The Oguaa Educator
Vol. 13, June 2019, pp. 52 - 69

Integration of Practical Work into Teaching and Learning of Physics at the Senior High School Level

Donusem Yao Asamoah[1] & Godwin Kwame Aboagye[2]
[1]Kpando Senior High School, Kpando
[2]College of Education Studies, University of Cape Coast, Cape Coast, Ghana
**Corresponding author's email address: aduaboagye@ucc.edu.gh*

Abstract
Practical work forms an integral part of teaching and learning as enshrined in the teaching physics syllabus designed for senior high schools in Ghana. This presupposes that the final grade of students is influenced by their performance in physics practical work. Hence, practical work in physics needs to be utilised to improve students' performance. This study, therefore, sought to examine how practical work is integrated into the teaching and learning of physics at the senior high school level in the Volta Region of Ghana. In all, 16 physics teachers and 212 science students randomly sampled took part in the study. It was found that though teachers accept practical work as an essential ingredient for students' understanding of concepts, they are not up-to-date on how practical work should be integrated into the teaching and learning of physics as prescribed by the syllabus for physics. Also, the teaching of practical work is done via group work, hands-on activity, interactive demonstrations, discussion and lecture. It is recommended that teachers should adopt integrating practical work into lessons instead of separating them from theory.

Key words: Integration, physics teachers, practical work, science teaching.

Introduction

The instrumental role science education plays in the development of any nation cannot be underestimated (Kola, 2013). As science is made up of various aspects, a fundamental subject among the natural sciences which plays a key role in the existing and future progress of mankind is physics (Wenham, Dorling, Snell, & Taylor, 1984). Physics is grounded on experiences and empirical facts finding (Michael & Möllmann, 2012) which calls for process-based science learning (Bybee, 2000; Wellington,

1989) to equip learners with knowledge, skills and attitudes as well as providing them with targeted learning support needed to solve real world problems each day. Also, learners are made to be active, interactive and positive during the learning process (Merriam, Caffarella, & Baumgartner, 2007). One of the key approaches through which learners are made to generate meaning between their experiences and their ideas to acquire physics concepts through process-based learning instead of memorisation is practical approach (i.e., integration of theory and practice) to teaching physics (Fadaei, 2012). In this paper, the use of integrating practical work and practical approach to teaching are used interchangeably.

Physics practical work is learner-centred and it enables a learner to process physics concepts in a systematic manner. Integrating practical work during physics lessons is seen to harmonise theoretical and practical skills which are prominent and distinctive features in physics education. In view of this, the effectiveness of practical approach to teaching physics is seen to be very crucial (Okebukola, 1986) and paramount. Learning through practical experience is very important since it provides learners with the opportunity to generate knowledge and meaning from an interaction between their experiences, ideas and the physical world which is the subject matter of science in general and specifically physics. Furthermore, how effective the practical approach of teaching of physics becomes depends largely on teachers and students undertaking practical work (Oyoo, 2004).

Generally, practical work in science education induces learners with scientific attitudes, problem solving skills and enhances assimilation of concepts (Tamir, 1991). Specifically, practical work in physics is a medium through which students' learning is improved, positive attitude towards physics is developed and more importantly stimulates permanence of knowledge (Azar & Şengülec, 2011). Many science students, particularly, find it difficult to construct knowledge since they need to develop both their conceptual and procedural understanding with appropriate activities (Scanlon, Morris, Terry, & Cooper, 2002). It is for this reason that physics teachers are to have knowledge of instructional approaches, experimental work, mathematical problem-solving, and students' preconceptions and models (Asikainen & Hirvonen, 2010). It is imperative to note that students can easily link theory to practice if knowledge and beliefs about science and subject matter are developed and integrated logically into the teaching and learning process (Van Driel, Beijaard, & Verloop, 2001).

