Teachers' Perceptions About Inquiry in Science Education

Master Thesis in Science Education
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Tiivistelmä – Abstract

Teaching and learning of science have continue to receive greater attention across the world due to their immense contribution to socio-economic development. The problem, however, is the decreasing number of students who enter tertiary institutions to further their studies in science related courses; a serious concern in most developed and developing countries. The issue has prompted governments of many countries including the United States, Canada, Australia as well as continental bodies like the European Union to introduce policies aimed at promoting the interest of students in science across all school levels.

One teaching approach that is currently enjoying monumental support across the globe for teaching science is 'inquiry'. To examine the perception of science teachers about the use of inquiry, a qualitative study was conducted in Eastern Finland with seventeen participants including seven teachers from 6th to 9th grades and ten student teachers being trained to teach at 7th to 10th grade. Data was collected using email questionnaire and paper-based questionnaire. Qualitative content analysis was used for the study.

The findings showed that both teachers and student teachers shared similar views and overwhelmingly endorse the use of inquiry in science. Inquiry-based teaching and learning has the potential to purposefully awake and sustain interest of students and promotes positive attitudes of students to learning science. It is perceived that inquiry as useful teaching and learning strategy to achieving learning outcomes as it promotes understanding of scientific concepts and enhances memory trace and active participation of learners in science lessons.

The study also found out that despite the numerous benefits of inquiry-based teaching and learning, challenges that confront teachers in its implementation in science classrooms. Common problems identified by the two groups include time for implementation of inquiry which usually is restricted by the curriculum, large class size, and teacher's own and judgment. Similarly, inadequate resources and equipment were found to be a limitation to an effective implementation of inquiry-based learning in science lessons.

Avainsanat – Keywords
Inquiry, Inquiry-based learning, Students' interest, Constructivism.

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1 Introduction

Educators today are required to be highly knowledgeable to improve academic standards in schools. Teachers have the responsibility of imparting knowledge and training the current generations with the needed knowledge and skills to fit into this current global world (Barnard, 2004). Due to the dynamic nature of the society, teachers have the responsibility to play new roles geared towards improved teaching quality in schools (Ampadu, 1998). Science for many is a complex subject and covers a wide range of knowledge and that research literature on its education comes with many students' misconceptions as well as their difficulties as they learn science (Duit & Treagust, 2003; Skamp, 2008). Therefore, there is the need to provide a serene environment that will motivate students to study science to acquire the knowledge and skills so that they can take up the challenge of making the world safer and better place.

Harlen (2009) posits that science education aims at developing scientific literacy and the capacity for continual learning. To her, scientific literacy means one's ability to effectively and efficiently work with wide range of scientific ideas, with nature of science and its limitations, and with science processes as well as having the competency to apply the gathered ideas to make informed decisions as a concerned citizen (p. 34). Scott et al. (2007) are of the view that as a responsive task, several external factors affect teaching. They however believe that some approaches may be better in terms of effectiveness compared to others. These are teaching approaches that are aligned to clearly stated objectives, and offer activities that arouse and sustain, students' interest, calls students to think critically through engagement or offer students the chance to communicate their progressive understandings (p. 51).

The choice of my topic has been informed by my experience as science student and science teacher. As a student, I was taught by different teachers at the secondary school. Most of their methods were teacher centred and we were always expected to study science by rote. We had to sit quietly in class as teacher explained concepts after which notes had to be written from the chalkboard. As a science teacher at the Junior High School in Ghana and Secondary School in South Africa, activity based learning formed a greater part of the science curricula of the two countries stressing students' active participation as an essential ingredient in the process of teaching and learning. These methods always promote students understanding and students feel at ease during science lessons; even those with negative attitudes towards

science related subjects. As a master student in Educational Sciences and having gone through many different courses and how these courses are instructed, I have come to appreciate the important role inquiry plays in teaching and learning: showing the direction of teaching and learning, motivating students as well as enhancing students' understanding.

It has emerged from various reports of a significant drop in students' interest and enrolments in science education in secondary schools and more especially at university level in some OECD countries. For instance, Dekkers & De Laeter (2001) as well as Goodrum, Hackling & Rennie (2001) have reported of growing disinterest of Australian students for science. The same problem has been identified in France and the United States as reported by Lyons (2006) and in Germany by Haas (2005). The situation is not different in the United Kingdom (Murphy & Beggs, 2003). OECD (2006a) also reports of how the number of young people who specialises in science related subjects has been decreasing constantly although the overall number of young people entering university is growing steadily. Archer et al. (2010) postulate that at age 10, the attitudes of many children towards science is positive but at age 14, these interests drastically decline. Rogers & Ford (1997) attribute increases in negative attitudes towards science to some unpleasant experiences that they encounter in previous courses in science which finally result in the formation negative perceptions. In their study, Lloyd, Neilson, King, & Dyball (2012) found that student's negative perception about science result from inappropriate teaching strategies adopted by science teachers.

The European Commission has set a guideline for all European countries which envisions that: by 2020 people within 15 years who have insufficient capabilities in reading, mathematics and science should be less than 15 %. For this and other reasons the Commission tasked a team of experts to "critically examine samples of initiated programmes and to gather reasonable knowledge and practice proven to produce positive results aimed at bringing about an extreme change in the interest and attitudes of young people towards science studies and to identify also the necessary requirements that must be met (European Commission, 2007). The team after their work presented a report which recommended inquiry methods to be used by science teachers in Europe to arouse students' interest and provide them with the needed scientific knowledge and skills.

Other studies and projects on inquiry-based learning have also been sponsored by the Commission aimed at providing solutions to the dwindling interest in science education in

member countries (e.g. Rocard et al. 2007; Eurydice 2008 see https://webgate.ec.europa.eu/fpfis/mwikis/eurydice/index.php/Publications; PRIMAS 2013; Mascil 2014; Fibonacci Project 2012, see http://www.fibonacci-project.eu) with all recommending the use of inquiry-based methods in science teaching and learning. Per Fibonacci project (2012), the emphasis on inquiry-based education is because an effectively carried out inquiry lesson "facilitates understanding ... first-hand experiences are important, particularly for younger children, but all learners need to develop the skills used in testing ideas – questioning, predicting, observing, interpreting, communicating and reflecting" (p. 5).

It is not surprising therefore that most countries have also introduced educational policy doctrines in recent times advocating for inquiry-based science or scientific inquiry as a solution to the present challenges facing science education (Goodrum et al., 2001; Miller, Osborne & Nott, 1998; National Research Council [NRC], 1996, 2000, 2007). Indeed, the use of inquiry in Finnish science lessons is evident as I have been instructed through this approach. I also had the opportune time to interact with some student teachers who were taught how to use inquiry in teaching. There were miss feelings in their responses to using the approach in the teaching and learning of science. Hence my quest to finding out the views of both teachers and student teachers on the use of the approach. It is believed that the study will provide the needed information about how inquiry in science is observed by preservice and in-service teachers in this field of education.

2. Theoretical Framework

In the school, the teacher is credited with the role of mediator between the learner and what the learner learns. Due to the changing needs and aspirations of societies, teachers have no option than to embrace new knowledge, ideas, skills, and technology to promote effective teaching and learning to help students develop interest in their respective fields. Different teaching approaches have been outlined and are being adapted and applied in the classroom. There remains the question as to whether the approaches and methods being used by teachers really promote students' interest especially in learning science which has taking the centre stage in the development of the world.

In an ongoing debate, many are advocating for the use of teaching methods that principally focus on learner in the teaching and learning process. One of such approaches to is the inquiry-based learning which is being researched into by many researchers around the globe. Inquiry is rooted in constructivism. This study therefore takes its theoretical framework from the constructivist theory of learning which proposes that learners create their own knowledge as they experience new ideas, interact and actively get involved with the learning environment while teachers act as facilitators and guides who assist these learners to construct accurate knowledge (Ward, 2001).

2.1 Theories of learning

The evolvement of learning theories over the years has brought enormous implications to education. Different schools of thought have come up with these theories to guide the teaching and learning activities that are adopted by educators in their fields of teaching. Brief descriptions of behaviourism, cognitivism and constructivism which are related to this work are provided.

2.1.1 Behaviourism

Behaviourism is an approach in psychology which maintains that behaviour that can be observed and measured is the only appropriate subject matter that can be scientifically subject to psychological investigation (Reber, 1985 p. 86). Leonard (2002) defines behaviourism as the conviction that teaching is attained through visible, quantifiable and manageable goals a

teacher sets for learners to meet to obtain explicit group of responses resulting from a controlled set of stimuli.

Jonassen & Jonassen (2004) also see behaviourism to be related to what the teacher requires the learner to learn under the direction of the teacher. Behaviourism is a theory of learning which lays emphasis on learner's behaviour as well as the behavioural change which will be manifested after learning takes place (Woollard, 2010 p.10). These different definitions point to one central theme that behaviourists are of the firm conviction that learning is said to have occurred when there is change in behaviour which can be observed publicly. To the behaviourist, learning is a continuous change in achievement or prospects of performance resulting from an encounter with 'experience' as well as 'interaction' of the learner with the environment. (Driscoll, 2000 p.3).

To Cohen *et al.* (2004) teaching approaches adopted by behaviourist include strategies aimed at inducing learning by reception. The concept of the presented material must be in-cooperated into the already existing body of knowledge. Some methods that are born out of behaviourist theory include among others

- Dogmatic method: principles and rules to be followed by learner to solve a given problem is clearly and emphatically given by the teacher. Teacher owns and gives information while the student sits back and listens to the teacher and puts down notes.
- Lecture Method: teacher explains concepts to students whiles students attentively listens. There is one way communication in which information flows from the teacher to the learner. (Adentunde 2007).
- Content-focused teaching methods: this method boarders on the teaching of the whole class without considering the abilities and background knowledge of the individual learners. (Ball & Kuhs 1986).

During behaviourist lessons, the owner of knowledge is the teacher and students therefore usually acquire knowledge based on what they are told by the teacher. In such classrooms, students constantly give factual answers to questions on topics they have learnt. It is the teacher who determines the level of learners' understanding and these learners unequivocally give credence to teacher's decisions as well as answers (Confrey 1990).

Despite its widely acceptance, many concerns have been raised by critics about behaviourist theory of learning. Naik (2003) notes that behaviourists are unable to provide an explanation on how human behave and learn because they fail to accept the mental processes of the individual and how knowledge is constructed by the individual. It is argued by Berglas (2002) that approach adopted by behaviourist has a single dimension to behaviour and offers no opportunity for one to willingly accept and fails to consider influences from within the individual. It does not give room for factors like feelings, the mood of the individual as well as his or her thoughts. Davis & Davis (1998) also contend that creating new knowledge surpasses external behaviour that could be observed, which does not give credence to sense making, description and conception.

Abrams & Lockard (2004 p. 6), believe that the heart of behaviourism which is the principle of reinforcement, fails to fully describe the whole nature what goes into "thinking, memory, problem solving, and decision making". Behaviourism therefore promotes competition and encourages individual work. It rather focuses on gifted students and give no attention average and student and those below average in the classroom. For the reasons enumerated above among others, psychologist and researchers have advocated for new theories of learning that caters for the learner's interest and motivation as well as their active participation in the process of teaching and learning.

