of teachers in the viewed inadequate professional physics teachers as a constraining factor to teaching and learning physics (with a mean score of 3.98) (Table 4.5); the majority of teachers also viewed inadequate laboratory equipment as a constraining factor to the teaching and learning of physics with a mean score (3.88) (Table 4.5); The data further indicates that the factors perceived by teachers as a hindrance to teaching and learning physics were parental and societal perceptions about the difficulty of physics/lack of technical support (3.88); students' misconception about physics (3.84) and inadequate teacher subject knowledge (2.78)(Table 4.5). Other factors were inadequate number of physics teachers (3.72), and overloaded curriculum/lack of teacher mentors (3.68) (Table 4.5). The data revealed that inadequate professional physics teachers is the most significant factor influencing the teaching and learning of the subject; even though physics teachers received some form of higher education including First and second degrees, there still need much education on the subject of physics. Other factors include students' perception.

Table 4.5: Teacher Views on Constraining Factors to Teaching and Learning of Physics

	Percentage Responses					
Statements on constraining factors	**N**	**R**	**S**	**A**	**Mean**	**Std. dev**
Constraining Factors						
1. Students" perception about physics	0	6.0	4.0	90.0	3.84	0.51
2. Parental and societal perception about the difficulty of physics	0.0	0.0	12.0	88.0	3.88	0.32
3. Inadequate professional physics teachers	0.0	0.0	2.0	98.0	3.98	0.14
4. Inadequate teacher subject knowledge	0.0	6.0	10.0	84.0	3.78	0.54
5. An overloaded curriculum	0.0	12.0	12.0	76.0	3.68	0.69
6. There are too many mathematical concepts in physics	0.0	2.0	12.0	86.0	3.84	0.42
7. Inadequate physics teachers	0.0	8.0	12.0	80.0	3.72	0.60
8. Inadequate laboratory equipment	0.0	0.0	12.0	88.0	3.88	0.32
9. Lack of technical support	0.0	0.0	12.0	88.0	3.88	0.32
10. Lack of teacher mentors	0.0	4.0	24.0	72.0	3.68	0.55

Source: Field Survey (February, 2022)

4.7 Students Constraining Factors

Table 4.6 shows the percentage responses, mean scores and standard deviations of students responses to items of constraining factors to quality teaching and learning of physics. The students responses to the items were coded as 1 for never(N), 2 for rarely(R), 3 for sometimes(S) and 4 for always(A).

The most critical issues students saw as restricting the quality of teaching and learning were students finding physics as challenging (3.86) and students being bored about what they do in physics (3.72); physics being too mathematical (3.70); students think they are not good at mathematics (3.68); physics being too mathematical (with a mean score of 2.67); students find it difficult to understand physics they do (2.53); students' curiosity about what they do in physics (2.50). The other factors perceived by students as limiting the quality of teaching and learning were students think physics is too hard (2.34)

Table 4.6: Students' Views on Constraining Factors to Teaching Physics

Statements on constraining factors	Percentage Responses					
	N	R	S	A	Mean value	Std. dev
1. I am curious about what we do in physics	0	0	49.0	51.0	2.50	0.50
2. I am bored with what we do in physics	0.0	8.0	12.0	80.0	3.72	0.60
3. I don‟t understand the physics we do	14.0	20.0	66.0	0	2.53	0.71
4. I find physics challenging	0.0	0.0	14..0	86.0	3.86	0.35
5. I think physics is too hard/difficult	0	18.0	31.0	51.0	2.34	0.75
6. I am not good at mathematics	0.0	10.0	12.0	78.0	3.68	0.65
7. Physics is too mathematical	2.0	37.0	8.0	53.0	2.67	0.63
8. Physics is too mathematical and scares me	0.0	8.0	14.0	78.0	3.70	0.61

Source: Field Data (February, 2022)

4.8 Way Forward for Teachers

Data on the teachers' views on the way forward to improve the teaching and learning of Physics captured the following variables for the presentation of results and findings. These are better in-service education; cluster meetings of Physic teachers for collaboration and experience sharing; development of Physics teachers' practical skills; development of Physics graduates as professional teachers and general improvement in working conditions including salary and incentives as motivations to boast Physics teachers' performance. These factors are presented in Table 4.7.