Owing to the importance of practical work in school science in Ghana, the teaching syllabus designed for Senior High Schools (SHS) by the Curriculum Research and Development Division (CRDD) of the Ministry of Education (MoE) laid emphasis on practical lessons. Prominence in the syllabus is placed on a wide range of activities such as projects, experiments, practical activities, demonstrations and scientific enquiry skills designed to bring out the resourcefulness and ingenuity of the physics student (MoE, 2010). The syllabus implemented by schools and teachers clearly recognise the importance of scientific practical work, and for that matter the acquisition of enquiry processes, practical and experimental skills, values and aptitudes in science by students needed to practise science in the more efficient and cost effective way. Engaging students in practical activities improves their knowledge, understanding and connection of what happens, how it happens, and why it happens.

Statement of the Problem

Physics is a natural science which deals with the study of matter, energy and their interactions (Chiu & Lin, 2002) as well as measurements. Physics is seen and posited by many students in Ghana as difficult to conceptualise, abstract and theoretical in nature (Buabeng & Ntow, 2010) which has led to an increase in lack of understanding, comprehension and assimilation. The perceived difficulty of physics alluded to by students call for a pedagogical framework with reinforced emphasis on well-established tools such as the practical approach of teaching physics in senior high schools. This will serve as an anchor in providing an in-depth understanding of concepts taught in physics. It has been observed that the extent to which students are engaged in extended practical work provides them with insights into scientific practice and motivation to continue the study of science (Jakeways, 1986; Woolnough, 1994). Furthermore, the extent to which teachers effectively integrate practical work into instructional time and their knowledge of instructional approaches determine the success of engaging students in practical work (Millar, 2004).

Etkina (1997) pointed out that all physics experiments used in instruction can be classified into three types/groups: (a) observational experiment with a goal to observe a new phenomenon and students later devise explanations for the observations; (b) testing experiment in which students test whether the explanation devised for some observed phenomenon works; and (c) application experiment whereby students are made to apply the explanation that has been tested to explain new phenomena or design technical devices. Findings from the Physics Chief Examiners' reports over the periods 2014, 2015 and 2016 revealed persistent weaknesses of candidates in both Physics 2 and 1 (theory) and Physics 3 (practical) in the West African Senior School Certificate Examination (WASSCE) for school candidates. These include: (a) inadequate practical experiments involving report writing as was revealed in the answers provided by candidates; (b) students are not exposed to and made to use laboratory equipment frequently; (c) less time is devoted to practical lessons [West African Examinations Council (WEAC), 2014; 2015; 2016]. It has been established that little science practical activities are actually conducted and integrated into instructional time by teachers in Ghanaian schools in spite of government spending on equipping second cycle schools to a high level (Institute of Physics [IOP], 2014).

Although practical work forms part of the senior high school physics curriculum in Ghana (MoE, 2010), it is not clear whether there is general lack of organisation of practical work on the part of teachers or whether teachers do not integrate practical work during physics lessons as prescribed by the syllabus also remains an area of concern. Based on these unclear issues, whether teachers integrate practical work into their teaching and how they go about the teaching of practical work, this paper addressed the following research questions:

1. Why do teachers integrate practical work into their physics lessons in senior high schools?
2. How is the teaching of practical work done by physics teachers in senior high schools?

