The Usefulness of Qualitative and Quantitative Approaches and Methods in Researching Problem-Solving Ability in Science Education Curriculum

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ABSTRACT

Research in science education is to discover the truth which involves the combination of reasoning and experiences. In order to find out appropriate teaching methods that are necessary for teaching science students problem-solving skills, different research approaches are used by educational researchers based on the data collection and analysis used at a given time. Though qualitative and quantitative research methods lies on separate continuum, they all aimed at identifying educational problems using different approach. This study critically examined the usefulness of both qualitative and quantitative approaches in researching problem-solving ability in science education curriculum. In doing this, six articles relating to problem-solving were examined to show the usefulness of both qualitative and quantitative research approaches to educational research. Advantages, disadvantages, strengths and weaknesses of both methods were discussed. Ethical consideration in relation to research in problem-solving instructions were discussed as well as suggestion for future research.

1. Introduction

Progressive curriculum school of thoughts emerged perhaps as a result of the inability of a traditional oriented curriculum to meet the dynamic societal needs, values, and aspirations because curriculum is argued to be an avenue for solving problems of the society (Udom, 2013). Sciences were included in the progressive curriculum to inculcate and equip the learner with the necessary skills and experiences for solving problems around the learner and society at large as opposed to the traditional school of thought curriculum whose main aim is only to teach learners how to read and write. Today, we all solve problems in our daily lives. We teach problem-solving to our students' day-by-day using sciences instruction curriculum as planned and organized experiences. Science education produces scientists as well as artisans for national technological and economic development. As a result of this, (FME 2004 & 2008) stresses that science education shall lay emphases on the teaching and learning of science process and product so as to inculcate problem-solving abilities on the students. Problem-solving was said to be a special case of meaningful learning (Ausubel, 1968). This can perhaps be associated to a definitive concept of problem-solving "as the mental process which is used in arriving at a "best" answer to an unknown subject to a set of unknown" (Woods, 1987). In an attempt to find out the appropriate teaching methods to be used in teaching science students problem-solving skills, educational researchers use different research approaches based on the methods of their data collections.

There has been controversy over the usefulness of qualitative or quantitative approach in educational research (Cohen, Manion & Morrison, 2011). This paper will discuss the advantages and disadvantages of qualitative and quantitative research approaches and methods, evaluating their usefulness as well as any ethical considerations in relation to problem-solving instruction in science education curriculum with indication of the dominant approaches in the area. First of all, I will outline the advantages and disadvantages of qualitative and quantitative research approaches and methods. Secondly, I will discuss the issue of problem-solving in science education. Next I will highlight the strength and weaknesses of qualitative and quantitative research approaches and methods on the issue. Then I will analyse few necessary qualitative and quantitative research studies and the dominant approaches on problem-solving instruction. Finally, I will evaluate their usefulness as well as any ethical consideration in relation to problem-solving instruction.

2. Philosophical Framework

The essence of educational research is to improve educational programmes. Perhaps, research may be seen as an honest enterprise where reasoning, interest, critical thinking, experiences and expertise are combined with the purpose of discovering the truth so as to find solutions to problems confronting education through investigation and analyses. There are no standard procedures of carrying out research. In other words, research is not a routine

activity because it "suggests mystical activity" (Leedy and Ormrod, 2014, p141-190). Research designs are either classified as qualitative, quantitative research or mixed method. Method of research is generally believed to reside in paradigms and communities of scholars (Cohen, 2011, p4). Kuhn (1970) (cited in Hammersley (2012) examines paradigm as a "set of philosophical assumptions about the phenomena to be studied (ontology), how they can be understood (epistemology), and the purpose and product of research". Kuhn's work accounts for the understanding of the nature of qualitative and quantitative research approaches used in educational research today. The paradigms are characterized by the methods of data collection and analysis as well as methodological approaches to research which has been generating much controversy among researchers. Bryman (2008, p22-23) argues that qualitative and quantitative research differs in their paradigmatic approaches with respect to their epistemological (ways of knowing and enquiry in nature of reality) and ontological (what is to be known and assumptions about the nature of reality) foundations. In ontological orientations, qualitative and quantitative researchers are constructivism and objectivism respectively in terms of their strategies. However, in epistemological orientation, quantitative researchers are objectivists and positivists in their research approach while qualitative researchers are subjectivists and anti-positivists in their research approach (Creswell, 2009, p4-17).

