AN ASSESSMENT OF SECONDARY SCHOOL PHYSICS TEACHERS PEDAGOGICAL CONTENT KNOWLEDGE (PCK) IN EDO SOUTH SENATORIAL DISTRICT, NIGERIA

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Abstract

Students' performance in physics over the years in external examinations have been very poor and not encouraging, this may be due to their poor conceptions or misconceptions about the physics concepts they are exposed to in schools. Teachers are critical factors in students' learning; thus assessing the Pedagogical Content Knowledge (PCK) of secondary school physics teachers becomes imperative. This study was aimed at assessing the Pedagogical Content Knowledge of secondary school physics teachers in the concept of force and motion. Two research questions were raised and one hypothesis tested in the study. The research design for the study was the survey design. A sample of 80 physics teachers selected from both public and private schools across the seven L.G.A in Edo South senatorial district participated in the study. The instrument used for data collection was the Questionnaire on Physics Teachers Pedagogical Content Knowledge (QPTPCK) which was validated by two secondary school physics teachers, a Lecturer in Physics Department in University of Benin, and an expert in measurement and evaluation. The reliability coefficient for the QPTPCK was found to be 0.80 using the cronbach alpha technique. The data collected were analyzed using the means and t-test of independent samples. It was revealed in this study that secondary school physics teachers had average (moderate) level of PCK. There was a significant difference in the level of PCK held by physics teachers of different qualification and teaching experience but there was no significant difference in the level of PCK held by physics teachers of different specializations. Based on the findings of this study, it was recommended among others that there is the need for the organization of workshops, seminars and any other form of in service training for physics teachers.

Introduction

Physics is an important subject in the school curriculum because of its contribution to the scientific and technological development of any society. Thus the adequate foundation and knowledge in physics is needed for the advancement and development of science and technology in our society.

Students' performances in physics over the years in external examinations have been very poor. A review of the performance of students in physics in external examinations over the past decade is quite alarming; as the performance level of students with credit pass and above in physics for the year 2004, 2005 and 2006 were not up to 50% (WAEC, 2006). Recently the results have become worse as the percentage of students who pass physics with credit and above in external examinations are not up to 30%. For instance, the percentage pass in physics with credit level and above for the May/ June WASSCE 2010 was 29.49% (as reported in Economy Magazine, 2012); for NECO Nov/Dec. 2011 was 0.05%(as reported in Omoifo, 2012) and for NECO Nov/Dec. 2012 it was 2.49% (as reported in Sun Newspaper , April 1 2013). This decline in the performance of students in physics in external examination has become worrisome for stakeholders both in the educational sector and the society at large.

The West African Senior School Certificate Examination (WASSCE) Chief Examiners' Reports (WAEC, 2007; 2008) revealed that candidates weakness in physics were traceable to lack of knowledge of the basic principles, concepts, laws and their appropriate applications to explaining and solving physics problems. These are as a result of physics students having poor understanding of physics concepts, a situation which may arise from a number of causes; one of which is students having misconceptions (a situation that occurs when an individual idea is at

variance with the current scientific agreed ideas, views or explanations) of physics concepts. Studies on students' understanding of physics concepts show that many students posses misconception of some concepts that are basic to the thorough knowledge of physics; as it is now widely acknowledged that students' misconceptions in physics do impede their meaningful understanding of and good performance in the subject (Chee, 2010; Helm, 1980; Ivowi, 1984; 1986; Simanek, 2008). Studies on students' conception of physics concepts revealed that many students do have misconceptions of physics concepts after receiving formal instruction (Chee, 2010; Dariese, 2012; Helm, 1980; Ivowi, 1986).

Students misconceptions in physics may originate from many sources, these include: interactions with the socio-physical world prior to formal science instruction, textbooks, reference books, teaching, language , cultural beliefs and practices (Balci, 2006; Ivowi, 1987 Soyibo,1993). Of particular interest in this study is teaching as a source of students' misconceptions in physics. It is however expected that formal instructions in physics should lead to either the modification, reduction or even a change of misconceptions in students because effective teaching should not only teach students what is correct, it also ensures that students do not believe what is incorrect(Dergisi,2010). Since students have misconceptions after instruction, it therefore indicates that physics teachers need a knowledge base to help students undergo a process of conceptual change from the unscientific conceptions they might hold to acceptable scientific conceptions. One of such knowledge base is what Shulman(1986) calls Pedagogical Content Knowledge (PCK).