Table 4.7 shows the percentage response, mean values and standard deviations of teachers responses to items of improving the quality of teaching and learning of physics. The teachers responses to the items were coded as 1 for never(N), 2 for rarely (R) , 3 for sometimes and 4 for always(A).

Table 7 shows that the items relating to the way forward for improving physics teaching and learning were all highly regarded by the teachers, with a mean score of 3.64 and above for all of them. Almost all of the teachers believed that better wages and/or incentives for physics teachers are needed to improve physics teaching and learning. With a mean score of 3.86, this item appears to be the most important for teachers. The next important way forward is to encourage and support more physics graduates to be trained as teachers (3.82). Others were better pre-service education (3.72) and physics cluster meetings to collaborate ideas on physics teaching (3.68). Also, the response of the teachers suggests that they want to witness more teacher professional development in physics practical as the item recorded a mean score of 3.64. The data implies that there is also no significant difference as teachers' views on the way forward could help address the problem of teaching and learning Physics given all the response SD values are less than 1% with a mean value averaging 3.5.

Table 4.7 Teachers' Views on Way Forward to Improve Teaching and Learning of Physics

Statement on the way forward	**Percentage responses**					
	N	**R**	**S**	**A**	**Mean values**	**Std. dev.**
1. Better in-service education	0	6.0	16.0	78.0	3.72	0.57
2. Physics cluster meetings to collaborate ideas on physics teaching	0	8.0	16.0	76.0	3.68	0.62
3. More teacher professional development on physics practical	0	12.0	12.0	76.0	3.64	0.69
4. More physics graduates are encouraged and/or supported to be trained as teachers	0	6.0	6.0	88.0	3.82	0.52
5. Better salary and/or incentives for physics teachers	0	0	14.0	86.0	3.86	0.35

Source: Field Survey (February, 2022)

4.9 Way Forward for Students

This section presents data on students' responses as to how teaching and learning physics can be improved. It captures statements like teaching and learning physics should be practical, the need for adequate laboratory equipment, physics teachers should engage students more during lessons, the need to allocate more time to physics than other subjects and problem-solving should have more examples. Table 8 provides details. Table 8 shows the percentage responses, mean scores and standard deviations of students responses to improving teaching and learning of physics. These items are coded as 1 for never(N) , 2 for rarely (R), 3 for sometimes(S) and 4 for always(A).

From the table 4.8, this was followed by (3.67) mean score of students indicating the need to allocate more time to physics than other subject and finally, Also, the mean score of those indicating physics teachers should engage students more during lessons were (3.53), the mean score of students indicating the need for more practical work to enable them to grasp concepts of physics was (3.48). Again, the mean score of those who indicated the need for laboratory equipment in the schools were (3.44). students who indicated „problem-solving should have more examples in terms of the mean score were (3.43). The data revealed no significant difference in students' perspectives regarding the way forward since all responses given in terms of standard deviation were less than 1.

Table 4.8: Students' Views on Way forward to Improving Teaching& Learning Physics

Statement on the way forward	Percentage responses					
	N	R	S	A	Mean values	Std. dev
1. Teaching and learning Physics should be practical	0.00	0.00	52.0	41.0	3.48	0.50
2. Adequate laboratory equipment	00.0	00.0	55.0	45.0	3.44	0.50
3. Physics teachers should engaged students more during lessons hours	00.0	00.0	47.00	53.00	3.53	0.50
4. Allocating more hours to Physics than any other courses	00.0	00.0	33.0	67.00	3.67	0.47
5. Problem solving should have more examples	00.0	00.0	45.0	55.0	3.43	0.51

Source: Field Data (February, 2022)

4.10 Discussions of Results and Major Findings

The results of this study and major findings are presented in this section. Emphasis has been given to teaching approaches, constraining factors and the ways forward to enhance the teaching and learning of Physics in Senior High Schools.