Johnson and Christensen (2012, p31) stated that a paradigm is an approach about research or doing research. The authors identified qualitative, quantitative and mixed research as the three major paradigms in educational research. The authors were however silent on the foundation or orientation on which these paradigms were classified. Guba and Lincoln (2005, p183), in their work, argue that paradigm are "beliefs that guide that guide one in his activity". Guba and Lincoln acknowledged that paradigms are human constructions and therefore subject to change. The authors refer to paradigm as encompassing four distinct terms which are: ethics (axiology), epistemology, ontology, and methodology when dealing with positivist (quantitative researcher) and social constructivist (qualitative researcher). Guba and Lincoln (1994, p109) stated four distinct paradigms associated with social researches as being: constructivism, critical theory, positivism and postpositivism. Constructivism and critical theory are associated with qualitative research, while positivism and postpositivism are associated with quantitative research.

The next section will consider the advantages and disadvantages of qualitative and quantitative research approaches and methods in relation to problem-solving instruction in secondary school science education curriculum.

3.0.   Advantages and disadvantages of qualitative and quantitative research

Over the years, debate and arguments have been going on with regard to the appropriateness of qualitative or quantitative research approaches in conducting social research. Robson (2002, p43) noted that there has been a paradigm war between constructivists and positivists. But the two methods are incompatible in the sense that each has its own unique ways of gathering and analysing data. The two methods are tools used to achieve the same goal with different techniques and procedures, despite the fact that they have different strengths and logic (Paul, 2007, p4; Maxwell, 2004, p3-11; Maxwell and Loomis, 2002, p241-271). Both research approaches fall on a research continuum (Creswell, 2009, p3 and Johnson and Christensen, 2012, p32).

It is interesting to note that in the research approaches, whether qualitative or quantitative method, the key words "explaining phenomena" are used irrespective of the approach (Muijs, 2004, p7-45). All the definitions, criticisms, arguments and counter arguments made by authors about the research approaches border only on the methods of data collection, analysis and summary of the results. The fact is that neither constructivists nor positivists have claimed that their instruments are more reliable and valid than the other, thus showing that they are meant to achieve the same goal. It is worth knowing that since qualitative and quantitative research approaches are based on divergent theories and assumptions, one should be more advantageous than the other and vice versa, depending on the nature of research and data collection methods.

3.1.1 Advantages of Qualitative Research Approach

Berg and Howard (2012) characterise qualitative research as meanings, a concept, a definition, metaphors, symbols and a description of things. This definition clearly show that qualitative research contains all necessary instruments that can evoke recall which aids problem-solving. Qualitative data instruments such as observation, open-ended questions, in-depth interview (audio or video), and field notes are used to collect data from participants in their natural settings. The methods employed in data collection give full description of the research with respect to the participants involved. The participants' observation and focused group nature of

qualitative research approach create wider understanding of behaviour. Hence, qualitative research approach provides abundant data about real life people and situations (De Vaus, 2014, p6; Leedy and Ormrod, 2014).

Secondly, the system through which data are retrieved in qualitative research approach is regarded as being unique. The reliance on the collection of non-numerical primary data such as words and pictures by the researcher who serves as an instrument himself makes qualitative research well-suited for providing factual and descriptive information (Johnson and Christensen, 2012, p29-37).

Thirdly, in this research approach, theory emerges from data. Different authors use different words or phrases such as: 'investigative, do-it-yourself and bottom-up' to explain the originality and independent nature of the qualitative research approach (Maxwell, 2013; Shank and Brown, 2007; Johnson and Christensen, 2012). The emergent of theory from data allows the researcher to construct and reconstruct theories where necessary, based on the data he generates, instead of testing data generated elsewhere by other researchers. Expressions and experiences of the participants are easily understood even when there are little or no information about them (Leedy and Ormrod, 2014, p141).

Moreover, a qualitative research approach views human thought and behaviour in a social context and covers a wide range of phenomena in order to understand and appreciate them thoroughly. Human behaviours, which include interaction, thought, reasoning, composition, and norms, are studied holistically due to in-depth examination of phenomena. The close relationship that exists between the researcher and the participants in this approach makes it easy for the participant to contribute to shaping the research. This however account for significant understanding of experiences as its participants understand themselves and also understand experience as unified (Sherman and Webb, 1990, p5; Lichtman, 2013, p4).