2.1.2 Cognitivism

The work of the human memory is entirely different from the scanner or videotape. Mental models are rather constructed constantly through interactions with the environment (Gilovich et al., 2002). Cognitive theory is largely concerned with the intercommunication that exist between mental constituents and the information which is processed via a composite network (Neisser, 1967). To Baron & Byrne (1987), cognitive theorists believe the combination of occurrences into an active system of storage which is made up of organizational structures (schemata) constitute learning. During the learning process the individual actively creates cognitive structures which determine their self-concepts as well as that of the environment (McEntire, 1992). Psychologist differ in approaches to discovering human learning and behaviour. Mayer (1981) opines that some psychologists put much premium on comprehensive examination of skills for processing information. To others, the concentration is on mental representation and the development of intellect.

To Bell-Gredler (1986), the schemata are very important in human cognition. Their functions include to accumulate and keep information in long-term memory and construct substructures where fresh facts and ideas are placed so that the receiver can understand. The schemata modulate consciousness, arrange the exploration of things around the individual. As (Baron & Byrne (1987) summarise it: the schemata are applied by the human mind to carefully assemble every information received by the individual from the environment and manage it to make sense out of it. In accordance with one's interest, motivation, and perceptions the system chooses, arranges and encodes new information for storage (Bell-Gredler, 1986).

Cognitivist theory of learning is also referred to as information-processing literature of learning, (Rumelhart & Norman's 1978; Norman, 1978, 1982). Rumelhart & Norman (1978) identify three different phases of the learning process which have been summed up by Norman (1982, p. 81):

- Accretion: adding new knowledge to already existing memory schemas. The framework already exists; however, fresh data are added. Accretion to Norman is the commonest way of learning.
- Structuring: the generation of rather new conceptual structures; new conceptualizations. The existing schemas will no longer serve any purpose, and that new schemas are required. The structuring process does not occur frequently and usually demands great pain and strive. Norman believes that structuring is arguably the most essential of all other modes.
- Tuning: the reasonable regulation of knowledge to adapt to given task(s). The actual schemas prevail and suitable knowledge if found in them. However, they are insufficient to achieve the desired goal. This may be attributed to the fact that they are extremely unfocused they to meet the required standard for use. Therefore, constant knowledge tuning and regulation is required to direct it to the task. One way by which tuning could be accomplished is through continuous practice. Thousands of hours may be needed for constant practice for one to reach a tuning stage where one becomes an expert. Norman opines that the slowest of the modes of learning is probably tuning. Nonetheless, tuning is what transforms bare knowledge of a topic into masterly performance.

To Norman, the sequential order of the three modes of learning is only tentative. He believes that they need not follow any sequential order and that a student can at the same time accrete

knowledge in an aspect of a topic and restructure knowledge in a different aspect of the same topic (Norman, 1982).

2.1.3 Constructivism

The constructivist theory fundamentally hinges on the efforts of Piaget, Vygotsky, Bruner and John Dewey's philosophical ideology. Woolfolk *et al.* (2008) state that many researcher and authors have given different opinions about constructivism. Confrey (1990 p. 107), defines constructivism as an idea that any knowledge the result of we create in our minds. Lambert *et al*. (1995) on their part see constructivism as a learning theory which assert that past encounters and convictions, together with cultural backgrounds and worldviews of individuals meaningfully contribute to the process of learning and that these factors have an impact on the way they deal with and give meaning to their experiences with new concepts and phenomena. Commeyras (1995) argues students rather than the teacher, should be allowed to be the front runners in class questioning as well as discussion which would lead students to a more meaningful learning while teachers also gain new experiences from their students. Commeyras therefore calls for the extension beyond a change in content that simply harmonizes children's own interests within the curriculum framework, to a complete overhaul and reframing of the whole teaching process.

Orton (2004) holds that within the constructivist paradigm, students have the chance to make use of their already existing knowledge, encounters, findings and conceptions to construct new concepts, and the focal point is the formation of new concept and not teaching for acquisition of concept, which is the norm in behaviourist classrooms. In Bruning et al. (2004, p. 195) view, constructivist learning theories generally offer teachers and for that matter educators a deeper understanding of how students acquire new knowledge and these theories premise on two core principles: that learners are active constructors of their own knowledge; that social interactions constitute essential feature for the construction of knowledge.

Ward (2001) observes that construction of new knowledge by the individual learner occurs as he or she encounter new experience, interact and actively participate in activities within his/her learning environment. Learners construction of new knowledge is pivoted on already

existing constructed knowledge. Students therefore grasp the concepts easily and progressively go beyond simply knowing a given concept to full understanding of the concept. Engagement, reflective thinking, and problem solving are the activities that characterise constructivist classroom (Abrams & Lockard 2004). The external world of the learner has a great influence knowledge acquisition and it is largely dependent on how individual utilises his/her cognitive frame for the construction of knowledge (Glasersfeld, 1989).

Ward (2001) opines that teachers play crucial roles in guiding and assisting students to construct accurate knowledge as they explore the environment and meet varieties of ideas. Vygotsky (1978), believes learning first occurs as the individual learner interacts with others before he or she internalises it. He adds that from their lower receptive level of thinking, individual learners can move to higher levels of thinking with guidance from knowledgeable adult or peer. Moving from the lower thinking level to the higher level, there is a gap and this gap is what Vygotsky terms 'Zone of Proximal Development' (ZPD). To him, Zone of Proximal Development is the gap between the already existing knowledge of the individual and what he/she knows not, and may need a higher level of thinking than what the student possesses.

Atherton (2013) maintains that in the process of learning, the focus is on the one described as "maker of meanings". The teacher's role is to dialogue with learners, guide them to make meaning of the material to be learned, and to help them to revise their understanding until it is in tune with that of the teacher. Teacher may gradually challenge the learners to achieve more as he or she observes them to bridge the two developmental levels of ZPD (Gray & Macblains, 2015). The lower level gives the threshold measure of what could be achieved independently by a learner. The higher level is what the learner achieves through teacher's guidance. Learning strategies of constructivists are self-regulated and allow the individual learners to take full responsibility of their own learning and to engage with the external world to construct new knowledge (Woolfolk *et al.* 2008).

Draper (2002) opines that constructivism is a descriptive learning theory and that changing it from a learning theory to theory of teaching remains a major challenge that needs to be addressed. To Draper, the implementation of constructivist theory may require an overhaul of practices that already exist in the classroom. The implementation of constructivist approaches

may be difficult for most teachers in their respective classrooms because there are many problems which come with their application especially during the teaching of concepts that are abstract in nature.

The application of cooperative or group learning, a characteristic of constructivism in the classroom poses several challenges. Gillies (2003) opines that some cooperative learning may not lead to conceptual understanding since merely grouping students and giving them work to do may not in itself encourage cooperative learning. Pijls et al. (2007) have established that a teacher may find it extremely difficult to observe students as they work collaboratively (p. 309). In her study, Boaler (2006) found out that when students work in groups, not always does it yield the expected result since some students often do more compared to others in the same group.

2.2 Review of related literature

In exploring work previously done by researchers, writers and authorities which are related to the topic under consideration, this chapter embodies the review of literature related to the topic documented by some writers, authorities, and researchers. The literature was reviewed under these themes: Meaning of inquiry, forms of inquiry, importance of inquiry, use of inquiry and challenges associated with inquiry-based learning.

2.2.1 Definition of Inquiry Based Learning

Inquiry definition over a decade has been discussed, agreed, and disagreed by science educators (Bloom 2006). The meanings and approaches to the application of inquiry have also been interpreted differently, leaving science teachers in a dilemma in implementation of these approaches in the actual classroom. (Anderson 2002; Kielborn & Gilmer 1999). However, Bhattacharyya, Volk & Lumpe (2009, p. 200) believe that what is generally agreed by science educators is that the focal point of science teaching and learning must be geared towards the development of science inquiry skills and not a mere knowing of scientific facts and concepts, and that the best approach to developing these inquiry skills is doing science.

The National Research Council (1996) seeks to compare scientific inquiry and inquiry in science education:

- Scientific inquiry describes the various procedure scientists adopt to explore the world and proffer evidence-based report obtained from their work.
- Inquiry could also mean the tasks students perform through which they broaden their repertoire of knowledge and comprehension of science related facts and develop clearer views on the way scientists investigate to know more about the natural world.
- In conducting inquiry, the inquirer needs to identify assumptions, apply critical and analytical thinking, and take into cognisance alternative explanations which are the prerequisites. Students undertake some activities in chosen areas of inquiry through which they gain insight into the procedure scientists use to know the natural world. The expectation is that students through these activities develop the needed skills to handle full inquiries on their own (p.23).

Hofstein & Lunetta (1982, 2004) also see scientific inquiry as a procedure scientists adopt to conduct investigation into the natural world as well as the activities through which science-acquired proofs from study are interpreted. Similarly, Lunetta, Hofstein, & Clough (2007) reviewed literature on inquiry and concluded with definition of inquiry as the process through which problems are identified, questions are formulated, investigations are designed and planned, data are collected and analysed, results from the study are summarised, conclusions are reached and the research is communicated.

Inter Academy Panel (IAP) (2012) view inquiry based science education as a gradual development of principal scientific concepts of students as they learn the appropriate ways of doing investigation and successfully enhance their knowledge as well as how they understand the natural world. Usually, students adopt the skills used by scientists including questioning, collecting data, analysing and making review of evidence using what is known already, making deductions, and exchanging views about the results. Inquiry-based instruction aids the learning (the teaching act together with its supporting justifications) (IAP 2012). Inquiry-based learning covers a collection of instructional strategies connected at a convergent area where students go to explore to find answers to questions and solve problems (Aditomo et al 2013). Inquiry can also be the process through which questions are posed and investigated for answers (Quintana et al., 2004, p. 341). Egbert (2009, p. 157) observes that inquiry in education has been used to mean terminologies like research, investigation, guided discovery.

He remarks that as the inquiry process progresses, students pose questions and explore for appropriate answers to them.

Per their definition, there are different stages in organising inquiry including problem diagnose, analysis of experiments, alternatives determination, investigations planning, making hypothesis, exploring for information, models construction, exchanging views among peers, and making reasonable arguments (Linn, Davis & Bell, 2004, p. 16). Minner, Levy, & Century (2010) give some essential ideas for using inquiry in teaching: science content must be included, engaging students with content of science, responsibility of students to learn, critical thinking of students, provision of questions to motivate students, designing experiment, data gathering, drawing conclusion and communicating it. Scientific inquiry lays emphasis on problem-solving capabilities of people, way of discovering scientific knowledge, critical thinking and logical thinking capabilities. As considered by social constructivism, inquiry in science also stresses on dialogue, reporting, deliberation as well as debate (Keys & Bryan 2001). Teachers must draw students to practicing these skills to promote understanding and achieve lesson objectives.

The principal focus of inquiry-based learning 'develop the inquiring minds' as well as positive orientation needed to surmount the unforeseeable future. This learning strategy premises on the assumption that students dynamically embrace the attitude of questioning. Students identify problems relevant to them, make inquiry into them as they raise questions, investigate and analyse their results. When questions are open with several strategies for solving the problem, learning is propelled. Teachers respond quickly to assist students who encounter some difficulties while at the same time helping those who are sailing smoothly through their investigations by strategically asking questions leading to effective learning. Students' contribution as well as mistakes are appreciated by teachers. Learning is scaffold using student's logical thinking and practical knowledge. Everyone in the classroom feels involved and therefore work extensively towards the stated goal (Project mascil, 2014, p. 7).