Methods

The study adopted a cross-sectional survey with quantitative and qualitative methods of data collection from senior high school physics teachers and students offering the general science programme in the Volta Region of Ghana. In order to ensure equal representation of school-types (i.e., male and female single sex schools), multistage sampling technique was adopted to collect data from a population of 56 SHSs who offer general science programme. First, the school population was stratified into three (i.e., three male single sex, three female single sex, and fifty mixed schools]. Second, two male single sex, two female single sex and two mixed schools were simple randomly sampled using computer generated random numbers. Third, 216 SHS3 physics students were selected using the computer generated random numbers to take part in the study because these students are believed to have been taught quite a number of practical lessons. To give all students equal opportunity to partake in the study, 36 students were selected from each school. However, actual sample size for the study was 212 since four students did not return their questionnaires. Fourth, a census of 16 physics teachers of the sampled students (that is, all physics teachers at the point of data collection) from all school-types also took part in the study. From the census of teachers, 6 physics teachers were purposively sampled and two each of their practical lessons observed with the use of a structured observation checklist to record the interactions and events that took place. Questionnaires for physics teachers and students, and structured lesson observation checklist were the instruments used for data collection. The questionnaire for teachers was in three parts. The first part was an open-ended question type which solicited teachers' knowledge of how practical work should be integrated into teaching and learning as prescribed by the physics syllabus. The second part was a four point Likert scale (strongly disagree [1], disagree [2], agree [3] and strongly agree [4]) which had subscales of reasons for integrating practical work into physics lessons, and how teaching of practical work is done. The third, which was on a scale of 'yes' or 'no', sought to investigate pedagogies teachers use in integrating practical work into teaching and learning of physics. The questionnaire for students, on the other hand, was in two folds: Students' views on the integration of practical work into physics lessons, and pedagogies teachers use during practical lessons. Items on the observation checklist focused on how teaching of practical work should be done.

The various instruments were developed after extensively reviewing literature on how practical work is integrated into teaching and learning. Content validity of the instruments were done by experts in physics education. The validators were asked to independently determine the appropriateness of the content of the instruments used to achieve the purpose for which it was designed for. They independently assessed the quality of each item on the questionnaires and the observation checklist in the context of ambiguity and clarity of the items. The recommendations of the validators were then used to revise the content of the instruments. Pilot testing of the instruments were carried out on five physics teachers and 30 SHS3 physics students across three schools in the Central region of Ghana. These participants were used since they possess similar characteristics as those used for the main study. The internal consistency of the items on both teacher and student questionnaires were determined using Cronbach's alpha correlation and found to be .79 and .81 respectively which indicate high reliability (Pallant, 2011). Data was collected by administering the sets of closed and open-ended questionnaires to the sampled students and teachers. After retrieving the questionnaires from the participants, six physics teachers' lesson were observed using the structured checklist. Themes, means and standard deviations, percentages and pie chart were used to analyse data in order to answer the research questions raised.

Results

The results of this study are presented based on the research questions raised.

Reasons for integrating practical work into physics lessons in senior high schools

Research question one sought to find out why physics teachers integrate practical work into their lessons. To answer this, the researchers investigated, first, the knowledge of teachers on why practical work should be integrated into the teaching of physics as prescribed by the physics syllabus. Themes of how teachers responded to the questions were captured. The extent of knowledge given by the teachers are presented below:

> It has to do with activities in which students are made to observe and manipulate materials minds-on and hands-on. Out of a total of six (6) periods allotted for physics per week, two (2) is designated for practical work. (N = 3)

> It has to do with tasks in which students observe or manipulate real objects or materials and/or partake in demonstrations. Practical work motivates and also arouse or stimulate and sustain students' interest. (N = 2)
>
> It involves minds-on and hands-on activities which enable students acquire practical and experimental skills. It forms one-third of students' total assessment. Two (2) periods out of six (6) is allotted for practical work per week. (N = 2)
>
> It involves practical and experimental physics which provides activities to students via demonstrations, field work and experiments, the opportunity to acquire the needed knowledge, skills and attitudes to become well informed and productive citizens. It forms one-third of the total score for students and as such two (2) periods are allotted for it per week. (N = 4)
>
> It is a profile dimension which takes care of students' acquisition of practical and experimental skills (psychomotor). It also involves activities which engage students minds-on and hands-on. Two (2) periods are allotted per week for practical work out a total of six (6). (N = 3)
>
> Practical work is part of the physics curriculum which aid students' understanding of theoretical concepts. It is to be carried out after students are adequately prepared in the theory. (N = 2)

These comments suggest that the teachers accepted practical work as hands-on and minds-on activities for students to help them develop skills, knowledge and understanding regarding various topics in physics. Consequently, teachers' responses indicate that practical work is allotted two periods per week out of six and forms one-third of students' total assessment. This results clearly show that teachers are abreast with the prescriptions in the physics syllabus. It is thus expected of teachers to concurrently integrate practical work into instructional time within the allotted timeframe.