3.1.2. Disadvantages of Qualitative research Approach

Despite the usefulness of a qualitative research approach for conducting research in problem-solving instruction in secondary school science education curriculum, there are still some criticisms about the efficacy of the approach. The problems associated with using qualitative research approach in problem-solving instruction for secondary school science education are highlighted below.

Christensen and Johnson (2012, p32-36) found that qualitative researchers view the social world as being dynamic and not static. In view of this, they limit their findings to the particular group of people being studied instead of generalizing (De Vaus, 2014). In studying problem-solving instruction in secondary school science education, the research approach is presumably deemed to have covered a large proportion of the study group. Perhaps qualitative approach could have been good method for the study if its finding are reflective of a wider population (Shank and Brown, 2007, p27).

However, replicability is another problem associated with a qualitative research approach. Critics of this approach argue that the constructivist has abandoned the scientific methods and procedures of enquiry and investigation (Cohen, 2011, p20-21). The users of the approach are said to write fictions because they have no means of verifying their true statements. Since the approach is characterized by feelings and personal reports, it is believed that the approach cannot give reliable and consistent data when compared to using quantifiable figures (Atkins and Wallac, 2012, p18-23).

As well, the subjective method employed by the qualitative approach users may be wrong, inaccurate and misleading, as suggested by Bernstein (1974) in Cohen and Morrison (2011, p21). The authors' criticism was based on ontological and epistemological paradigms, that is, how the researchers understand and negotiate the situation. Researchers impose their meaning and understanding of a situation to a given time and place to other people. Denzin and Lincoln (2005, p4-8) stated that constructivists' approach is a multidisciplinary field, therefore their research is only exploratory.

Finally, non-use of numbers by qualitative researchers makes it difficult and impossible to simplify findings and observations. Qualitative researchers believe that the social world (phenomena and experiences) has many dimensions, hence explanations are based on the interpretations of the researcher (Leedy and Ormrod, 2014, p141; De Vaus, 2014, p5-7). In view of this, proper explanation cannot be given because the result depends on the explanation of the researcher at that time of which different researcher may give a different explanation. So, the research cannot be repeated by another researcher at another place and still get the same results (Williams and May, 1998, p1-21).

3.2.1. Advantages of Quantitative Research Approach

The first advantage of this research approach is the use of statistical data as a tool for saving time and resources. (Bryman, 2001, p20) argue that quantitative research approach is the research that places emphasis on numbers and figures in the collection and analysis of data. Imperatively, quantitative research approach can be seen as being scientific in nature. The use of statistical data for the research descriptions and analysis reduces the time and effort which the researcher would have invested in describing his result. Data (numbers, percentages and measurable figures) can be calculated and conducted by a computer through the use of a statistical package for social science (SPSS) (Gorard, 2001, p3; Connolly, 2007, p2-34) which save lot of energy and resources.

Secondly, the use of scientific methods for data collection and analysis make generalization possible with this type of approach. Interaction made with one group can be generalized. Similarity, the interpretation of research findings need not be seen as a mere coincidence (Williams and May 1998, p1-21). The study of problem-solving instruction in secondary school science education within one particular area or zone can be reflective of the wider society in terms of samples, contents and patterns (Shank and Brown, 2007, p28; Cohen and Morrison, 2011, p243).

However, replicability is another benefit derivable from the use of this research approach. Since the research approach basically relies on hypotheses testing, the researcher need not to do intelligent guesswork, rather he would follow clear guidelines and objectives (Lichtman, 2013, p4). The research study using this type of research tool is conducted in a general or public fashion because of its clear objective and guidelines , and can therefore be repeated at any other time or place and still get the same results (Shank and Brown, 2007, p27).

Moreover, this research approach gives room for the use of control and study groups. Using control groups, the researcher might decide to split the participants into groups giving them the same teaching, but using different teaching methods, bearing in mind the factors that he is studying. At the end of the study teaching, the groups can be gathered and the researcher can then test the problem-solving ability of the students and be able to access the teaching method that best impacts the problem-solving abilities amongst the students. (Johnson and Christensen, 2012, p34).