In a description of The National Science Education Standards (NRC, 1996), inquiry is an activity with multiple sides having variations in form as well as instruction. The process is characterised by five essential elements, comprising engaging learners through questioning, evidence for proof, the developing successive explanations, evaluating other possible

explanations and justifying the findings (NRC, 1996; Kazempour, 2009; Varma, Volkmann & Hanuscin, 2009).

Cimer (2004) provides some principles of effective science teaching which include among others:

- reviewing previous knowledge of students,
- motivating students to apply the newly acquired skills and concepts in varying situations,
- stimulating students to actively get involved in lessons,
- providing a stimulating environment for students to inquire,
- promoting cooperative learning in students, and
- continuously assessing students and giving appropriate feedback.

These principles are also features of inquiry and form part of components of effective teaching

In inquiry learning, the role of students is no longer passive receiver of knowledge (Anderson 2002), but self-regulated learner entrusted with the responsibility of taking over the learning process (Grandy & Duschl 2007; Somekh & Davies 1991; Urhahne et al. 2010). The expectation is that learners use their hands as well as minds to actively get involved in the learning process (NRC, 1996).

2.2.2 Forms of Inquiry

As the scope of inquiry based approach is being delved into by researchers and experts in the field, so are different authors dealing with the classification of the concept into levels depending on the degree of teachers' involvement in comparison with that of their students. NRC (2000) categorise inquiry-activities into a wide-range of methods, including structured inquiry, guided inquiry and open inquiry. Dunkhase (2000) adds another level of inquiry called coupled inquiry found between guided and open inquires and which exhibits the characteristics of these two levels. Banchi & Bell (2008) describing a continuum of four inquiry levels begin with confirmation which is lower than structured inquiry.

A. Confirmation inquiry

Banchi & Bell (2008) posit that confirmation inquiry provides students the opportunity to confirm facts their teacher presents. Teacher gives questions and procedures to be followed by students with end results that are already known. Students practice some specific sub skills of inquiry.

B. Structured inquiry

Structured inquiry sometimes called directed inquiry is usually guided by the teacher. Teacher formulates questions and students are asked to investigate through prescribed procedure. At each stage, instructions are given to students until they arrive at a predetermined discovery. Due to its nature and administration, this sort of inquiry is like working with a recipe towards desired outcome. This level of inquiry helps students to become acquainted with inquiry skill but does not meet the requirements to be classified as inquiry-based learning (Bell, Smetana, & Binns, 2005).

C. Guided Inquiry

Guided inquiry which is the second and middle level of inquiry provides students the opportunity to investigate teacher-formulated question for investigation. The students with the help of the teacher then determine the process and draw their own conclusions. Teachers might have an idea of expected results but do allow students to lead the process and reach conclusions that are unforeseen and self-formulated (Banchi & Bell, 2008; Dunkhase, 2000; NRC,2000). Guided inquiry gradually leads students to open inquiry at which point students take full responsibility of their learning and knowledge construction. Guided inquiry has proven to promote learning.

A study conducted by Conway (2014) for pre-nursing and paediatric students showed statistically significant improvement in grades obtained by students who were instructed using all guided inquiry and those partially guided inquiry over their colleagues who were instructed through lecture only. The study was conducted for students of combined chemistry and biochemistry course. In a similar study to compare the impact of guided inquiry-based

teaching to traditional laboratory verification teaching, Blanchard et al (2010) found out that students instructed through guided inquiry obtained higher post-test scores compared to their peers who were instructed through verification laboratory instruction. The results also showed steady improvement and consistent memory trace in students from high school and those from middle school especially where their teachers were adequately resourced with the needed skills to implement inquiry strategies.

Again, to examine how effective inquiry-based instruction is, Wilson et al (2010) conducted a study on 58 students of age range 14-16 years. The students were randomly placed in two groups with one being instructed through inquiry-based materials using 5E Model while the other was instructed through commonplace teaching strategies. Findings from the study showed significantly higher achievement levels for the inquiry-based group in comparison with their counterpart in the commonplace teaching.

Bilgin (2009) also conducted a study to examine the effects of guided inquiry through cooperative learning environment on students at the university in relation to students' achievements and attitudes on acids and bases concepts. Results from the study revealed that students in the experimental group (those who were instructed through inquiry) had better understanding of the concepts and showed more positive attitude toward guided instruction.

D. Coupled Inquiry

In-between guided inquiry and open inquiry is an intermediate stage referred to as coupled inquiry. Dunkhase (2003) opines that in other to address the issue concerning content control as well as curriculum goals, teacher employs coupled inquiry through the combination of or by "coupling" guided inquiry with open inquiry. To him, couple inquiry require that teacher still adhere to student centred full inquiry. Dunkhase (2003) explains that coupled inquiry follows a cycle of components which include:

I. Invitation to inquiry: This stage of the cycle referred to as the "motivator" or "hook" is a designed activity aimed at arousing or stimulating the interest of students in the concept or topic under investigation. It is not enough for the teacher to announce what to be learnt but rather the teacher may use field trips, demonstrations, guest speakers, current events and other strategies that will arouse students' interest coupled with

excitement so that they will fully participate in pursuing the understanding which the inquiry process seeks to promote.

II. Guided inquiry: this stage of the cycle opens the door for the teacher to direct students towards objectives of specific concept required by the curriculum. The teacher controls the direction of the investigation and its expected outcomes and approach is more tilted towards the teacher's comfort zone. Students can choose a question for inquiry from a data bank of a range of pre-set questions. Students are however not involved in the questions formulation. Results usually amazes students giving room for lively class discussion.

III. Plan your own: Dunkhase contends that the most important of the stages of coupled inquiry is the plan your own since it provide the grounds for students' curiosity as it encourages them to explore phenomena of interest. Students have the chance to "play around" with provided apparatus or materials. They can also determine their own questions for the next stage which is the open inquiry stage thereby creating a link between the guided and open inquiry. Students are given a reasonable amount of time to explore at this stage after which they have the chance to list pressing question that arise. They discuss them and select the best question for investigation in an open inquiry.

IV. Open inquiry: this stage is purposefully intended to be an entirely student centred that offers students the opportunity to take control of their learning (knowledge creation). Students at this stage are given the opportunity to discuss questions generated at the "plan your own" stage and negotiate for selecting the most appropriate question for further investigation. Students are asked to refine their question to make it clearer and one that can be investigated with materials that are available in the classroom or within their environment. Serious consideration must be given to curriculum, time as well as materials and concerns on safety while deciding on the question for investigation. Students can design the investigations on their own, conduct them, do data analysis and then present their findings and explanations they the whole class and sometimes the whole community.

V. Inquiry resolutions: Many teachers do have a concern on their comfortability of using inquiry in teaching because students might not have learnt anything when an

investigation has ended. The resolution stage of inquiry is aimed at helping students get an understanding of the science concepts and to reach the goal of the curriculum. To achieve this, the teacher may review the inquiry presentations of students to get a common conclusion for understanding. The teacher also may engage students in discussion to find out what they have learnt so far and what next, they wish to investigate. A demonstration challenging or confirming students' findings could be performed by the teacher. It is also essential for teacher to use direct instruction if necessary to clarify concepts of science when students are in a dilemma or when closely related concepts interfere to create state of confusion in student' mind. The resolution stage is the most appropriate platform for discussing how new acquired science concepts together with the inquiry results could be applied to student's lives.

VI. Inquiry assessment: To assess students' progress and issues they are bothered with; formative assessment is to be employed at each stage of the cycle of inquiry. When the cycle has ended, the teacher needs to conduct summative assessment to evaluate it success or otherwise. The summative evaluation should be "authentic" or "performance component" rather than simply being a traditional paper and pencil test which is only conducted for evaluation. For example, teacher may give students a task that involves the application of knowledge acquired from the targeted concepts to solve a problem. Teacher can also create a situation for students to apply the acquired knowledge to make personal or societal decision: informed decision making assessment grounded on scientific literacy. The assessment stage could be structured to cause students to initiate additional inquiries to ensure the continuation of the cycle bearing in mind the available time and curriculum pressures. Dunkhase (2003) believes coupled inquiry can assist teachers in hesitation to use student-centred inquiry to successfully experience it.

E. Open Inquiry

The last and the most challenging level of inquiry is the open inquiry. In this level of inquiry, teacher only gives the knowledge framework definition in which the inquiry is carried out and allows learners to formulate several questions. Students investigate these topic-related questions through their own designed or students' selected procedures. Questions are posed by the students and that teacher only acts as a facilitator. Smith, Barnatt, Friedman, & Pine

(2009) are of the firm conviction that the pivot of higher inquiry level is student's involvement in questioning. This they believe gives students the opportunity to have personal control of learning and promotes students interest. At each stage of the open inquiry process, students make decisions themselves. Open inquiry reflects experiments performed by scientists. Colburn (2000) defines open inquiry as a student-centred approach that starts with student's question and continues with student or groups of them designing and conducting experiment and investigations and finally ends with communicating their results.

Martin-Hansen (2002) postulates that higher-order thinking is a fundamental ingredient for open inquiry as students normally work 'directly with the concept and materials, equipment' and all other resources required to make it successful (p. 35). Open inquiry requires the teacher to provide the needed resources and materials and ask students what investigations could be carried out using the provided resources. Students then devise a plan and carry out investigation into the questions with the provided materials which they by themselves gather and collect data. The recorded data is analysed after the completion of the investigation. Students then present their results based on the collected and make claims and share the processes and the outcomes for critiquing by the class (Martin-Hansen, 2002).

Active participation or involvement of students in open inquiry promotes greater learning compared to those forms that are leaned toward teacher-directed (Minner et al., 2010). A study conducted by Jiang and McComas (2015) however revealed the opposite that students' achievement in science peaks when their level of involvement in inquiry activities are restricted to 'conducting activities and drawing conclusion from data only' but not in activities of inquiry at higher level including investigation design or raising self-questions. A similar study conducted in Israel by Sadeh & Zion (2009) on the impact of guided inquiry as against open inquiry instruction among students in high schools revealed that students group who were instructed through open inquiry showed a significantly higher performance compared to their counterparts who were instructed through guided inquiry.

Golding (2013) maintains there exist a tension that arises as the teacher uses inquiry learning in the classroom. Whether the teacher should direct students as they strive to find solutions to questions (a situation that does not help students to learn to inquire for themselves) or allow students to do the inquiry by themselves (which means students may not find the correct answers). Golding is of the view that teachers must work harder to overcome this tension if they are to make gains in the use of inquiry as strategy for teaching and learning. He proposes

that teachers should strike a balance between the two paths. For example, teacher may use questions to "lead students to the answer the teacher thinks is the best, or to invite students to share their responses without critical evaluation, or to encourage critical reflection" (Golding, 2013. P. 95).

2.2.3 Importance of Inquiry based learning

Proponents of inquiry-based learning have touted its use because it is applicable in several environments, it's more relevant to modern day teaching and learning than traditional methods of teaching, provides opportunity for developing thinking as well as transferable skills, promoting lifelong learning and has the capacity to produce adequate human resource to meet industrial requirements (Hutchings & O'Rourke 2004; Oliver & McLoughlin 1999).