Furthermore, the extent to which physics teachers and students disagree or agree to statements involving reasons for integrating practical work into physics lessons was rated on a four-point Likert scale with strongly disagree (1), disagree (2), agree (3) and strongly agree (4). The results are presented in Tables 1 and 2 respectively.

Table 1: Teachers' reasons for integrating practical work into physics lessons (N = 16)

Reasons for integrating practical work into physics lessons	Mean	Std. Dev.
1. It is a good strategy for students of all abilities.	3.75	.447
2. Knowledge of instructional approaches is a precondition for a meaningful integration of practical work.	3.56	.512
3. I do integrate practical work into lessons to show adequate knowledge of subject matter.	3.00	.966
4. The integration of practical work into instruction is dependent on teacher's experience.	2.75	.856
5. Integration of practical work is dependent on the extent of knowledge of students' preconceptions and perceived difficulty associated with concepts and theories.	2.56	.964

The teachers do integrate practical work into teaching physics because it is a good strategy for students of all abilities [*M* = 3.75, *SD* = .447] and knowledge of instructional approaches is a precondition for a meaningful integration of practical work [*M* = 3.56, *SD* = .512]. Also, teachers indicated that they integrate practical work into lessons to show adequate knowledge of subject matter [*M* = 3.00, *SD* = .966]. The finding also indicate that teacher's ability to integrate practical work into lessons is dependent on teacher's experience [*M* = 2.75, *SD* = .856) and also dependent on the extent of knowledge of students' preconceptions and perceived difficulty associated with concepts and theories [*M* = 2.56, *SD* = .964].

Table 2: Students' views on the integration practical work into physics lessons (N = 212)

Views on integrating practical work into physics lessons	Mean	Std. Dev.
1. I become more excited and motivated when practical work is integrated into the teaching and learning of taught concepts and theories.	3.84	.361
2. It is a good strategy adopted by the teacher to promote learning.	3.80	.402
3. It is an effective means of helping students understand theories, laws and principles of physics.	3.75	.467
4. It promotes student's understanding of concepts and theories of physics perceived to be difficult.	3.67	.612
5. It enables students to interact more with colleagues to promote group discussion.	3.57	.574

To students, they become excited and motivated when practical work is integrated into physics lessons [*M* = 3.84, *SD* = .361]. Also, the students indicated that integration of practical work into physics lessons is a good strategy adopted by the teacher to promote learning [*M* = 3.80, SD = .402]. In addition, students stated that integrating practical work into physics lessons promotes their understanding of theories, laws and principles of physics [*M* = 3.75, *SD* = .467] as well as concepts and theories of physics perceived to be difficult [*M* = 3.67, *SD* = .612]. Finally, students indicated that integration of practical work into physics lessons enables them to interact more with their colleagues to promote group discussion [*M* = 3.57, *SD* = .574]. These reasons given by both teachers and students showed that they appreciate the importance of integrating practical work into teaching and learning.

How practical work is taught by physics teachers in senior high schools

Knowing the essence of practical work in the acquisition of concepts in physics, the study further sought to find out how practical work is taught by teachers in senior high schools. The responses were rated on a four-point Likert scale with strongly disagree (1), disagree (2), agree (3) and strongly agree (4). The results are shown in Table 3.