Finally, Denscombe (1998, p173-176) describe quantitative research as "researcher detachment" research approach. When looking at the "researcher detachment", it may be seen as a strength of quantitative research approach from one angle, yet from another angle it may seen as its weakness. The issue of researcher being bias with either his data collection or data analysis will be highly eliminated when the researcher is not in direct contact with the participants, that is, he collects his data through either telephone, internet or even pencil-paper questionnaire. There is full control for alternatives such as interpretations, explanations, and conclusions. In other words, the objectivity of the researcher will not be compromised. Secondly, this may perhaps guarantee respondent anonymity (Muijs, 2004, p7-45; Litchman, 2006, p8; Bryman, 2012, p408; Creswell, 2009, p4).

3.2.2. Disadvantages of Quantitative Research Approach

Researcher detachment from the participants is also a weakness within the quantitative research approach. Researcher detachment means that he is an "observer" or an "outside looking in". With this type of researcher/participant relationship, it will extremely difficult to get the in-depth study of the phenomena within its natural settings. He will neither understand the group or individuals working with him nor will he appreciate them (Shank and Brown, 2007, p63; Berg, 2007, p4; Christensen and Johnson, 2012, p35). In studying problem-solving instructions for science education in secondary schools, the researcher need not be an observer nor detach himself from the participants. It is dehumanising as well as undermining life and mind (Cohen, 2011, p14). The experiences gathered may not be that of the participants mind and opinion (Berg and Howard, 2012, p61).

Quality and quantity are very important in any educational research since research is an instrument of change. Those two words cannot be neglected when explaining phenomena (Dabbs, 1982 cited in Berg and Howard, 2012, p3). In the quantitative research approach, the participants have no room to contribute to the study. The researcher is at the "driver's seat" (Bryman, 2001, p286). The linear and non-flexibility nature of a quantitative approach demands that the researcher follow a certain order. He starts by setting the research question and hypotheses, conducts a literature review, collects data, analyses the data and summarises the result (Litchman, 2006, p7-15; Creswell, 2009, p17). For educational studies such as problem-solving instruction for secondary school science students, the researcher may decide to observe the teaching methods first and see how the method affects students. Following his initial observation, he may repeat the visit for another observation, if necessary,

before planning the main research. Input made by the participants can help form researchers' point of orientation. This process is not possible within a quantitative research approach wherein its liturgical order of study does not support several ways of knowing. This is predicated through the use of variables to search for the meanings instead of patterns, as argued by Shank and Brown (2007, p61). Researcher decides the orientation of the research even if participants have a significant point to make or not.

A quantitative research approach is characterized as being structured with predetermined variables, hypotheses and design (Denscombe, 1998, p173; Bryman, 2012, p408; Creswell, 2009, p17; Christensen and Johnson, 2012, p34-5). As a result of using predetermined working strategies, the approach does not require or encourage imaginative, critical and creative thinking (De Vaus, 1996, p8). Any data collected is geared towards supporting or rejecting the predetermined paradigms. This, however, shows that the tool is effective for studying what is already known instead of assisting in unravelling the unknown and revamping the known. Perhaps, findings from the studies with this tool may lead to propounding laws and facts that can stand on their own regardless of it being true or not (Shank and Brown, 2007, p58).

When considering the existence of social differences in the society and schools in particular, a quantitative research approach is not well "suited to examine the complex and dynamic contexts of public education in its forms, sites and variations" (Denzin and Lincoln, 2005, pxi). But are there true experiments in educational research? Certainly there is no true experiment in educational research (Gorard, 2001, p2).

3.   Problem-solving instruction in science education curriculum

Problem-solving is the application of mental and physical abilities in resolving a tasking situation. It is synonymous with reasoning and critical thinking, which are behavioural processes (Sidenvall et al. 2015; Thomas and Goldfried, 1971, p107-126). Ausubel (1968) argued that problem-solving is a special case of meaningful learning involving a higher order thinking skill. Hiremath (2015) stressed that in science education, emphasis should be placed on deep understanding of a concept that leads students to acquiring skills in critical thinking and a logical approach to problems. In classroom instruction, unnecessary cognitive loads have to be minimized for the promotion of problem-solving skills (Frank and Warner, 2015).

Due to the dynamic nature of human society and science in particular, science education is saddled with the responsibility of proffering solutions to our daily problems. To this end, educationist and researchers have left no stone unturned in searching for the best approach to instil appropriate problem-solving abilities in the secondary school science students.