Ozkal, Tekkaya, Cakiroglu & Sungur (2009) postulate that students perform academically well when they are instructed in a learner-centred, constructivist learning environment where knowledge construction is interactive, inductive, and collaborative. Additionally, investigations conducted by students as well as their hands-on activities could potentially enhance conceptual and procedural understanding, promote practical and intellectual growth, and boost their understanding of nature of science (Hofstein et al., 2008). It has emerged that inquiry based education has the capacity to enhance the interest of students as well as their performance in science (Dorier & Garcia 2013; Kikis-Papadakis 2013; Rocard et al. 2007).

The promotion of inquiry as a teaching approach is premised on the idea that it is a student-centred pedagogy capable of enhancing student's learning outcomes with specific emphasis on the development of higher order skills (Justice, Rice, & Warry 2009; Prince and Felder 2006; Spronken-Smith et al. 2008a). Abd-el-Khalick et al. (2004) argue that when students constantly participate in inquiry-based learning, it results in educational improvement particularly, in science and mathematics education globally.

Many studies have been conducted to ascertain the effectiveness of inquiry to the teaching and learning of science. Reports from these empirical studies per Minner, Levy & Century (2010) shows encouraging learning outcomes ranging from improved academic performance, students' ownership and eagerness to study science, and above all the development of scientific skills, and these cut across all levels of the educational ladder. Additionally,

inquiry-based learning as an approach to learning can improve the content knowledge of students and influence their attitude positively toward science in schools (Lord & Orkwiszewski 2006), arouses and sustains their interest to learning science (Tuan, Chin, Tsai, & Cheng 2005), and help develop their understanding of nature of science (Backus 2005). Deters (2005) reiterates that the use of inquiry develops and promotes communication skills of learners.

It has also been claimed by Inter Academy Panel (IAP) (2012) that inquiry-based learning gives learners the opportunity to develop key scientific ideas through learning how to investigate and gain more knowledge and understanding of the world around them, using skills scientist employ including questioning, collection of data, reasoning and reviewing evidence taking into consideration what is already known, drawing conclusions, and discussing results (p.19). It has also been reported in different studies that inquiry-based learning experiences stimulate learners interest in science (Deboer, 2002; Gibson & Chase, 2002; NCR, 2005). Learners understanding of concepts is improved through inquiry-based learning (Gott & Duggan 2002). Inquiry based learning is considered to promote motivation among secondary school students creating interest in the process of acquiring scientific knowledge and skills (Gibson & Chase, 2002). It is regarded as a motivational tool for learning science and enhances students' achievement and promotes the development of scientific process skills (Sola & Ojo, 2007; Khan & Iqbal, 2011). It is argued that high academic motivation has consistently been linked to increased levels of students' academic achievement (Kushman, Sieber & Harold, 2001).

2.2.4 Use of Inquiry-based learning

A study was conducted by Granger et *al* (2012) on the efficacy of student-centred instruction in supporting the learning of science to ascertain whether student-centred instruction or teacher-centred would produce a better learning outcomes. The study revealed a higher learning outcome for student-centred approach compared to teacher-centred instruction.

Inquiry is described as an effective tool for promoting learners' interest and an essential tool for sustaining it. Akerson & Hanuscin (2005), Cuevas, Lee, Hart & Deaktor (2005) and

Murphy, Murphy & Kilfeather (2011) report that there is a shift in paradigm towards the use of inquiry in curricula of science as well as science teaching methodologies for lessons in the primary schools. It has also been advocated recently by Kim, Tan, & Talaue (2013) on the need to focus science education on the process more than the product of scientific knowledge.

Research conducted under the project mascil (2014) revealed a positive orientation of teachers all over Europe to implement inquiry-based learning in science and mathematics classrooms. The report however indicates that inquiry based learning has not been incorporated into the usual teaching activities. There were clear differences between both the countries as well as between mathematics and science, with science teachers using the approach more than their counterparts teaching mathematics.

A study conducted by Ramnarain (2014) on the perception of Physical sciences (physics and chemistry) reveals positive perceptions among teachers in South Africa on the use of inquiry-based learning in high schools. Participants for the study were drawn from urban, suburbs, towns and rural schools in the country. Gibson & Chase (2002) also in a study assessed the impact of a Summer Science Exploration Programme at Hampshire College Amherst between 1992 and 1994. It was a Science inquiry camp conducted over a two-week period for students of middle school. Results from the survey showed that student who participated in the summer school showed more positive attitude towards science compared to the peers who applied for the camp but did not get the chance to take part.

Brown *et al*. (2006) opine that teacher's beliefs, values and understanding of inquiry is crucial the successful implementation of inquiry-based teaching in the classroom. This has also been reaffirmed by other researchers that the levels of implementation of inquiry-based instruction is significantly dependent on the teacher's knowledge about inquiry-based teaching (Rop 2002; van Driel et al. 2001). In a study conducted by Tseng, Tuan & Chin (2013) experienced science teachers suggest the following to beginners who want implement inquiry: (a) watching concrete demonstrations of other teachers and instructors, (b) organising their own inquiry activities, (c) creating their own beliefs on inquiry as well as how it is used for teaching, and reviewing some literature on inquiry and how it is organised for teaching. The above method would lead a beginner to understanding and in no time, he or she could proficiently use inquiry for teaching. They also found most teachers hold the belief that students' role in teaching activities of inquiry is so crucial to the success of the process

and that teachers must always pay attention to such roles. It is expected that students do exploration, devise strategies for learning, understand the processes of inquiry, and find solution to problems by themselves.

To examine the effects of child-led scientific inquiry, Murphy et al (2015) organised a workshop dubbed community of Scientific Enquiry (CoSE) for 17 teachers in Northern Ireland after which participants taught students aged between 8 and 11 years. Findings from the study showed positive impact on both teachers and their students. Their interview with teachers after lessons revealed that children had developed scientific skills like questioning and observation as well as vocabulary and understanding of scientific concepts. Also, skills in formulating and arguing opinions manifested in children as reported by teachers. Another positive outcome of CoSE was its enhancement of participants' science teaching abilities.

A few studies have also revealed that inquiry may not necessarily promote positive attitude towards science. For instance, Simsek & Kabapinar (2010) conducted an 8-week long study to ascertain the impact of inquiry-based learning environment on conceptual understanding of students, their scientific process skills as well as their attitudes toward science. Twenty students in 5th grade participated in the study. The findings from the study revealed positive impact on the students' conceptual understanding and their processes skills. However, students' attitudes towards science was not influenced by the inquiry-based learning.

The teacher plays an enormous role in the implementation of inquiry-based learning (Keys & Bryan 2001; Wallace & Kang 2004). In a study to ascertain the attitudes of science teacher in inquiry-based teaching and learning, DiBiase & McDonald (2015) reported that teachers were not ready to implement inquiry in the classrooms since they did not possess the skills needed for effective implementation of inquiry activities. It was also revealed that teachers believed inquiry may not necessarily prepare students for end of year assessment. Another revelation that needed attention was that students in collaborative learning through inquiry had difficulties in effectively managing their allotted time. It is therefore important that much effort is put in to prepare pre-service teachers as well as organise staff development programmes on inquiry-based learning for in-service teacher to adapt to this learning approach.

To promote inquiry in science education in European partner countries, the European Commission (2013) have made some observations that are essential for teaching science:

- Inquiry naturally occurs when students are offered the chance to pose/formulate their own questions and find answers to them
- Inquiry involves both hands-on and minds-on activities and paves way for better conceptual understanding upon which real activities are built, leading to the development of skills such as observation, data analysis, using evidence and drawing conclusions based on facts. It however takes longer time that traditional teaching methods.
- Learners get motivated through inquiry it must be adjusted desired learning outcomes and time available
- as a multi-dimensional activity, teachers are to select dimensions that advance understanding, learning and involvement of all learners
- Teachers are obliged to experiment with the own practice.
- We can only achieve authentic open- inquiry when curricula and assessment are also open-ended to represent the number of possibilities that are rooted in science
- For effective implementation of inquiry support of management as well as colleagues is vital.
- There is the need to consider the general purpose of education in relation to prospects of inquiry.
- Teachers must play the role of facilitators and must always be a role model of inquiring person
- Teachers need not to act as expert knowledge bearer, instead, they need to promote the establishment of inquiry community that hinges on trust, honesty and multifarious roles.
- Emotional engagement of students in the learning process in an organised way for motivation
- The development of metacognitive blueprints of students need to be consciously developed.
- Teachers together with their supporting staff should be given technical and pedagogical training in the use of ICT for modelling tools, simulations, data analysis tools and communication tools.

2.2.5 Challenges for Implementing Inquiry

The effectiveness and efficiency of implementing inquiry-based learning come with a few limitations that need to be addressed by the teacher. Though it is largely agreed by many teachers that inquiry is an important tool and effective teaching and learning of science (DiBiase & McDonald 2015), the knowledge, skills and capabilities of teachers in its implementation remains a problem that needs to solved.

Roehrig & Luft (2004) indicate that there are barriers for the enactment inquiry-based teaching. For instance, as it is often done, detailed information is provided by traditional teachers in the form of lecture, teacher led discussion and lab work aimed helping students to conceptualise or confirm a given concept. It has also been documented by researchers that many science teachers do not have the requisite knowledge needed to implement inquiry-based teaching; and this has become a barrier for them to successfully implement this pedagogy (Crawford 2000; Kang et al. 2008; Keys & Kennedy 1999; Wallace & Kang 2004; Windschitl 2004). It is always difficult for one to successfully put into practice any method that one has limited or no knowledge about and that science teachers' limited knowledge will impede the implementation of inquiry in their classrooms.

Some challenges that confronts teachers when using inquiry have been documented by others. These impediments reported by (Anderson & Helms (2002) and Luera & Otto (2005) include: large class size, interest and abilities of students, inadequate time, weak comprehension of nature of science on the part of the teacher, inadequate skills in pedagogy, the inappropriateness of curricula, existence of tensions between emerging roles to be played by teachers during inquiry lessons, views held by teachers on inquiry and the culture of the school. They also mention the conflict that exist between model standards and true revelations in science classes.

It must be noted here that researchers have criticised idea that the duty of the teacher is to prepare students to perform in test. For example, Amrein & Berliner (2002) maintain that emphasis on test preparation may improve test scores in the short term, however, they do little to improve student learning. The student must be developed holistically to be able to acquire the needed skill to be able to contribute meaningfully to solving problems

confronting the society. These skills are acquired through active participation of the student in scientific processes.

In a European Commission supported project dubbed 'Mathematics and Science for Life' (mascil), Doorman, Jonker & Wijers (2014) conducted a large-scale survey on the use of inquiry based learning across 14 European Union countries. The study identified three categories of factors which affect the implementation of inquiry-based learning, namely: System restrictions, classroom management and resources. It is reported that these three factors hinder the smooth implementation of inquiry-based learning. System restrictions was found to be most desirable for predicting the use of inquiry-based learning whereas classroom management was most preferable for predicting attitude towards inquiry-based learning (p. 26).