Table 3: Teachers' responses on how teaching practical work is taught (N = 16)

	Item	Mean	Std. Dev.
1.	The practical work performed by my students are taken from WAEC past questions.	3.94	.721
2.	During practical work, students observe a new phenomenon and later devise explanations for the observations.	3.46	.814
3.	During practical work, students test whether the explanation devised for some observed phenomenon works and predict an outcome of a new experiment.	3.23	.663
4.	During practical work, students apply the explanation that has been tested to explain new phenomena or design technical devices.	3.16	.771
5.	Practical work performed by my students are taken from the internet and related electronic sites/sources.	2.31	.934
6.	Practical work performed by my students are designed and carried out by the students.	2.11	1.20

The results obtained from the teachers clearly reveal that practical work performed by their students are very often taken from West African Examinations Council's (WAEC) past questions [*M* = 3.94, *SD* = .721]. Besides, the findings indicate that during practical work, students often observe a new phenomenon and later devise explanations for the observations [*M* = 3.46, *SD* = .814], students test whether the explanation devised for some observed phenomenon works and predict an outcome of a new experiment [*M* = 3.23, *SD* = .663], and apply the explanation that has been tested to explain new phenomena or design technical devices [*M* = 3.16, *SD* = .771]. On the contrary, teachers noted that practical work performed by their students are not often taken from the internet and related electronic sites/sources [*M* = 2.31, *SD* = .934] and not often designed and carried out by the students [*M* = 2.11, *SD* = 1.20].

Integration of practical work into teaching and learning

Pedagogies teachers to integrate practical work during instructional periods were also enquired. From Table 4 shows, nine of the teachers representing 56.3% used interactive demonstration, discussion, group work and hands-on activity as pedagogies for conducting physics practical work. This suggests that majority of the teachers used students-centred approach to integrate practical work into physics lessons. Also, the finding indicates that 4 (25%) of the teachers used lecture method as a pedagogy to integrate practical work into physics lessons while the remaining 3 (18.7%) of the teachers used field work, project and portfolio design as forms of pedagogies employed in conducting physics practical work.

Table 4: Teachers' response on pedagogies teachers used to integrate practical work into teaching and learning of physics (N = 16)

	Pedagogical method used by teachers in teaching practical work	f	%
1.	Interactive demonstration, discussion, group work & hands-on activity	9	56.3
2.	Lecture method	4	25.0
3.	Field work, project & portfolio design	3	18.7
	Total	16	100.0

Students were also asked of the pedagogies used by teachers to conduct practical work. Figure 1 reveals that majority [87 (41%)] of the students asserted that teachers used hands-on activity as the main pedagogical method during practical lessons. Fifty-six students representing 26% of students confirmed that teachers used group work and 50 students forming 24% indicated interactive demonstration as pedagogical methods used. Ten (5%) of respondents said discussion and the least method affirmed by students was lecture method representing 4%.

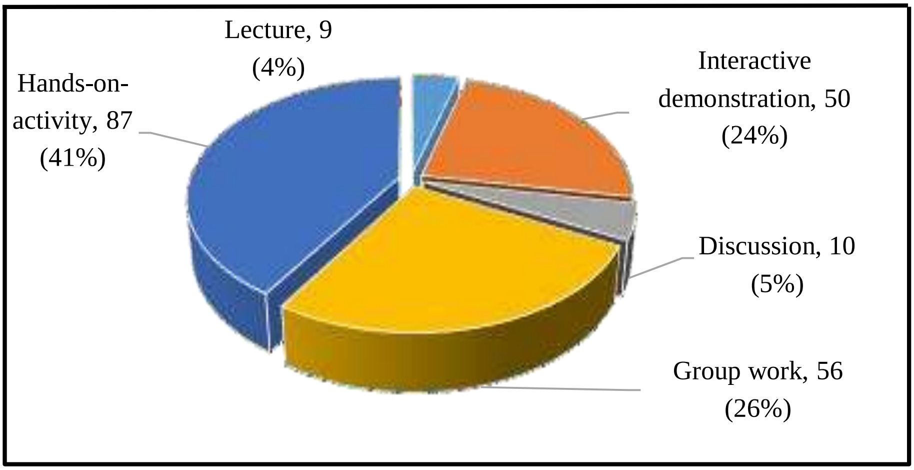

Figure 1: Students' responses on pedagogies teachers used during practical lessons

In order to confirm the responses from both students and teachers on how the teaching of practical work is being done by physics teachers in senior high schools, a structured practical lesson observation checklist was used to observe 12 lessons from 6 purposively sampled teachers (i.e., two lessons from each teacher) from each of the 6 schools (two male single sex, two female single sex and two mixed). The results from the lesson observation checklist are presented in Table 5.