4.   The strengths and weaknesses of qualitative and quantitative research approaches and methods on the issue

Cohen (2011) argues that a quantitative research approach in its epistemological and ontological orientation regards human behaviour as an object that can be controlled, thereby ignoring opinions and contributions as opposed to a qualitative approach. Qualitative research approaches help to define what needs to be studied when there is no theory on the topic and variables are not known (Leedy and Ormrod, 2014), as opposed to quantitative approaches that use theory to generate data.

In positivist researcher's attempt to reduce bias in data collection and interpretation distances himself from the participants. This separation will invariably deter the researcher from getting better understanding, interpretations and explanations of the phenomena being studied. Moreover, the selected variables with which the quantitative researcher deals with, will only allow him access to some selected aspects of peoples' beliefs or actions (De Vaus, 1996, p8; Litchman, 2006, p7), as opposed to subjectivist.

 Qualitative research has no structured procedure and relies heavily on the researchers' interpretation and ingenuity who collects, interprets and analyses the data. It is argued that it will be not possible to conduct the same research and get the same result at any other time and place. In other words, qualitative research is not replicable as opposed to quantitative research (Bryman, 2008, p391)

In testing hypotheses, quantitative researchers try to look at cause and effect relationships which perhaps enable them to predict and generalize their findings to a relevant larger population. This is not possible with qualitative

researchers who view human behaviour as being dynamic, and as such, tries to understand the beliefs and values with respect to the research being conducted (Christensen and Johnson, 2012, p33; Bryman, 2008, p394).

The use of hypotheses, theories and variables makes the work of a positivist clear and elucidative to readers and subsequent researchers. Such a researcher considers the previous studies done on the topic, field or area by researchers before him. Good research work is carried out when researchers read and use the research of others (Gorard, 2001, p2) as opposed to a constructivist who at the same time cannot establish in clear terms what he did and how he did it; as with regard to the people chosen for observation, the method of data analysis and conclusions (Bryman, 2008, p392). In other words, a quantitative research approach may perhaps be more transparent than a qualitative research approach.

5.   Critical Analysis of Relevant Qualitative and Quantitative Research Articles

 This section reviews available literature on problem-solving instruction in secondary school science education students based on constructivists (subjectivist) and positivists (objectivists) paradigm. Six articles have been chosen, all focusing in the area of problem-solving instruction in secondary school science education students. The first three articles are within the constructivist paradigm and the other three are within the positivist paradigm.

Article one: Reigosa, and Jimenez-Aleixandre, (2007) 'Scaffolded Problem-Solving in the Physics and Chemistry Laboratory: Difficulties hindering students' assumption of responsibility'

Article two: Jurdak, (2006) 'Contrasting Perspectives and Performance of High School Students on Problem Solving in Real World Situated and School Contexts'

Article three: Yap, and Wong, (2007) 'Assessing Conceptual Learning from Qualitative Problem Solving of a Plane Mirror Problem'

Article four: Chun-Yen, and Barufaldi, (1999) 'The Use of Problem Solving Based Instructional Model in Initiating Change in Student' Achievement and Alternative Frameworks'

Article five: Aurah, Cassady, and McConnell (2014) 'Predicting Problem Solving Ability from Metacognition and Self-Efficacy Beliefs on a Cross Validated Sample'

Article six: Henk, Harskamp, Suhre and Goedhart (2008) 'The Effect of Hints and Model Answers in a Student-Controlled Problem-Solving Program for Secondary Physics Education'

Article one: This article aimed to explore scaffolding problem-solving in both physics and chemistry laboratories. The research used a small sample of participants which were not selected through a probability procedure in line with constructivist view. The researcher's use of discussion and analysis is based on the paradigm of social constructivist. The article devoted much time to the review of theories and past research, which is not much of concern to a social constructivist as viewed by (Cohen, 2011, p8; Bryman, 2008, p394). Adequate attention was given to the method as they used ten pages to describe the method they used. The research, being a case study, is exploratory action research in nature which they designed to improve teaching. Ontologically, the research realities were jointly constructed by the research parties and conducted in a natural setting in line with the Lincoln and Denzin (2005) view on ontology in qualitative research. There was full interaction between the researcher and the participants and data were collected through audio and video recordings, verbal and physical actions and reports of each task. There were no research hypotheses and questions in line with qualitative method, but they tried to put forward a research question at the middle of their research on page 311. Researchers subjected their explanations to intersubjective interpretations among authors to ensure validity, although they were trying to confirm a hypotheses which was never stated from the on-set. The discussion was quite descriptive, conforming to the subjectivist research paradigm. Reigosa and Jimenez-Aleixandre (2007) recommended that an alternate approach be used for subsequent research and made no comment on ethical issues on their research.