Some authors have also questioned the effectiveness of inquiry. To them, many of the minimally led inquiry learning experiences 'do not work' (Kirschner et al., 2006). Bevins & Price (2016) postulate that 'models of inquiry are too limited, revolve around extensive practical work and omit the wealth, power and complexity of the scientific endeavour' (p. 19). On his part, Anderson (1996) argues that teaching through inquiry is hindered by three dimensional limitations: technical problems, political limitations, and cultural issues. He further explains the technical challenge constitute teacher's inability to fully teach due to inadequate teaching skill development. The political dimension encompasses frictions resulting from inadequate supply of resources as well as limitation on time. The cultural problem is associated with the perception that students must be prepared for promotion to the following school level.

In assessing challenges faced by pre-service teachers on the use of inquiry based teaching, Yoon, Joung & Kim (2012) found out that six difficulties are usually encountered which included:

(a) helping students to develop ideas on their own as well as their curiosity,
(b) assisting students to design an experiment to suit hypotheses they have set,
(c) scaffolding students' interpretation of data as well as their discussion,
(d) friction emanating from guided inquiry and open inquiry,
(e) partial insight into hypothesis
(f) lost confidence in the content knowledge of science.

To them, a, b and c are experienced when the lesson is ongoing therefore are referred to as ‘on the lesson’ difficulties. The last three difficulties: d, e and f are difficulties in the minds of pre-service teachers called ‘under the lesson’ difficulties. The researchers opine that under the lesson difficulties are likely to impact negatively and create difficulties that appeared ‘on the lesson’ in class. These difficulties were intertwined and featured in the decision-making process preservice teachers’ and affected their inquiry teaching based on hypothesis.

3 Research questions

The Finnish National Core Curriculum has it that "learning results from pupil's active and purposeful activity, in which they process and interpret the material to be learned based on their existing structure of knowledge with new possibilities opening up for understanding culture and the meaning that culture contains, and for participating in social activity. It encourages teachers to adopt diverse working approaches that develop "social, thinking, working, problem solving-skills and foster active participation as well as create opportunities for creative activity, experiences and develop skills in information and communication technology". The National Core Curriculum requires that teaching of Biology, Chemistry, Geography and Physics from 7th to 9th grade should aim at developing students' skills in observation investigation, interpretation, explanation. This experimental orientation grasp the nature of science leading to the adoption of new scientific, concepts, principles and models, and to help them develop manual skills as well as abilities for experimental work and cooperation and finally, to stimulate pupils to study these science subjects. Emphasis is made in Biology that 'instruction must be inquiry-based learning' leading to developing pupils' thinking in the natural sciences (Finnish National Board of Education, 2004) now the Finnish National Agency for Education.

A considerable number of studies have been conducted on the perceptions of either in-service teachers or preservice on the effects of inquiry on enhancing interest and motivation of learners. However, a limited number of studies have tried to combined perceptions of teachers and student teachers on the use of the approach for instruction and students' learning. This study therefore aimed at finding out the perceptions of teachers and student teachers about the use of the constructive teaching strategy. The findings would form part of the bases upon which further research in this area could be conducted.

The therefore explores how science teachers and student-teachers perceive Inquiry-based teaching and learning in Finnish Basic Schools. The overall question guiding the study was: What are the perceptions of Finnish Basic School Educators and student teachers towards inquiry? Related research questions are:

1. What are the views of science teachers and student teachers about inquiry-based learning?

2. How do science teachers and student teachers perceive the effectiveness of inquiry in the learning of science?
3. What limitations have teachers and student teachers identified to be associated with inquiry-based learning?

4 Methodology

Introduction

This chapter gives a view of employed methods for data gathering in the study and entails the methods used, the population and sample, research instruments, procedure for data collection and finally, data analysis. To know more about different perceptions of science teachers and student teachers about the use of inquiry in teaching science, with emphasis on upper primary and lower secondary schools: the study sought to find out how science teachers and student teachers perceive inquiry approach in their teaching and future teaching respectively, and how teachers and student teachers' perceptions differ.

4.1 Method

Merriam (1998) states: "being able to trust research results is especially important to professionals in applied fields, such as education, in which practitioners intervene in people's lives" (p. 198). This study therefore employed two methods for collecting data including literature review and qualitative approach in which online and paper based questionnaires were administered to teachers and student teachers respectively. Denzin & Lincoln (2005, p. 3) offer a broader definition for qualitative research:

> *Qualitative research is a situated activity that locates the observer in the world…. Qualitative research involves the studied use and collection of variety of empirical material – case study; personal experience; life story; interviews; artifacts; cultural text and productions; observational, historical, interactional, and visual texts – that describe routine and problematic moments and meanings in individuals' lives.*

To them, qualitative study must be conducted in the natural settings to understand or explain phenomena, events, or situations and how people perceive them.

As pointed out by Hiatt (1986), the prime focus of qualitative research methods is to unearth and find in-depth meaning to the experiences and perceptions as well as thoughts that participants hold. Qualitative research therefore systematically investigates meaning,

conviction or reality. Gavin (2008) also mentions six features of qualitative research including:

- Qualitative research uses natural settings in which to gather data.
- The researcher is an integral part of data collection.
- Analytical techniques are predominantly inductive.
- Reports are entirely descriptive, expository, and demonstrative and provide participants a voice.
- There is an emergent focus in addition to focus on the product of research.
- There is less of a focus on validity/reliability than on trustworthiness and credibility.

Choosing qualitative method as a research to for this study was because of researcher's interest in finding of how teachers and students teachers perceive inquiry as teaching and learning approach in science education and its usefulness to the teaching and learning process in this contemporary world. It was to afford participants the opportunity to freely reflect on the questions and give their own conceived ideas and opinions concerning the meaning and the use of inquiry approach to teaching and learning of science and not to limit them to multiple choice questions which always fails to give room for alternative answers from those options provided in the questions.

Although qualitative research method has become a powerful tool being used by many researchers today, there are some concerns raised by researchers. Gavin (2008) discusses the problem of generalising qualitative data and suggests that the results or findings could be transferred to another situation or to a different data gathering using the same sample. He continues that the results should be dependable and stand over time. Lincoln & Guba (1985) postulate that the problem of subjectivity of qualitative data is always an issue that need to be addressed. They propose confirmability: one of the five criteria for ensuring authenticity, credibility, and trustworthiness of qualitative research. Confirmability involves documenting data, methods employed, decisions that were made during the project and finally its product. Being able to cope with the above criteria will minimise the problems to get a generally acceptable research.

This study employs the case study research design which is increasingly opted for in social sciences as an appropriate and a flexible approach (Yin, 2003). Case study is the systematic process through which data on an individual or group's actions, thoughts as well as beliefs is

organised and reported under specific conditions or circumstances (Romberg, 1992 p. 57). Yin (2003) on his part sees case study as an approach to researching into a real-life case in which the inquirer can rarely manipulate the subjects under investigation. Simons (2009) defines case study as an in-depth investigation into a project, policy, institution or system from diverse perspectives of their complex nature and distinctiveness in a "real-life" context. It is an empirical study which enjoins diverse methods and driven by evidence (p. 21).

Based on different assumptions and purposes, there are different forms of case study. For instance, Yin (2003, p. 5) provides five forms of case studies.

1. the single- case study which focuses on just one case
2. multiple-case studies which encompass more than one case treated concurrently one study
3. exploratory case studies which determine the questions and hypothesis for future study
4. descriptive case studies which constitute a total account of a situation or event and
5. explanatory case studies: provides data on correlation between cause and effect and offers an explanation on how phenomena occurred.

As explained already in the first chapter, the choice of this topic was based on the numerous calls by governments, policy makers and researchers for the need to shift the teaching paradigm from the traditional teaching method to a more student-centred driven method. I was also moved by the limited research evident in the use of inquiry in the Joensuu area. As recommended by Yin (2003), it is more appropriate to use case study when conducting research in actual setting and when the phenomena cannot be influenced by the researcher. To gain further insight into the problem under investigation the multiple case study approach was deemed suitable for the study. The cases for the study involved two teacher groups: teachers and student teachers. The study investigated the perceptions teachers and student teachers hold about the use of inquiry in the teaching and learning of science in Lower Secondary Schools and the relationship between their perceptions.

Case study does not comply strictly to any method and therefore cannot be constrained by either time or resources. It can therefore be conducted over several years or even within a matter of few days. This flexibility nature of case study makes it easy for researchers to modify research design in an event of change in policy or when an unforeseen issue arises (Simons, 2014).

Despite the advantages case study enjoys, there are some concerns that case study researcher may face. The subjectivity of both participants and researchers in case study just like other qualitative studies has been echoed by Simons (2014). The interpretations provided may be influenced by researcher's own beliefs and values. Parton (2002) postulates that the biases of the researcher makes it difficult to verify the validity and reliability of case study research. Researchers fail to generalise the findings of a study conducted using case study is a serious challenge. Case study is inconsistent with and contradict what is required of statistical sampling procedure which is regarded as the building blocks for generalising research findings (Schofield, 1990, p. 203).

4.2 Population

The population targeted for the study was all science teachers in Joensuu and student teachers in the School of Applied Educational Science and Teacher Education at University of Eastern Finland. However, for financial constraints and time limits, the study was restricted to upper primary and lower Secondary school science teachers and student teachers who were studying to teach at the stated levels. The selection of both teachers and student teachers was purposefully made to establish difference(s) if any in perceptions of experienced teachers and pre-service teachers.

4.3 Sample

The sample for the study consisted of 7 science teachers and 10 pre-service teachers (student teachers). They were selected because the researcher was situated there and had had an encounter with some of the participants during an observation lessons in some schools. The researcher had an opportunity to meet student teachers during some science courses and had had some interactions with some of them. Purposeful sampling was used therefore appropriate and met the demands of the study. All seven teachers who participated in the study were Physics and chemistry teachers. All seven teachers teach grades 7, 8 and 9 with two of them teaching in grades 5and 6 as well.

Student teachers who responded to these questionnaires were mostly been trained to become biology and geography teachers. 6 respondents were learning to become biology and geography teachers; 2 were learning to Biology and Geography and Natural and Environmental Studies teachers; 1 studying Biology, Chemistry, and Physics; and one Biology, Chemistry and Geography. All student teachers were being trained to teach in 7, 8 and 9th grade.

4.4 Data collection Procedure

Based on the aims and objectives of the study, qualitative data was collected. However, a few closed-ended questions were added to the data to inquire about participants' background data. The researcher contacted the participants through the supervisor and established contact and relationship needed for the study. Teacher participants agreed with the researcher that questionnaires were to be sent to them via online since they had little or no time to meet the researcher face-to-face. Student teachers were having lectures and at the same time preparing for examinations. It was therefore the safest option to give participants paper based questionnaire to answer at their convenience.

Semi-structured questions comprising of generally open ended questions were sent to participants. The questions were in two sections. Section A was made of 7 closed ended questions aimed at finding out about participants' background data and the methods they employ in their teaching. Section B on the other hand consisted of 8 questions with 7 open ended questions and one which was closed ended. These questions were primarily focused on finding out how participants perceive the meaning of inquiry, the usefulness of the approach and limitations which need to be addressed for its effectiveness in science classrooms.