4.10.1 Teaching approaches

The findings of this study were conducted with physics teachers and students in senior high schools in the Greater Accra Region. The results (2.66) been the mean value indicate that teaching and learning of physics were teacher-centered as opposed to student-centered. This was seen more in students' perceptions. This may seem that students most often did not have the opportunity to be at the center of what happens during classroom physics interaction. From the results, it was clear that students had to follow teaching approaches; which were not appreciated by students. Meanwhile, research has indicated that teaching and learning which is not student-centered is an ineffective way of imparting knowledge on scientific concepts to students (Sunal et al, 2015). The traditional approach to teaching is also demonstrated in the students' responses that indicated that teachers deliver lessons on problem-solving on the Whiteboard without the participation of the students. Again this is an indication that most senior high schools in this study show that teachers still use the traditional system way of lesson delivery. This is in line with the findings of Sunal et al. (2015) who identified that physics interaction classes were dominated by a teacher-centered approach and Whiteboard instruction. In today's competitive environment things are fast changing coupled with increasing technology, it is therefore expected that teachers especially physics teachers adopt new methods of teaching to enhance the knowledge acquisition and skills development of their students so that they can be relevant in any society they find themselves in.

For effective teaching and learning of physics as a way forward from the views of the students for improving teaching and learning of physics is that there should be a need for more practical work so that it puts students at the center of teaching and learning. This study corroborates the findings of Masika (2011) on the view that teaching must be more practical where the teacher guides the students to perform experiments. In addition, the study also supports McDermott and Shaffer (2000) that the focus of physics teaching must be on the students as learners, as close contact with students provides the opportunity to observe the intellectual struggles of students as they try to understand important concepts and principles. Therefore, there should be a more student-centered approach to teaching and learning of physics to boost students' interest in the subject in this modern society in general.

Another way of viewing the traditional approach to teaching and learning physics in senior high schools is that it leads to most students thinking that physics is a difficult and boring subject that can discourage them from pursuing physics in the future. It seems most students will like to take physics as a course just because it is a requirement and not because they like or have an interest in the subject. Physics is a requirement for most of the courses at the tertiary level such as medicine and engineering which means that to pursue such programmes one needs to fulfill the requirement of passing physics. As has been indicated by many scholars, students will be interested in studying physics if the approach to its teaching is made student-centered. Teaching and learning of physics can be boosted by adding technology.

In addition, teaching and learning approaches are not static which means that the system keeps changing and therefore, the need for continuous capacity building for physics teachers so that they can be abreast with the new ways of teaching as suggested by Campbell et al. (2011) who were of the view that teaching and learning of physics can be enriched with other teaching approaches such as simulations, animation and modeling.

The most important teaching approaches of physics identified were:

- Demonstration and discussions to illustrate concepts or phenomena
- Laying emphasis on qualitative thinking and presentation of concepts
- Laying emphasis on mathematical presentation of concepts/students planning and doing their own experiment
- Teacher demonstration of problem-solving on the white board e) Teaching and learning being teacher directed

4.10.2 Factors Constraining the Quality of Physics Teaching and Learning

The results indicated that teachers have the view that there are inadequate professional physics teachers, inadequate laboratory equipment, students' perception about physics and inadequate teachers teaching physics as major constraining factors in teaching and learning physics in senior high schools.

The results also indicated that inadequate laboratory equipment is a challenge to quality teaching and learning of physics in senior high schools. This might be the reason why most science teachers use the traditional teaching approach in presenting concepts on a whiteboard. Teachers using the traditional teaching method is a constrain to the study of physics by students in senior high schools, especially the less endowed senior high schools teaching facilities. Lack or inadequate laboratory equipment also deprive the student of doing more practical work to enhance their knowledge and skills development in the subject. The results further indicated that inadequate professional physics teachers are a constraining factor in teaching and learning physics. This constraining factor is more likely to be seen in senior high schools in the areas rural where most of such schools have inadequate number of science teachers to teach the students. This problem must be addressed by the necessary authorities because failure to do so will lead to a decline in performance in science subjects on the part of the students.