Article two: The author followed a constructivist approach in his design, method, analysis and reporting of findings. The researcher used small groups and conducted the research in the natural setting in accordance with constructivist view as stated by Creswell (2009,p13). The researcher did not give theories and previous research reviews much attention, though he did state one theory guiding his research. This is still in line with the

constructivist principle as stated by Leedy and Ormrod (2014, p141) that a qualitative research approach is used when there is little theory and information about the topic. Qualitative research interprets social actors' experiences, opinions and feelings (Miles and Huberman, 1994). The researcher maintained direct interaction with the participants throughout the study, asking them questions about their approaches and views to the questions, bearing in mind that participants' input can change the point of orientation of the researcher according to Bryman (2008,p393). The researcher consulted few teachers to check if the constructed task has face validity, since the validity and reliability test is not a great concern to the constructivist. The researcher confirmed the hypothesis which was never stated, and even if it is stated, it will be at variance with the constructivist approach to research. The discussion is descriptive in line with a qualitative research approach, though no recommendation for further research was made. There are no reports of any ethical issues.

Article three: This is a report on assessing conceptual learning from quantitative problem solving using plane mirror focussing on conceptual understanding and content analysis. This study is rooted in the Ausubel (1968) definition of problem solving as a special case of meaningful learning. The article is considered to be phenomenological research as in interpreting human experience. The researchers, being the primary data collectors themselves, used interpretive and participatory methods with a small number of participants. The research exhibits qualitative research approach qualities in line with (Johnson and Christensen, 2012, p34-35) classification. Figures like "30%, 20%" were used in the discussion which is the quality of positivist approach and not constructivist (Maxwell, 2013, p29-30). The weakness of a qualitative research approach in being consistent and reliable (Bryman, 2008, p394) were however projected by the researchers through the use of phrases such as "about 20%, about 30%" in their discussions. The methods were fully discussed, though neither the research question nor a hypotheses guiding the research were stated. This research agrees with Litchman's (2006, p9) submission that no type of qualitative research is designed to test hypotheses. Control of any variable or validation of instrument used were not mentioned by the researchers. The analysis is descriptive and the content of the whole study is much shorter compared to the other two.

Article four: Chun-Yen and Barufaldi (1999) report on a quantitative study of a problem-solving based instructional method for earth science secondary school students. Quasi-experimental methods were used with emphasis on observation, measurement and statistical analysis which characterize an objectivist nature of social research. Data were collected from a sample of 172 students using a questionnaire, an achievement test and a survey, although the researchers did not account for how the samples were selected. The parties in the research were: researchers, teachers and students. Unlike qualitative research where the researcher deals directly with the students, here, the researcher deals with the students via the teachers. The authors gave a detailed explanation of the methods and procedure adopted for the research. Variables in the study were explained but neither research question nor hypotheses were stated, which does not agree with an objectivist view of social research outlined by (Lifchman, 2006, p7). The research still agrees with Bryman's (2011, p621) view of quantitative research which states that 'quantitative research does not entail the specification of a hypothesis'. Covariance and chi-square were used for data analysis. Consequently, chi-square was used to test an alternate hypothesis which was not stated at the beginning. The researchers placed emphasis on the validity and independent variables. Discussions and conclusions were made, but limitations and suggestions for future research were not presented. There is no doubt that this research falls under the ambit of positivism.

Article five: The fifth article explores the power of self-efficacy and metacognition on genetics problem-solving ability among high school students in Kenya using quasi-experimental design. Quasi-experimental research, though lacking internal validity, (Bryman, 2012, p56; Johnson and Christensen, 2012, p319) but being an experimental research study, (Cohen, 2011, p312; Creswell, 2009, p12) by nature is a quantitative research approach. Five pages were dedicated to a review of related research and theoretical underpinning. The data collected from 2138 students through questionnaires and assessment tests were analysed using descriptive statistics, multiple regressions and correlations to test the hypotheses stated. There is no clear report on validity, but accounts of variable control were given. Discussions, conclusions, and a guideline for future research were given. Generalization of the result to other domains may not be warranted because self-efficacy is domain-specific (Aura, Cassady and McConnell, 2014).