As stated earlier, this qualitative study employed online and paper-based questionnaires as the instrument for data collection. In the words of Peer et al (2012), "questionnaires are used as data collection tools for many types of survey projects, including fact-finding questionnaires; determining opinions, perceptions, and attitudes; identifying interests and experiences; conducting needs assessments; and so on". Denscombe (2014) provides three essential features of questionnaires which include:

- they are designed purposefully for collecting information that are eventually used for data analysis,
- they consist of a list of identical questions and
- they collect information through asking people (respondents) directly about salient issues relating to the research.

Wright (2005) believes that with the use of online survey, the researcher can have access to participants who are very difficult to reach and give the researcher the chance to get participants in distant locations which could have otherwise prevented them from participating in the research. He is also of the conviction that using online survey saves the researcher time and reduces the amount of effort to be put into data collection since automated data is collected conveniently. It is also clear that within a short period, researcher can reach many participants of similar characteristics (Taylor, 2000). The use of online questionnaire impliedly is the reduction of cost of doing research. It takes away costs involved in printing questionnaire papers, cost for posting questionnaires to participants as well as cost for data entry (Llieva et al, 2002).

Paper-based self-completion questionnaires were administered to student teachers on campus to be completed and returned later. They were given ample time to respond to the questions. The focus of self-completion questionnaire was to give participants the opportunity to independently respond to the questions without interference from the researcher.

In a study to finding the different effects of three tool for questionnaire administration; computer-based, web-based, and paper-based, Hardré et al (2007) found out that paper-based administered questionnaires were slightly favoured to provide quality data compared to the other two. They however emphasised that the differences observed were not statistically significant. Electronic-based questionnaire is seen to be less costly compared to paper-based questionnaire and has a faster response rate (Thomas, 2004). Thomas further states that electronic questionnaire automatically transfers the data to a given database compared to paper-based questionnaire which requires coding the information and entering the data into the computer. As summarised by Best & Krueger (2004), the internet today is a popular channel for data collection since it gives access to the growing number of potential participants of research, quickly transmits and receives information and it is also cost effective compared to face-to-face interview or paper-pencil questionnaire.

Despite the numerous advantages enumerated, electronic questionnaires have some limitations that may arise and need to be curtailed. Web-based questionnaire to Thomas may also require some programming skills to load questionnaire onto the web which some researchers may lack and need to pay for. Participants without internet access and or without computer competence are marginalised and denied the chance to take part in email interviews (Jowett, Peel, & Shaw, 2011) just as in the case of online questionnaires. Most often, there is unnecessary delay in receiving data since participant only attend to questionnaires in their convenient time. Researchers must wait for long time to get their responses from participants. Furthermore, there is no social cues such as paralanguage, inflections, body language as well as tone between the interviewer and interviewee which sometimes leave the participants with misinterpretation and ambiguity.

However, measures were put in place to reduce the impact of these issues. For instance, teachers who took part in the study were first contacted through my supervisor before questions were sent to them. Reminders were also sent to participants who delayed in responding to questions. Again, participants were given the chance to ask for clarity when they encounter any ambiguity or some statements they found difficult to comprehend.

4.5 Data analysis

After receiving responses, they were all carefully examined for accuracy and completeness. Content analysis was the method used to analyse the data. Schreier (2012) sees content analysis as the objective and systematic way by which a phenomenon is described and quantified. Hsieh & Shannon (2005) on their part define content analysis as a research method used to subjectively interpret the text data's content using systematic process of classification through coding and theme or pattern's identification. To them, the underpinning reason for content analysis is to code raw data into categories that are conceptually congruent.

As mentioned by Schreier (2012), qualitative content analysis is characterised by some identifiable features including data reduction, flexibility and finally, systematic data procedure. To reduce the subjective and bias nature of content analysis, categories should be geared towards precision (Orkodashvili, 2016). As argued by Bengtsson (2016), the presentation of data is usually done in either words or themes making it easier for drawing

some interpretation from the results obtained. She opines that no criteria have been established for content analysis. However, the analysis can either be manifest or latent. This study is analysed by the manifest content analysis. Manifest content analysis is a procedure that allows the researcher to give a description of what is said by the respondents, keep close to the texts, make use of the actual words, and give a description of what are so glare and visible in the text (Bengtsson, 2016). Quantitative data were analysed using simple tables, frequencies, and percentages where necessary.

4.6 Trustworthiness of the study

Lincoln & Guba (1985) argue that it is always possible to negotiate for trustworthiness rather than it being restricted and subjected to incontrovertible validation where readers do not have an option to refuse an account. They propose five criteria for establishing trustworthiness of a qualitative study which include:

- Credibility: Showing materials (interview transcripts or written reports) to the participants of given research to ascertain whether they agree or disagree on how the report has been presented. This they refer to as 'member checks'.
- Transferability: giving elaborative and vivid description of the study settings to give readers sufficient information so that they make judgement whether the finding can be applied in different settings they know.
- Dependability: done by auditing involving documentation of gathered data, methods used and decisions taken during the study and its result.
- Confirmability: a reflective activity through which the researcher systematically provides a self-critical report showing how the research was carried out by way of auditing.
- Authenticity: it is shown by the researcher through the demonstration of presentation of range of different realities ('fairness').

Since trustworthiness of research is very important, these criteria were adhered to in this study. The questions were first given to colleague students who have been in the teaching field before in a pilot study to ascertain their understanding. The pilot study results helped in modifying the questions. Questions were then sent to an expert (supervisor) to make content and construct as well as face validity. The use of content analysis offered an opportunity for the use of actual texts provided by respondents. That is information provided afford the readers the opportunity to make informed judgement on the study. Information on data

collected, methods used and decisions made together with results have been duly documented.

4.7 Ethical Considerations

Lankshear & Knobel (2004) see ethics in research as what the researcher does to ensure that the well-being and interests of participants are catered for so that they are not harmed because of the research being conducted. Some guidelines have been suggested by Bogdan & Biklen (2003) when conducting qualitative research.

- Avoid research sites where participant may feel they are being coerced to partake the study.
- The privacy of informants must be honoured and respected.
- Make available every needed information to participants.
- Identities of participants must be fully protected unless otherwise agreed upon.
- Participants must be treated with respect and their cooperation must be sought.
- Terms of the agreement should be clear and must be abided by the researcher when requesting for permission to do the research.
- Be truthful when writing and reporting the findings.

To conduct a research whose finding would be valid and trustworthy, participants were given all the assurance concerning the protection of their privacy, identities and were given the opportunity to agree on whether to participate in the study. Participants were also given enough time to respond to the questions (in their own free time). They also had the space they needed to answer the questions and reflective thinking on answers they provided. Participants were therefore at ease to respond to questions and on their own free will and their convenience. They were encouraged to ask for clarity on questions they did not understand.

5 Results

This chapter presents the findings of the study in relation to the research questions asked. Questions as stated earlier were analysed using content analysis method. Descriptive statistics such as frequency counts and percentages were used to analyse close-ended questions. Analysis was done under the following themes: respondents' background information, meaning of inquiry, effectiveness of inquiry and challenges of using inquiry.

5.1 Teachers' background information regarding their teaching.

All seven teachers who took part in the study were teaching chemistry and physics. In the case of student teachers, six were teaching biology and geography, 2: Biology, Geography and, Natural and Environmental Studies, 1: Biology and Chemistry whereas the remaining one was teaching Biology, Chemistry, and Geography.

Table 1. Teaching subjects

	No.	Biology	Chemistry	Geography	Natural and Environmental Studies	Physics
Teachers	7		O			O
Student Teachers	6	O		O		
	2	O		O	O	
	1	O	O			O
	1	O	O	O		

From the table 2, 5 teachers representing 71.48 % had been teaching for over 15 years.

Table 2 Teaching experiences (years)

Teaching Experience	Number of teachers	Percent (%)
1-5 years	1	14.29
6-10 years	1	14.29
Over 15 years	5	71.48

Out of 10 student teachers who participated in the study, 9 indicated they had taught for a year while the remaining 1 had no teaching experience.

Methods teachers used in science lesson

Responses from participants revealed that inquiry, discussion, and demonstration were methods they usually used in science class. All 7 teachers indicated that they have made use of inquiry, demonstration, and discussion as teaching methods in science lesson. Five of teachers stated that they use lecture in science lesson. Other methods that teachers stated that they make use of include cooperative learning, role play dramatization. These were clearly and explicitly expressed in teachers' responses. Interestingly, 9 student teachers indicated they have been using discussion, Lecture, and inquiry in science class; seven of them also used demonstration; however, one teacher had not used inquiry before.

Table 3 Teaching methods used

Teaching method	Teachers	Student Teachers
Lecture	5	9
Discussion	7	9
Demonstration	7	7
Inquiry-based Learning	7	9
Other	cooperative learning, role play dramatization	drama, ICT quizzes and group work

When asked about teaching methods that aid students' participation and understanding, all seven teachers ticked discussion, six of them indicated demonstration and inquiry while three teachers believed that lecture enhances students' participation and understanding. Other methods expressed by teachers included role play and drama, cooperative learning, and quizzes.

Table 4 Teaching methods that aid students' participation and understanding

Teaching method	Teachers	Student teachers
Lecture	3	8
Discussion	7	9
Demonstration	6	8
Inquiry-based Learning	6	10
Other	role play and drama	drama, ICT and group work

5.2 Meaning of Inquiry-based learning

The general impression gathered from teachers' definitions of inquiry-based learning reveals some commonalities of expressions:

- Students working in pairs or small groups with equipment to solve problems through experimentation and this was common definition provided by three teachers.
- Two teachers' definitions express inquiry-based learning as Students solving problems by themselves with a guide from teachers.
- Cooperative learning is featured in definitions of two teachers
- Posing questions, making observations, finding answers and reporting results were terms used by one teacher in defining inquiry-based learning.
- Trying to understand the world was also identified in one teacher's definition.

A teacher defined inquiry-based learning:

> *The students are given a phenomenon, problem etc. And equipment to solve it in pairs or small groups. What matters is that they do by themselves and discuss about the topic.* (T 2)
>
> *Inquiry-based learning is about taking a topic and approaching it with different aspects. Wondering the world and making observations, experiments. Finding a solution and learning to understand the world.* (T 7).

Below are some descriptions teachers gave regarding their understanding of the inquiry:

> *The students try to solve a given or self-posited (better option) problem together with pair/small group. The problem is in my teaching related to phenomena and reactions of the nature*. (T 5)

Students find out by themselves of the topic. In science, this means getting to know the theory and carrying out experiments. (T 3)

Making scientific experiments based on instructions or on open assignment. (T 4)

On the part of student teachers, impression obtained from various definitions implied that inquiry-based learning is:

- 'an experimental way of learning' and this expression was visible in definitions given by four student teachers.
- 'A participatory learning for solving problem through examination' cut across views expressed by four student teachers.
- Two student teachers were of the opinions that inquiry-based learning is an 'avenue for students to cooperatively learn through empirical research'
- And finally, one student teacher stated further that inquiry-based learning is 'premised on the assumption that new concepts must be based on students' previous knowledge'.

One teacher student remarked:

Students searches information based on a problem aiming at solving it. Students co-operates while examining. The examination can be practical (empirical experiments) or data acquisition online, depending on the problem. (S T 7).