Another constraining factor to teaching and learning of physics as indicated by teachers is students' perception about physics. Students think that physics is a difficult subject to learn and this is consisted with Vosniadou (2007) who also found that most physics students think that the subject is difficult because of the teacher-centered approach used in teaching students. Again, the findings is similar to the report of Wieman et al, (2008) that Physics teaching should include more student interactive approaches than the way it is now, and when physics is taught in this way, the subject would be made more accessible to all students. Other constraining factors identified by teachers were overloaded curriculum and lack of teacher mentors.

The results of the study also showed that students viewed physics as being too mathematical and challenging. This is not surprising because from the previous discussions on teaching approaches. It is clear that most physics teachers in this study used the traditional teaching approach of teaching physics in senior high schools which means that most of the students were going to have difficulty with physics. It was also revealed previously that lack/inadequate laboratory equipment and inadequate teachers are some of the challenges confronting teaching and learning physics in senior high schools. In this regard, it is clear that the system needs to be holistically looked at when it comes to science education.

The main challenges associated with the quality teaching and learning of physics in high schools were (key findings):

- Inadequate professional physics teachers
- Inadequate laboratory equipment
- Students" perception about physics
- Inadequate teachers teaching physics
- Students finding physics as too mathematical
- Students finding physics as challenging
- Students finding physics as too mathematical and scaring them

4.10.3 Way Forward to Improve Teaching and Learning of Physics

The findings from the teachers" responses revealed that some of the ways physics teachers want teaching and learning of physics to be improved. One of the ways teachers want teaching and learning of physics to be improved is for government to enhance the salary and/or incentives of physics teachers. This seems to be most important to the physics teachers. Research has revealed that it is very difficult for institutions to function well without effective reward systems (Nzulwa, 2013). From the above, it can be deduced that for an organization to function well there is a need for effective and efficient financial and non-financial institutions. The same can be said about physics teachers because teachers can do well in teaching and learning physics in the classroom when they are financially motivated. The next important way forward identified was that teachers want to see more teacher professionally developed in physics practicals.

Professional development is crucial to the success of every organization. When employers of organizations continuously train and develop employees, it is likely to help improve performance and hence productivity. The government and the appropriate authorities have the responsibility to make sure science teachers regularly receive professional training to enhance their teaching skills. Supporting more physics graduates to be trained as teachers is another important way according to teachers can help improve the teaching and learning of physics.

These findings bring to light the view held by Timperley (2011) which underscored the need for a teacher professional development to help improve quality. The study also confirms Mizell (2010) as he argues that effective professional development provides the teacher with adequate information and skills needed to address students" learning difficulties. On the other hand; as discussed earlier on, inadequate number of teachers in physics in senior high schools are a major challenge. Many senior high schools in the rural areas seem to be the major affected as compared to those in the urban centers. Most schools are not performing in physics and other science subjects such as biology and chemistry because there are not enough science teachers to help the children acquire the needed knowledge and skills. These findings are similar to the work of Loucks-Horsley et al. (2010) whore are of viewpoint that the need for Physics teachers to have strong content knowledge and pedagogical skills for teaching the subject. Again, the study shows that for the situation of teaching and learning physics to improve, there is the need to train more graduate teachers who will help the students to perform well in the subject. Other ways to improve the teaching and learning of physics as revealed by the results were better pre-service education and physics cluster meetings to collaborate ideas on physics teaching.