The outcomes from Table 5 indicate that out of the 6 teachers observed, there were evidences of lesson plans showing practical work to be undertaken. Besides, during all teachers' lesson observations, each of teachers introduced the activity to be carried out on a board, presented or introduced the apparatus to students, guided students as they try to explain the apparatus and when students were busy with the activity. However, the findings show that among all teachers' lessons observed (100%), teachers do not challenge students to look for apparatus fit for any of the activities, students did not write any scientific report in which they justify their conclusions and as such they did not present or communicate findings.

Table 5: Results from the observation checklist

Statements	Yes f	Yes %	No f	No %
1. There is evidence of a lesson plan showing a practical work to be undertaken.	12	100.0	0	0.0
2. Teacher introduces the activity on a board/electronically.	12	100.0	0	0.0
3. Teacher presents/introduces the apparatus.	12	100.0	0	0.0
4. Teacher guides students as they try to explain the apparatus.	12	100.0	0	0.0
5. Teacher challenges students to look for apparatus fit for the activity.	0	0.0	12	100.0
6. All students are given the chance to handle and use apparatus.	9	75.0	3	25.0
7. Teacher involves small groups (less than five students) in the activity.	7	58.3	5	41.7
8. Teacher involves large groups (more than five students) in the activity.	5	41.7	7	58.3
9. Students know what to do because the teacher developed procedures for the activity.	11	91.7	1	91.7
10. Students know what to do because the teacher guides them as they are busy with the activity.	12	100.0	0	0.0
11. Students write a scientific report in which they justify their conclusions.	0	0.0	12	100.0
12. Students present or communicate findings.	0	0.0	12	100.0

Discussion

Findings from these study suggest that though teachers accept practical work as hands-on and minds-on activities for students to help them develop requisite skills, knowledge and understanding concepts.

Integrating practical work during instructional time ensures that physics is taught not only at the factual knowledge level but that students will also acquire the ability to apply scientific knowledge to issues and problems, and will also acquire the capacity for practical and experimental skills that are needed for scientific problem solving" (Ministry of Education, 2010, p. vii). Literature allude to the fact that integrating theory and practice promote active learning where students practice more than listening, more emphasis on skill development than knowledge transmission, and engage in higher order thinking and inquiry (Wrenn & Wrenn, 2009). Integration of theory and practice is, therefore, essential in the learning of physics and other science related fields. Incorporating practical work into teaching helps to develop students' cognitive processes needed to function effectively in today's world. Teachers are entreated to employ active engagement strategies to aid the development of students' cognitive, affective and psychomotor domains. By this, students not only acquire procedural understanding of concepts but learn meaningfully through active involvement and participation (Al-Naqbi & Tairab, 2005).

The findings from the study also revealed that both physics teachers and students had similar opinions about why practical work should be integrated into teaching and learning of physics in senior high schools. These opinions on physics practical work, most importantly, enhances students' acquisition of scientific skills and attitudes, promotes understanding and demystifies scientific theories, concepts and principles taught to enable them practice science in the most effective and efficient scientific way. The outcomes from the study also portrayed that teachers integrate practical work into teaching and learning of physics in order to sharpen student's powers of observation, stimulate questions and help develop new scientific understanding and vocabulary. These findings are in consonance with Ottander and Grelsson (2006), and Perkins-Gough (2007) who reported that practical work enable students to acquire and practice process skills, enhance the mastery of subject and enhance the learning of scientific knowledge. Similar findings were discovered by Millar (2004), Millar and Abrahams (2009), and Tiberghien (2000) that practical work motivates students by stimulating interest, to develop their understanding of laboratory skills and to enhance their understanding of scientific knowledge.