Some definitions provided by student teachers are provided below:

The student familiarises him/herself with the topic with tools provided. Optimally, these are similar to real scientific research. (S T 6)

In inquiry-based learning the student studies through scenarios, experiments and problem-solving. Inquiry-based learning is communal learning. (S T 3)

Learning through participation and experimental teaching based on students' previous knowledge. (S T 2)

Students get to know the topic and find out of it for themselves. A hypothesis can be created and after examination of the phenomenon or topic. (S T 1)

5.3 Effectiveness of inquiry

Both teachers and teacher student generally agreed that inquiry-based learning is effective in achieving learning outcomes if it is well executed. Four teachers and six student teachers believed Inquiry-based learning is for memory trace, and leads to better understanding. They also believe inquiry-based learning is very effective for talented and average students. One teacher commented:

> *Because students are much more interested in the topic, learning outcomes are better.* (T 2).

Other teachers observed:

> *Students do not understand physics and chemistry very deeply without inquiry-based learning. A lecture or reading from books and making assignments makes learning superficial and is mostly only about memorising.* (T 5).

> *Through inquiry-based learning things will be solved and experienced personally. Very effective and leaves a memory trace.* (T 7)

A few teachers however retorted that inquiry may not be very effective in achieving learning outcome due to factors such as limited time, the topic under discussion and students' ability. For instance, some teachers write:

> *If efficiency is defined by quantity/time, not very efficient. But would the memory trace be more permanent?* (T 1).
>
> *Efficiency depends on students' attitudes/motivation and working skills. Average and talented students learn better through inquiry than through teacher-led studying. For weaker students' inquiry is suitable if the teacher divides the assignment in smaller tasks.* (T 3).
>
> *It activates students and especially understanding experiments increases. Not so fast and efficient as e.g. teacher-led studies, but essential for understanding.* (T 4).

Student teachers were also of the view that inquiry-based learning inspires, motivates and improves students understanding, leads to the acquisition of knowledge and skills, and promotes memory trace.

> *I have noticed that inquiry-based learning motivates students to problem-solving. In my opinion, learning outcomes are achieved efficiently through inquiry based learning.*

It inspires the students and improves depth understanding of the phenomena at issue (hopefully). (S T 2)

Students can apply something possibly leading to the realisation and understanding. (S T 5).

Depends on execution. If well instructed and appropriate methods are used, then very effective. (S T 6).

The possibility of remembering is very high when students are instructed through inquiry-based learning as expressed by a student teacher:

Students remember the knowledge and skills better when they find it for themselves instead of the teacher lecturing. (S T 7).

On the other hand, some student teachers believed that the effectiveness of inquiry largely depends on the students' level of ability and that teachers must consider this factor so that all students will benefit from inquiry teaching. In situation where no consideration is given to the level of students' ability, inquiry-based learning may not be effective in achieving learning outcomes.

Very effective though not suitable for all students equally. (S T 1).

Starting level varies and inquiry-based learning enables students to work on their own levels. Thus, every student can develop their own skills on own level. (S T 8)

One student teacher indicated that inquiry-based learning is a time-consuming activity that may derail the effectiveness of the approach. Effective time management may be required to ensure that the process works:

Effective but time-consuming in practice. (S T 9).

Impression derived from responses of participants (both teachers and teacher students) indicate that inquiry has the tendency to arouse and sustain students' interest in science. Six

teachers believe that using inquiry-based learning is very effective to awakening and supporting students' motivation. A teacher wrote:

> *Very effective. Setting the problem, "setting an interesting starting point" is difficult for teachers too. Inquiry-based learning teaches the students a lot about the culture of doing. Role of the student becomes active and topic gets more interesting. People are made to be active not to stand still. Students enjoy doing and understanding and succeeding makes them happy- interest has been awoken.* (T 5).

One teacher however believes that for effective inquiry-based learning, other varying methods should be part of strategies teacher adopts. The teacher remarked:

> *If teachers use inquiry-based learning constantly, it would be too hard. Varying all methods should be preferred. Then they can awake students' interest. In inquiry-based learning also the topic affects students' interest.* (T 3).

All ten teacher students believed inquiry is effective. A teacher student put out a strong view that:

> *More effective than many "traditional" methods like lecture. On the other hand, the topic has a huge relevance in awakening the interest.* (T S 2).

However, one student teacher believed that the topic for the lesson must not be too difficult.

> *If topic is interesting enough and not too difficult, I think it awakes students' interest* (T S 9).

Other benefits of using inquiry in science class

In the quest to finding out how teachers and teacher students view the usefulness of inquiry, respondents were asked what they identify to be the benefits of inquiry-based learning. Views expressed by respondents suggest that inquiry is very beneficial in that it arouses interest, and enhances students' creativity, helps develop self-direction and promotes retention as well as promoting curiosity creating scientific thinking.

A teacher observed:

> *Learning outcomes are better when students are interested in the topic. Students believe in their own learning skills. Things in physics and chemistry that were found*

difficult, do not seem so difficult anymore. Students have the courage to choose those studies in the future as well. (T 5).

Another teacher remarked:

Students take more responsibility of their own learning. Teacher becomes more guiding and discussions about the topic in class are increased.

A teacher student also explained how students develop scientific inquiry:

It brings an experimental touch to the topic/ field of study and creates new observations and knowledge (T S 3).

Along with good learning outcomes it activates the students and encourages to initiative (T S 6).

5.4 Challenges of inquiry in science education

Inquiry as a teaching method despite its numerous benefits, has some setbacks which always limit its usage. Respondents expressed views relating to time, large class (big groups)

A teacher observed:

Big groups may entail restlessness. Not everyone gets excited and commit well. Some are very excited and may lead him/her to lead the group while others sponge. (T 7).

Another important issue raised was provision of feedback. Failure to provide feedback to students may leave students with doubts and this must be avoided. A remarked:

These take time, but once in a semester can be done. Requires also feedback from the teacher during all phases of the work. (T 3).

Responses from teacher students were not different from views expressed by teachers. They mentioned equipment, resources as well as time as the major limitations to inquiry-based learning. One intriguing issue raised by a student teacher was that effective implementation of inquiry in science class is largely dependent on teachers own judgements:

I think the possibilities are limitless. What limits is the prejudiced teacher (T S 3).

Participants (both teachers and student teachers) also mentioned methods including teacher-led discussions, videos, use of ICT, excursions, reading from textbooks, peer teaching (students teaching each other) creative work, demonstrations, lecture and games as those they would use beside inquiry.

6 Discussion

The goal of this study was to examine the perceptions held by teachers and student teachers on the use of inquiry in teaching and learning and to identify the difference in perceptions between teachers and student teachers. It was directed at teachers and student teachers for the upper primary and lower secondary schools. The findings from the study are discussed under five main themes, namely: teaching methods employed by science teachers, definition of inquiry-based learning, the use of inquiry in the teaching and learning of science, importance of inquiry in science and limitations to using inquiry. No significant difference was found between perceptions of teachers and student teachers.

6.1 Teaching methods employed by science teachers

In the process of teaching and learning teaching methods are very critical. From the findings, teachers like student teachers often use discussion, inquiry and demonstration as teaching methods in science classrooms. The use of these methods by teachers is an indication that teachers are heeding to the call to move from teacher-centred approaches to student-centred methods which provide opportunity for students to actively participate in science lessons. Discussion as teaching method is argued on one hand to promote understanding (NRC, 2007) whiles on the other hand analysis of PISA 2006 sample of Finnish students by Lavonen & Laaksonen (2009) reveals that debate which forms part of discussion does not have any positive effect students' performance.

The findings also indicate that methods including but not limited to discussion, demonstration and inquiry promote student's participation in science classrooms. Using these methods enhance the students understanding as well as their ability to participate fully in class. This is in consonance with Billings & Halstead's (2009) assertion, 'participation is the central theme for students' critical thinking and maximising their understanding'. Active participation in classroom discussion by students has been echoed by Weaver & Qi (2005) as having the tendency to give them better understanding than their mates who fail to actively participate. Providing an opportunity for students to fully participate in classroom activities will help these students to enlarge their scope of knowledge through experience and practice.

6.2 Meaning of inquiry

The findings indicated varied descriptions and definitions from teachers and student teachers in wording as well as how inquiry inquiry-based learning is organised in their respective science lessons. This is in line with Anderson (2002) and Wheeler's (2000) assertion that there is no definition generally accepted for inquiry-based learning. Descriptions and definitions were however geared towards the processes involved in scientific inquiry. The finding also indicated that two common levels of inquiry (guided and open inquiry) are the ones usually adopted by both teachers and student teachers. Some practices that were common in most of the definitions included problem solving, problem identification, data collection, experimentation, communal learning and result presentation. The application of any inquiry form will largely depend on the ability of learners and so teachers may begin using guided inquiry and gradually move students to the higher level which the open inquiry.

6.3 Effectiveness of inquiry in science

Inquiry-based learning has been prescribed by experts as the way for effective teaching and learning in schools. It is therefore being promoted in many countries by state policies and other stakeholders in the education sector. To this end this study sort to find out from respondents their perceptions regarding the usefulness of inquiry-based learning in science lessons.

On the usefulness of inquiry-based learning to achieving learning outcomes, both teachers and student teachers generally share similar views that inquiry potentially leads to achieving lesson objectives, understanding and memory trace. This confirms Justice, Rice, & Warry's (2009) assertion that inquiry-based learning is a means to improving academic performance and achieving learning outcomes. Prince & Felder (2006) also had similar findings when they reviewed four studies that evaluated inquiry-based learning. The results also indicated similar views expressed by both teachers and student teachers that inquiry-based learning is comparably effective to traditional methods in achieving several learning outcomes of students. Hofstein et al. (2008) have pointed out that as students engage in conduct of investigations and hands-on activities, their conceptual and procedural understanding of nature of science are enhanced and improved. The findings also confirm the findings of Berg et al. (2003) that student who were taught through open inquiry showed more positive

outcomes in achieving higher order learning, positive self-reflection, in-depth understanding of concepts and showed highly motivated to learn. Their study was conducted to compare the learning outcome of open inquiry to an expository version in chemistry laboratory experiments. In a move to restore the dwindling students' interest in science, teachers are expected to offer better alternative strategies of teaching aimed at yielding high academic performance, better process skills, developing students' analytical capabilities, promoting positive perceptions as well as developing students' creativity and skills in critical thinking. There is therefore the need for tor teachers to carefully plan and organise inquiry in science, bearing in mind the abilities of each student to cater for the need of all students to reap the full benefit of the approach.

From the findings, similar views are held by both teachers and student teachers that inquiry arouses and sustains student's interest in science. A successful implemented inquiry will arouse students' curiosity and gives them the opportunity to be active participants in the lesson. This finding is consistent with Gibson & Chase (2002) assertion that inquiry promotes students' motivation as they acquire scientific knowledge and skills. It has also been affirmed by Dorier & Garcia (2013) that the use of inquiry as a teaching approach capably generates students interest in science. Stotter & Gillon, (2010) also maintains that effective implementation of inquiry-based learning can potentially promote and sustain existing interest to help students to grow and develop their attitudes and values. Creating enabling environment for students to study through inquiry will motivate learners to take the centre stage in the teaching and learning process. This however requires special skills and adequate knowledge from teachers who are the facilitators of students' learning. Achieving this requires teachers to constantly and regularly upgrade their knowledge and skills through staff development programmes to keep abreast with the new roles they must assume in implementation of inquiry. It is also imperative for teacher trainers to help student teachers master the skills needed to organise inquiry lessons in science since they will soon assume the position of full in-service teachers and will be expected to apply inquiry in their teaching.