Regarding findings of students views on the way forward to improving the teaching and learning of physics in senior high schools, students suggested that there is needed for the appropriate authorities to provide the schools with adequate laboratory equipment to help improve the practical aspect of teaching and learning of physics. The findings confirm the position of Dünser et al., (2012) who contended that adequate technology given sufficient laboratory equipment would help provides physics educators with an exciting interactive environment to engage learners and enhance their understanding of key concepts. Another way students thought could improve the teaching and learning of physics is by giving teachers enough training on the subject. Some of them were of the view that the way and manner some of the teachers teach the subject makes physics even more difficult to understand. This collaborates the way forward identified by the teachers as their responses showed that there is the need for more teacher professional development in physics practicals. This is an acknowledgment from the teachers themselves that some of the teachers find it difficult to teach the subject to the understanding of the student. This is a worrying situation because there is already the perception that physics as a subject is too difficult and boring and it is obvious that students find it difficult to understand what the teacher teaches them which further compounds the problem.

CHAPTER FIVE

SUMMARY, CONCLUSION AND RECOMMENDATIONS

5.0 Introduction

This chapter provides conclusions of activities of the study which explored the factors affecting teaching and learning of physics in Ghanaian Senior High Schools Greater Accra. This final chapter focuses on the main findings of the study. It also draws some important conclusions based on which some recommendations are made for policy consideration.

5.1 Research Questions

1. What are the views of teachers and students on teaching approaches to physics in Senior High schools in Greater Accra?
2. What are the teachers and students constraining factors towards teaching and learning of physics in Senior High Schools in Greater Accra?
3. What are the solutions of teachers and students to the challenges to the teaching and learning of physics in Senior High Schools in Greater Accra?

5.2 Summary of the Research Findings

The study made use of quantitative research technique. A summary of the major research findings on the objectives is presented here. The first research objective captures views of teachers and students on teaching approaches to physics in Senior High schools in Greater Accra. The study revealed that the most important teaching approaches of physics adopted by teachers were: demonstration and discussions to illustrate concepts/phenomena; laying emphasis on qualitative thinking and presentation of concepts and laying emphasis on mathematical presentation of concepts and students planning their experiment own. Other teaching approaches to physics were; teacher demonstration of problem-solving on the whiteboard; and Teaching and learning being teacher-centered.

The second research objective has to do with challenges associated with the quality teaching and learning of physics in high schools. The key findings revealed that inadequate professional physics teachers, the inadequacy of laboratory equipment, students" perception about physics and the limited numbers of physics teachers were major constraining factors. Other issues identified as challenges to the quality of teaching and learning physics were; students finding physics too mathematical and scary; students finding physics as challenging.

The third research objective had to do with way forward to improve the teaching and learning of physics in senior high schools. The findings indicate the need for; better salaries and/or incentives for physics teachers; an increase in physics teachers' professional carrier development; and the need to encourage and support more physics graduates to be trained as teachers. The findings revealed the need for a better pre-service education; organizing physics cluster meetings to collaborate ideas on physics teaching and the provision of adequate laboratory equipment.

5.3 Conclusions

The findings of the study lead to several conclusions as far as teaching and learning of physics in senior high schools are concerned. First, the demonstration and discussions of the findings to illustrate concepts/phenomena, emphasizing qualitative thinking and presentation of concepts, emphasizing mathematical presentation of concepts and students planning and doing their own experiment, teacher demonstration of problem-solving on the whiteboard and teaching and learning being teacher-centered are the main teaching approaches of physics in senior high schools.

With regards to challenges in teaching and learning physics in senior high schools; the findings from the study revealed by students that physics teachers use more traditional approaches to teaching and learning of physics in senior high schools. Further findings indicate that the main constraining factors of teaching and learning physics in senior high schools were inadequate professional physics teachers, inadequate laboratory equipment, inadequate number of physics teachers and students' perceptions regarding physics as too mathematical and challenging subjective to study. With the inadequate professional physics teachers, there is the need for the appropriate authorities to put measures in place to ensure that physics teachers still receive training even after school. The point is that because of the limited time spent in school by physics teachers, it is most often difficult for them to acquire all the knowledge they need to function well in their teaching job.