Also, it can be observed from the findings of teachers and students that teachers used teacher-and student-centred approaches in teaching practical work. Most of the pedagogies used by teachers in integrating practical work into lessons include group work, hands-on activity, interactive demonstrations, discussion and lecture. The aim of integrating practical work during teaching, firstly enables students to observe a new phenomenon and later devise explanations for the observations. Secondly, it provides opportunity for students to test whether the explanation devised for some observed phenomenon works in order to predict an outcome of a new experiment, and thirdly it facilitates the application of explanation that has been tested to explain new phenomena. The study also reveals students rarely design and solely carry out practical work; there are inadequate practical lessons involving scientific report writing by students and as such students seldom present or communicate findings during practical lessons. Commenting on a pedagogical approach, Bates (1978), Lunetta, Hofstein and Clough (2007) as well as Pekmez, Johnson and Gott (2005) note teacher demonstrations, working in small groups, investigations, problem-solving activities or discovery experiments and lecture methods.

Conclusions

The findings of the study indicate that integrating practical work as a minds-on and hands-on activity into physics lessons both in and outside the classroom is an indispensable component of effective science teaching and it is inconceivable the possibility of teaching physics without practical work because it affords students with knowledge, content, practical and experimental experiences. Integrating practical work into physics lessons is a good strategy for students of all abilities since it aids the development students' knowledge, skills and attitudes. Integrating physics practical work during instructional periods challenges students to observe, explain and utilise scientific principles that will enable them practice science in a more effective and efficient way.

Recommendations

From the findings, it is recommended that practical work should not be taught as a separate entity from theory but instead as an integral part of teaching and learning of physics. This will reinforce students' knowledge construction and acquisition, understanding, attitudes and application of scientific skills. Students must be challenged by teachers to design and carry out practical work under their watch. Teachers must carry out adequate practical lessons involving scientific report writing by students. Students must be made to present or communicate findings during practical lessons.

References

Al-Naqbi, A. K., & Tairab, H. H. (2005). The role of laboratory work in school science: Educators' and students' perspectives. *Journal of Faculty of Education, 18*(22), 19-35.

Asikainen, M. A., & Hirvonen, P. E. (2010). Finnish cooperating physics teachers' conceptions of physics teachers' teacher knowledge. *Journal of Science Teacher Education, 21*(4), 431-450.

Azar, A., & Şengülec, Ö. A. (2011). Computer-Assisted and Laboratory Assisted teaching methods in physics teaching: The effect on student achievement and attitude towards physics. *Eurasian Journal of Physics and Chemistry Education* (Special Issue), 4350.

Bates, G. R. (1978). The role of the laboratory in secondary school science programs. In M. B. Rowe (Ed.), *What research says to the science teacher* (pp. 5-22). Washington, DC: National Science Teachers Association.

Buabeng, I., & Ntow, D. F. (2010). A Comparison study of students' reasons/views for choosing/not choosing physics between undergraduate female non-physics and female physics students at University of Cape Coast. *International Journal of Research in Education, 2*(2), 44-53.

Bybee, R. (2000). Teaching science as enquiry. In J. Minstrel, & E. H. Van Zee (Eds.), *Enquiring into enquiry learning and teaching in science* (pp. 20-46). Washington DC: American Association for the Advancement of Science (AAAS).

Chiu, M. & Lin, J. W. (2002). Using multiple analogies for investigating fourth graders' conceptual change in electricity. *Chinese Journal of Research in Science Education, 10*, 109-134.

Etkina, E. (1997). Teaching Physics to Gifted Students. Unpublished doctoral thesis, Moscow State Pedagogical University (in Russian).

Fadaei, A. S. (2012a). Investigating the effects of teacher training on learning Physics. *Latin-American Journal of Physics Education, 6*(1), 348-351.

Institute of Physics. (2014). *Promoting teaching practical physics in Ghana*. Retrieved from http://www.iop.org/publications/iop/index.htm.

Jakeways, R. (1986). Assessment of A-level physics (Nuffield) investigations. *Physics Education*, *21*(1), 12-14.