Teachers as well as and student teachers believe that acquisition of scientific process skills, developing creativity in students, encouraging students to take initiatives, developing students' thinking, promoting cooperation and communication skills are benefits of inquiry. Gress, Hadwin, Page & Church (2010) identified collaborative learning and group work as ways of promoting discovery. Teacher becomes a guide rather than information or knowledge

source and therefore focuses on evaluation more than lecturing. There is high level of discussion in inquiry lesson as students should justify the conclusions from their findings. These findings are consistent with Keys & Bryan (2001) assertion that emphasis of scientific inquiry is on problem-solving skills, processes for discovering scientific knowledge, critical thinking skills and logical thinking capabilities communication, discussion, and argumentation. The finding is however contrary to Plowright & Watkins (2004) finding that students usually find it difficult to cope with dynamics of participating in group activities when using inquiry. They advise that more time must be dedicated to developing other innovative strategies to encourage students come into terms with reasons for exploring their own beliefs and values which forms the basis for initial response practices.

6.4 Challenges to using inquiry

This study has highlighted an important role inquiry play in the study of science today. However, findings from both groups indicated few challenges with adverse impact on its smooth and effective implementation. The use of the inquiry is bedevilled with limited time, class size and resources (materials and equipment) needed. This is consistent with Beck, Czerniak & Lumpe's (2000) views that difficulties encountered by teachers when implementing inquiry-based learning include inadequate time, resources and appropriate curriculum materials. Goodenough (2004) has maintained that time is of essence as teachers are required to guide students to uncover their critical thinking capabilities required for inquiry-based learning. Like the limitations identified, a study conducted by Reaume (2011) on the topic pre-Service Teacher Perceptions and Experiences with the Implementation of Inquiry Based Science Teaching found inadequate resources as a major problem facing pre-service teachers in the science classroom. Policy makers in drawing the national core curricula could structure them taking into consideration the time teachers may use in implementing inquiry. It is equally important to look at the adequacy of resources and materials needed for inquiry lessons. Teachers could adopt improvisation especially in situations where some other resources could be used in place of the original when they are unavailable at all. This however comes with problems such inaccuracies and ineffectiveness. Grouping can also be used to solve the problem of large class size, but it doesn't entirely solve the problem. As policies are made, special attention is needed to fully adequately cater for these problems. This will motivate and encourage teachers to apply inquiry strategies in science.

One important assertion by a student teacher which is worth mentioning is 'teacher's prejudice' as a challenge to effective implementation of inquiry. This assertion could be attributed to teachers' preparation and lack of skills for using inquiry in science lessons. Consistent with this finding is Spronken-Smith et al. (2008) view that students like teachers may find it difficult to adapt to using inquiry-based learning resulting in some form of emotional challenges. To effectively implement inquiry in their class, teachers need positive attitude and work assiduously to acquire the necessary skills and techniques for smooth organisation.

6.5 Limitations to the study

Owing to financial difficulties, the study was limited to teachers in Joensuu and student teachers in University of Eastern Finland (Joensuu Campus). Though the results form a basis for further research, this result cannot be generalized due to small area covered as well as the limited number of participants.

Another major constraint of the research is the limited information provided by participants. This was largely because of inadequate time on the part of participants. I wanted to conduct interviews with them but due to their busy schedules, we agreed that questionnaires rather than interview be used for data collection. English language which is not the main language of the participants might also have contributed to the brief answers provided in most cases.

7 Summary, Conclusion, and Recommendation

This part presents the general remarks of the study and gives the key findings of the study. Recommendations for further research as well as those to teachers and policy makers will be made which are aimed at promoting effective use of inquiry-based teaching and learning in schools to awake students interest in science and to enhance students' understanding.

7.1 Summary and general remarks

The study aimed at examining the perceptions held by science teachers and student teachers on the use of inquiry-based learning in basic schools. The study was conducted using qualitative method. The researcher used questionnaire to gather the needed information for the study. 17 participants comprising of 7 teachers and 10 student teachers of science were sampled for the study. Participants were asked questions relating to their background relating to teaching and subject areas. Simple tables and percentages were used to analyse the information. Summary of key findings and are presented below.

7.1.1 Teachers and student teachers' views on inquiry

In spite diversity in wording, the findings have shown that both teachers and student teachers have similar opinions on the meaning of inquiry. To participants, inquiry implies finding answers to posed questions in small groups or pairs to understand the world through experimentation and observation. Students report findings and conclusions to find solution to problems. Teachers and student teachers point to the fact that inquiry as a teaching approach provide opportunity for students to use scientific processes through either guided or self-led activities to find answers to questions. It was obvious from responses that guided and open inquiry are the most common forms of inquiry teachers as well as student teachers use in science lessons whenever the approach is being implemented in science lessons.

Most respondents indicated that they often use inquiry in their respective science lessons; an important issue worth mentioning. The use of inquiry as expressed by participants implies that students will have opportunity to participate actively in science lessons. This will boost

students' confidence in science subjects and promote their interest in science if inquiry lessons are well executed.

The study also sought to find out teachers' perceptions about inquiry in achieving learning outcomes as well as awakening and sustaining student's interest in science. Results from responses shows that teachers and student teachers believe that inquiry has the capacity help achieve learning outcomes. It was generally agreed by participants that inquiry promotes understanding and give students the opportunity to fully participate in lessons which leads to memory trace. It was also evident from the findings that a well implemented inquiry lesson will give room for students' interest to be aroused and sustained. It is however important to ensure that all students abilities are considered so that they all benefit from the lessons.

Researchers have come out with finding that suggest that inquiry-based learning is beneficial to effective teaching and learning. These findings have been confirmed by the results obtained in this study. Teachers and student teachers alike indicated that inquiry-based learning motivates students to learn science, enhances students' curiosity and creativity, and helps them to develop self-direction. It also enhances student's scientific skills.

7.1.2 Challenges in conducting inquiry in science lessons: Views of teachers and student teachers

Even though much could be said about the usefulness of inquiry in today's science teaching and learning, there are some challenges that confront teachers in using this approach in their science lesson. Findings from the study shows that problems such large class size, inadequate time and resources, and teacher's prejudice are challenges that teachers are faced when implementing inquiry in science lessons. Curriculum demands always give teachers little time to be able to fully and effectively for instruction. The implication here is that the use of inquiry may be limited in science lessons and that these issues must be addressed by policy makers and stakeholders of science education if the approach is to be used often. It is equally important for trainers (lecturers) of student teachers to provide extended lessons on the inquiry approach aimed at addressing problems students encounter as they learn the approach. This will equip them with the needed skill and science of making.

7.2 Further research and Recommendation

The success of conducting inquiry largely depends on the teacher who is to guide students during the lesson. As mentioned earlier, the values and beliefs of the teacher as well as his or her knowledge in inquiry influence his or her application of the approach in science lessons. The findings from the study has shown that both teachers and student teachers have a positive conviction for inquiry as teaching and learning approach for effective teaching and learning. This could be attributed to the consistency of the National Core Curriculum and the orientations teachers receive as they go through teacher education. It is however believed that teachers may need staff development programmes (refresher courses) to be abreast with the changing dynamics of teaching science. Teachers must be taken through the appropriate ways of successfully using inquiry in science lesson to achieve the aims enshrined in Finnish National Core Curriculum and the goals of the European Union. Further study is therefore required on the practical applications of inquiry in science classrooms to ascertain the strengths and weaknesses of teachers in using this approach. This would give a base-line upon which staff development programmes could be organised for teachers to get them acquainted with effective ways of conducting inquiry lessons in science.

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Appendices

Appendix A

Teachers' Questionnaire

Dear Sir/Madam,

This questionnaire is part of a study aimed at obtaining information on teachers' perceptions on inquiry in science education. Your objective response will constitute a strong empirical basis upon which policies aimed at improving the teaching of science through inquiry will be based.

Confidentiality, except for the above purpose, in respect of whatever information you give is fully assured.

Thank you.

QUESTIONNAIRE ON TEACHERS PERCEPTIONS ON INQUIRY IN SCIENCE EDUCATION

Name
Email

SECTION A: Mark the alternatives.

Which subjects do you teach at school?

Natural and environmental studies ____
Biology _____
Chemistry ____
Geography ___
Physics _____

In which class level, do you teach? 5-6 classes____ 7-9 classes___

How many years Have you been teaching science? 1-5 years___ 6-10 years____
11-15 years____ Over 15 years___

What teaching approaches have you been using?

Lecture___ Discussion___ Demonstration___Inquiry-based learning___ Other_____

Which of the approaches in your opinion enhance students' participation and understanding?

Lecture___ Discussion ___ Demonstration___ Inquiry-based learning___ Other____

SECTION B

1. Define in your own words inquiry-based learning.

2. Have you used inquiry-based learning as a teaching approach?
   Never___ Sometimes__ Often___ Always___

3. If no, are there any reasons why you would not want to use inquiry in your science lessons?

4. How would you describe the effectiveness of this approach from the viewpoint of learning outcomes?

5. How would you describe the effectiveness of this approach to awake and support students' motivation?

6. What are the benefits of using inquiry in science class?

7. What are the limitations to using inquiry in your science class?

8. Apart from inquiry, which other methods you would employ in science lessons?

Appendix B

Student teachers' Questionnaire

Dear Sir/Madam,

This questionnaire is part of a study aimed at obtaining information on teachers' perceptions on inquiry in science education. Your objective response will constitute a strong empirical basis upon which policies aimed at improving the teaching of science through inquiry will be based.

Confidentiality, except for the above purpose, in respect of whatever information you give is fully assured.

Thank you.

QUESTIONNAIRE ON TEACHERS' PERCEPTIONS ON INQUIRY IN SCIENCE EDUCATION

Name
Email

SECTION A: Mark the alternatives.

Which subjects will you teach at school?

Natural and environmental studies ____
Biology ___
Chemistry ____
Geography ___
Physics ____

In which class level, will you teach? 5-6 classes____ 7-9 classes___

Have you taught at school?
How many years? 1 year___ 2 years____ 3 years____

Have you taught science? Yes___ No___

What teaching approaches have you been using?

Lecture___ Discussion___ Demonstration____Inquiry-based learning___ Other_____

Which of the approaches in your opinion enhance students' participation and understanding?

Lecture___ Discussion ___ Demonstration___ Inquiry-based learning___ Other____

SECTION B

1. Define in your own words inquiry-based learning.

2. Have you used inquiry-based learning as a teaching approach?
   Never___ Sometimes___ Often___ Always___

3. If no, are there any reasons why you would not want to use inquiry in your science lessons?

4. How would you describe the effectiveness of this approach from the viewpoint of learning outcomes?

5. How would you describe the effectiveness of this approach to awake and support students' motivation?

6. What are the benefits of using inquiry in science class?

7. What are the limitations to using inquiry in your science class?

8. Apart from inquiry, which other methods you would employ in science lessons?