On way forward to improving the teaching and learning of physics, the study revealed by teachers were better conditions of service including enhanced salary and/or incentives for physics teachers; resourced science laboratories to enhance the teaching and learning; professional carrier development of physics teachers on physics practical; coupled the training of more graduate teachers. Therefore, the onus lies on the government and the appropriate agencies responsible for the education sector to provide the necessary laboratory equipment to facilitate the teaching and learning of physics. This problem must be addressed by the necessary authorities because failure to do so will lead to a decline in performance in science subjects on the part of the students. This suggests that there is a need for physics teachers to adopt new and modern methods of teaching such as modeling, animation and stimulations to assist students to understand the subject. For students to have an interest and enjoy teaching and learning physics, there is a need to address the challenges discussed above.

5.4 Recommendations

Below are the recommendations based on the findings

1. Ghana's Ministry of Education and the Ghana Education Service should make provision for regular professional development of physics teachers.
2. The Government of Ghana should improve the conditions of service to physics teachers; better salaries and allowances will boost their morale.
3. Non-Governmental Organizations should consider awarding best performing physics students and physics teachers for further studies.
4. The administrators of senior high schools and Parents Teachers Associations (PTA) should consider introducing initiatives such as physics levy to help equip science reso
5. There must be better salary and/or incentives for physics teachers
6. More teacher professional development on physics practical
6. Encouraging and supporting more physics graduates to be trained as teachers
7. There must be better pre-service education
8. There must be physics cluster meetings to collaborate ideas on physics teaching
9. Provision of laboratory equipment.

5.5 Suggestions for Future Research

Firstly, the study used just three senior high schools from the Greater Accra Region. Future studies may look at other schools in other regions, especially those in the rural areas.

Secondly, future studies may look at factors affecting teaching and learning at the tertiary level, which can help policymakers to make a holistic decision on how science is taught in schools. There should be comparative studies from other regions.

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APPENDICES

APPENDIX A

QUESTIONNAIRE FOR TEACHERS

UNIVERSITY OF EDUCATION WINNEBA

Questionnaire

TOPIC: **FACTORS AFFECTING TEACHING AND LEARNING OF PHYSICS IN GHANAIAN SENIOR HIGH SCHOOLS: A CASE STUDY IN THE GREATER-ACCRA REGION.**

Dear Teacher,

This questionnaire seeks your opinions and concerns about factors affecting teaching and learning physics in Senior High schools. The questionnaire is part of master's research being done at the University of Education, Winneba. Your response will be treated confidentially and will be used for research purposes only. No person or school will be identified in the research. Your cooperation is greatly appreciated.

Section A

DEMOGRAPHICS

1.Gender [a] male [ ] [b] female [ ]

2.Age [a] 21-30 [ ] [b] 31- 40 [c] 41- 50 [ ] [d] 51 and above [ ]

3.What is your highest level of educational attainment? (Tick that apply)

PhD [ ] M.Sc. [ ] M.Ed. [ ]

1st Degree (BSc/BA) [ ]

1st Degree [ ]

Post Graduate Diploma [ ]

Diploma [ ]

Others (Specify)……………………

4.How many years of teaching experience have you had as a physics teacher?

<1year	[ ]
1 – 2	[ ]
3 – 5	[ ]
6 – 10	[ ]
11 – 15	[ ]
Above 15 years	[ ]

Section B: Classroom Practices

How often do you practice the following activities in your physics classroom? Please indicate by *ticking* the appropriate options

Section C: Constraining factors

Indicate your level of agreement with the following statement on constraining factors

N = Never, R = Rarely, S = Sometimes, A = Always

Statement	N N	RR	SS S	AA
Constraining Factors				
. Students" perception about physics	PE			
. Parental and societal perception about the difficulty of physics				
. Inadequate professional physics teachers				
. There is too much mathematics concepts in physics				
. Inadequate teacher subject knowledge				
. An overloaded curriculum				
. Insufficient classroom teaching time				
. Inadequate physics teachers				
. Inadequate laboratory equipment				
. Lack of technical support				
. Lack of teacher mentors				