Kola, A. (2013). Importance of science education to national development. *America Journal of Educational Research, 1*(7), 223-229.

Lunetta, V. N., Hofstein, A., & Clough, M. P. (2007). Learning and teaching in the school science laboratory: An analysis of research, theory, and practice. In S. K. Abell, & N. G. Lederman (Eds.), *Handbook of research on science education* (pp. 393-442). Mahwah: Lawrence Erlbaum Associates.

Merriam, S. B., Caffarella, R. S., & Baumgartner, L. M. (2007). *Learning in adulthood: A comprehensive guide* (3rd ed.). San Francisco, CA: Jossey-Bass.

Michael, V., & Möllmann, K. (2012). Low cost hands-on experiments for Physics teaching. *Latin-American Journal of Physics Education, 6*(1), 3-9.

Millar, R. (2004). *The role of practical work in the teaching and learning of science.* Retrieved from http://www.nationalacademies.org/bose/Millar_draftpaper_Jun_04.pdf.

Millar, R., & Abrahams, I. (2009). Practical work: making it more effective. *School Science Review, 91*(334), 59-64.

Ministry of Education. (2010). *Teaching Syllabus for Physics (Senior High School 1-3).* Accra, Ghana: Adwinsa Publications.

Okebukola, P. A. O. (1986). An investigation of some factors affecting students' attitudes toward laboratory chemistry. *Journal of Chemical Education, 86*, 531-532.

Ottander, C., & Grelsson, G. (2006). Laboratory work: the teachers' perspective. *Journal of Biology Teaching*, *40*(3), 113-118.

Oyoo, S. O. (2004). Effective teaching of science: The impact of physics teachers' classroom language. Doctoral Thesis, Faculty of Education, Monash University, Australia.

Pallant, J. (2011). *SPSS survival manual: A step by step guide to data analysis using SPSS* (4th ed.). Sydney: Allen & Unwin.

Pekmez, E. S., Johnson, P., & Gott, R. (2005). Teachers' understanding of the nature and purpose of practical work. *Research in Science & Technological Education*, *23*(1), 3-23.

Perkins-Gough, D. (2007). The Status of the science laboratory, special report. *Educational leadership,* 93-94.

Scanlon, E., Morris, E., Terry, D. P., & Cooper, M. (2002). Contemporary approaches to learning science: Technologicallymediated practical work. *Studies in Science Education*, *38*(1), 73114.

Tamir, P. (1991). Practical work in school science: an analysis of current practice. In B. E. Woolnough (Ed.), *Practical science: the role and reality of practical work* (pp. 13-20). Milton Keynes: Open University Press.

Tiberghien, A. (2000). Designing teaching situations in the secondary school. In R. Millar, J. Leach, & J. Osborne (Eds.), *Improving science education: The contribution of research* (pp. 27-47). Buckingham, UK: Open University Press.

Van Driel, J. H., Beijaard, D., & Verloop, N. (2001). Professional development and reform in science education: The role of teachers' practical knowledge. *Journal of Research in Science Teaching*, *38*(2), 137-158.

Wellington, J. (1989). Skills and processes in science education: an introduction. In J. Wellington (Ed.), *Skills and processes in science education: A critical analysis* (pp. 5-20). London: Routledge.

Wenham, E. J., Dorling, G., Snell, J. A. M., & Taylor, B. (1984). *Physics: Concepts and models*. London: Addison Wesley.

West African Examinations Council (2014). *Chiefs Examiners' Report.* Accra, Ghana: WAEC Press.

West African Examinations Council (2015). *Chiefs Examiners' Report.* Accra, Ghana: WAEC Press.

West African Examinations Council (2016). *Chiefs Examiners' Report.* Accra, Ghana: WAEC Press.

Woolnough, B. E. (1994). *Effective science teaching*. Buckingham: Open University Press.

Wrenn, J., & Wrenn, B. (2009). Enhancing learning by integrating theory and practice. *International Journal of Teaching and Learning in Higher Education*, *21*(2), 258 - 265.