Article six: This last article followed positivist approach through its focus on students' problem-solving behaviour while working with tasks and hints. The research is quasi-experimental with small sample of 37 students divided into two groups (11 experimental and 26 control). Unlike the two previous articles, the researchers-participants relationships were very close and they worked with teachers in supervising the work. Positivist feels that their closeness with the participants might compromise their objectivity (Bryman, 2008, p392; Johnson and Christensen, 2012, p36). Two research hypotheses were stated and data was collected through

assessment tests that were analysed using variance and covariate to test them. The researchers regarded the research as a small-scale study, although good explanations of the theories for the research, variable control, discussions and conclusions were given. Researchers made two recommendations for further research. However, it is important to note that nothing was said about how the samples were taken, how groups were assigned and what ethical issues were involved. Yet the use of numbers, testing theories, controlling variables and statistical analysis certify that this research, as a quantitative research approach, is in line with (Litchman, 2006; Bryman, 2012; Cohen, 2011; Creswell. 2009).

6. Ethical Considerations

The usefulness of qualitative and quantitative research methods lies within their strength, which was discussed earlier, but the integrity of the research depends on how the researcher designs his research. Integrity is about the ethics and ethics (Norman and Lincoln, 2005, p96) is about professional regulations and codes of conduct that guide the researcher in his dealings with participants. It is critical to the success or failure of an educational research study. Researchers must "do no harm" (Berg and Howard, 2012, p61) as they collect data from someone and report findings to someone. Research studies involving humans can cause physical and psychological harm. In this regard, treatment of research participants is the most important and fundamental issue that researchers confront (Johnson and Christensen, 2912, p103). In fact, ethical issues and principles are identified by different authors in so many ways (Hopkins, 1999, p221; Robson, 2002, p65; Cohen, 2011, p75; Maxwell, 2013, p93).In the research design, it is necessary to work out the details of value of research as regard to costs/benefits ratio (Cohen, 2011, p75) and obtain informed consent before the commencement of the research (Creswell, 2009, 086; Bryman, 2011, p138).

The six articles discussed earlier involved under-aged persons or children, so the ethical issue is a complex one. The questions now are: how can children be informed about the implication of the research, and how can they be informed of their rights (Cohen, 2011, p78). It is important to note that all six articles make no comment about ethical issues in their research, though there are abounding issues that demand ethical considerations within the research studies. The first of these issues is the fact that the value or scale of the study necessitates consideration of the costs/benefits in relation to sample size, duration of the research, laboratory work, production of hints, provision of computers, supply of model answers and textbooks. Secondly, there are issues around participant confidentiality in the articles. Assessment tests from the examination board, questionnaires, and audio and video tape data were all collected without reference to anonymity. Berg (2007, p68) argued that researchers should safeguard data by removing any identifiers to ensure confidentiality. Thirdly, dividing participants into control and experimental group is another ethical issue. The use of intervention for the experimental groups and just textbooks for the control groups discouraged teachers, students and parents from allowing their children to participate in the control group. Finally, the small-scale nature of the studies limits the comparison of results for generalization. However, it is important that ethical issues, no matter how small, be stated by the researcher so that the integrity of the research can be revered.

7. Conclusions and Recommendations

Qualitative and quantitative research approaches and methods represent different research strategies and differ in their theoretical, epistemological and ontological issue. The use of any approach depend on the researchers' method of data collection and analysis. Researching in problem-solving instruction in secondary school science education needs caution to avoid bias in data collection and interpretation. Though the two approaches are both being used by researchers, the quantitative approach is dominant due to its characteristics and strength makes it more preferred by the researchers.

This study has made significant findings on the usefulness of qualitative and quantitative research approaches in researching problem-solving ability in science education curriculum. But the study has not indicated the appropriate method for studying the problem-solving ability in science education curriculum. The study also did not discuss the specific contributions each of the research approach made to researching problem-solving ability in science education curriculum. These issues are in need for further study.

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