Section D: Way forward

Indicate your level of agreement with the following statement on the way forward

N = Never, R = Rarely, S = Sometimes, A = Always

tatement	N N	R R	S S	AA
Way Forward				
. Better in-service education				
. Cluster meetings physics teachers to collaborate ideas on physics teaching				
. More teachers are to embark on professional development in physics practical				
. More physics graduates are to be encouraged and/or supported to have professional training as physics be trained as teachers				
. Better salary and/or incentives for physics teachers				

THANK YOU FOR YOUR TIME

APPENDIX B

QUESTIONNAIRE FOR STUDENTS

UNIVERSITY OF EDUCATION WINNEBA

TOPIC:FACTORS AFFECTING TEACHING AND LEARNING OF PHYSICS IN GHANAIAN SENIOR HIGH SCHOOLS: A CASE STUDY IN GREATER-ACCRA REGION

Dear Student,

This questionnaire seeks your opinions and concerns about factors affecting teaching and learning physics in Ghanaian schools. The questionnaire is part of master's research being completed at the University of Education, Winneba. Your response will be treated confidentially and will be used for research purposes only. No person or school will be identified in the research. Your cooperation is greatly appreciated.

1. Gender [a] male [ ] [b] female [ ]

2.Age

10 – 14 [ ]

15 – 19 [ ]

20 – 24 [ ]

25 and above [ ]

Section B: Classroom Practices

How often do the following practices happen in your physics classroom? Please indicate by *ticking* the appropriate options

N = Never , R= Rarely, S= Sometimes A= Always

Statement	N	R	S	A
Teaching Approaches				
The teacher presents new materials on the whiteboard				
The teacher demonstrates problem-solving on the whiteboard (e.g. solving examples of physics problems)				
The teacher emphasizes the mathematical problem solving of new concepts				
Teacher emphasizes understanding of new concepts (qualitative thinking)				
The teacher uses demonstrations and discussions to illustrate concepts/phenomena				
Teaching and learning is teacher-centered(the decides what happens)				
Teaching and learning are students- centered (the students get a say in what happens)				
The teacher uses students" suggestions and ideas in teaching				
The teacher engages students in context based-activities (e.g. experiments or field trips)				
Students work with physics problems individually				
students work with physics problems in groups				
I have the opportunity to explain my own ideas				
We choose our own topics to investigate				
We do experiments by following instructions from the teacher				
We plan and do our own experiments				

Section C: Classroom Activities II

Indicate your level of agreement with the following statement on classroom practices

N = Never , R= Rarely, S= Sometimes A= Almost always

Statement on teaching approaches	N	R	S	A
Teacher presenting new materials on a whiteboard				
Teacher demonstrating problem-solving on the whiteboard (e.g. solving examples of physics problems)				
Emphasis on the mathematical problem solving of new concepts				
Emphasis on the understanding of new concepts (qualitative thinking)				
Use of demonstrations and discussions to illustrate concepts/phenomena				
Teaching and learning being teacher-centered				
Teaching and learning being student-centered				
Teachers using students" suggestions and ideas in teaching				
Teacher engaging students in context based-activities				
Working with physics problems individually				
Working with physics problems in groups				
Having the opportunity to explain your own ideas				
Doing experiments by following instructions from the teacher				
Planning and doing your own experiments				

Section D: **Constraining factors.**

Indicate your level of agreement with the following statement on the way forward

N = Never , R= Rarely, S= Sometimes A= Almost always

Statement on constraining factors	N	R	S	A
I am curious about what we do in physics				
I am bored with what we do in physics				
I don‟t understand the physics we do				
I find physics challenging				
I think physics is too hard/difficult				
I am not good at mathematics				
Physics is too mathematical				
Physics is too mathematical and scares me				

Section E: Way forward

Statement on way forward	**N**	**R**	**S**	**A**
39. Teaching and learning physics should be practical				
40. Adequate laboratory equipment				
41. physics teachers should engage students more during lessons hours				
42. Allocating more hours to physics than any other courses				
43. Problem solving should have more examples.				

THANK YOU FOR YOUR TIME.

APPENDIX C

MEANS AND STANDARD DEVIATIONS OF THE QUESTIONNAIRE ITEMS OF TEACHERS

Descriptive Statistics

Responses	N	Mean	Std. Deviation
I present new materials on white board	50	3.54	0.70
I demonstrate problem-solving on the white board	50	3.68	0.58
I lay emphasis on mathematical presentation of concepts	50	3.54	0.73
I lay emphasis on qualitative thinking and presentation of concepts	50	3.76	0.55
I use demonstrations and discussions of illustrate concepts and phenomena	50	3.86	0.58
Teaching and learning is teacher centered	50	3.70	0.61
Teaching and learning is students' centered	50	3.80	0.57
I engage students in context based-activities	50	3.62	0.56

Students work with physics problems individually	50	3.74	0.56
Students work with physics problems in groups	50	3.68	0.65
Students have opportunity to explain their own ideas	50	3.74	0.56
Students do experiment by following instructions from the teacher	50	3.70	0.45
Students plan and do their own experiment	50	3.80	0.57
Valid N (list wise)	50		

Descriptive Statistics			
	N	Mean	Std. Deviation
Student's perception about physics	50	3.84	0.51
Parents and societal perception about the difficulty of physics	50	3.88	0.32
Inadequate professional physics teachers	50	3.98	0.14
There is too many mathematical concepts in physics	50	3.84	0.42
Inadequate teacher subject knowledge	50	3.78	0.54
An overload curriculum	50	3.68	0.69
Inadequate physics teachers	50	3.72	0.60
Inadequate laboratory equipments	50	3.88	0.32
Lack of technical support	50	3.88	0.32
Lack of teacher mentors	50	3.68	0.55
Valid N (listwise)	50		

Descriptive Statistics			
	N	Mean	Std. Deviation
Better in-service education	50	3.72	0.57
Physics cluster meetings to collaborate ideas on physics teaching	50	3.68	0.62
More teacher professional development on physics practical	50	3.64	0.69
More physics graduate are encourage and/ or supported to trained as teachers	50	3.82	0.52
Better salary and/ or incentives for physics teachers	50	3.86	0.35
Valid N (listwise)	50		

APPENDIX D:

MEANS AND STANDARD DEVIATIONS OF QUESTIONNAIRE ITEMS OF STUDENTS

Descriptive Statistics			
Responses	**N**	**Mean**	**Std. Deviation**
Teacher presents new materials on the white board	300	2.66	0.67
Teacher demonstrates problem-solving on the white board (e.g. solving examples of physics problems)	300	3.64	0.69
Teacher emphasizes the mathematical problem solving of new concepts	300	2.59	0.55
Teacher emphasizes understanding of new concepts (qualitative thinking)	300	2.50	0.52
Teacher uses demonstrations and discussions to illustrate concepts/phenomena	300	2.50	0.56
Teaching and learning is teacher directed (they decides what happens)	300	2.66	0.67
Teaching and learning is students-	300	2.61	0.62

centered (they decides what happens)			
Teacher uses students' suggestions and ideas in teaching	300	2.40	0.63
Teacher engages students in context based-activities (e.g. experiments or field trips)	300	2.40	0.70
Students work with physics problems individually	300	3.72	0.57
Students work with physics problems in groups	300	2.29	0.74
I have opportunity to explain my own ideas	300	2.67	0.61
We choose our own topics to investigate	300	2.59	0.55
We do experiments by following instructions from the teacher	300	2.66	0.67
Teacher guide students to plan and do our own experiments.	300	3.72	0.57
Valid N (listwise)	300		

	N	Mean	Std. Deviation
I am curious about what we do in physics	300	2.50	0.50
I am board about what we do in physics	300	3.72	0.60
I don't understand the physics we do	300	2.53	0.71
I find physics challenging	300	3.86	0.35
I think physics is too hard/difficult	300	2.34	0.75
I am not good at mathematics	300	3.68	0.65
Physics is too mathematical	300	2.67	0.63
Physics is too mathematical and scares me	300	3.70	0.61
Valid N (listwise)	300		