Shulman presented a strong case for PCK as a specific form of knowledge for teaching which refers to the transformation of subject matter knowledge into a content that will facilitate students' understanding. PCK is a unique domain of teachers' knowledge which is critical to understanding what effective science teachers need to know. Physics teachers need this PCK in order to organize the content of their lessons, to develop comprehensive representations of the topics they teach, to understand and anticipate particular preconceptions, misconceptions or the possible learning difficulties students may encounter in a specific topic and so on. In order to do this, physics teachers must have sufficient knowledge in the subject matter content in order to understand the underlying structures and organization of the subject and also the appropriate teaching method to teach a particular subject matter topic (Bucat, 2004; Halim & Meerah, 2002; Regina, Achor & Ogbeda, 2010). Therefore this interplay between the subject matter knowledge (content knowledge) and the pedagogical knowledge is a form of specialized knowledge which is termed PCK by Shulman (1986). It is this PCK that differentiate a teacher (physics teacher) from a content expert (physicist).

There are different conceptualizations of PCK as found in literature. A critical review of these literature reveals that there is no universally acceptable conceptualization of PCK however all scholars whose work were reviewed agreed on two components of PCK(knowledge of subject matter and knowledge of pedagogy) as originally conceptualized by Shulman (1986). Shulman underlined the need for more research on PCK by referring to it as missing paradigm. Other scholars have expanded Shulman's definition of PCK by adding new components to it, but generally keeping these two components (knowledge of the subject matter and knowledge of pedagogy) in their definitions. One of such conceptualization is the one by Magnusson, Krrajcik and Borko (1999) where they presented PCK as a separate domain of teachers' knowledge which exists along side with other domain of teachers' knowledge. In their discussion on the nature of PCK, they presented a model in which PCK for science teaching consist of five aspects or components, namely: knowledge of orientations towards science teaching, knowledge about science curriculum, knowledge about assessment in science, knowledge about students' understanding of specific science topics and knowledge about instructional strategies for teaching science. Acknowledging that these domains or components may interact in very complex ways, these authors claimed that effective teachers need to develop expertise in all aspects of these domains of the PCK identified above with respect to all the topics they teach. It is only when the teacher is able to integrate these several components and apply them

appropriately (at right time, for the right students in the right circumstances) that effective teaching will occur. PCK is not a fixed or static body of knowledge it is dynamic in nature, in this regard Hashweh (2005) opined that PCK is a collection or repertoire of pedagogical constructions which teachers acquire when repeatedly teaching a certain topic.

Teachers' quality is one of the important contributing factors to students' learning; hence PCK enters the scene at this moment since it is one of the most critical elements in improving teachers' quality which in turn improves students' learning. This however explains why empirical research or study on PCK will add a new perspective to science education in Nigeria because an empirical work on teachers PCK will also tell the quality of teachers teaching physics in our secondary schools. One of the areas of research in science education which appears to have received limited research attention in Nigeria over the past two decades is the study of PCK among secondary school teachers, this study therefore investigate secondary school physics teachers PCK using the concept of force and motion. The choice of these concepts is because it is one of the concepts that is widely taught in schools as compared to other physics concepts and studies have shown that students do have misconceptions in the concept of force and motion (Dariese, 2012; Ivowi, 1984).

Statement of the Problem

Physics teaching in Nigeria secondary schools is to some extent characterized of teachers with poor subject matter knowledge, lack of pedagogical knowledge, poor experience (novice teachers), unqualified (untrained) teachers, and non-physics specialists; therefore there is bound to be problems in conveying the content knowledge appropriately to students among physics teachers. The inability of physics teachers to convey physics concepts appropriately to their students may lead to students still holding misconceptions of physics concepts after physics instructions. Incompetent teaching may leave students with series of deficiencies that may make physics difficult for them to understand. An effective physics teacher must be able to teach in a way that allows students to achieve adequate mastery of the topic and develop confidence in their ability to understand and apply what they have learnt in their daily life; doing this will reduce the misconceptions students do have in physics concepts.

Since students still hold misconceptions after formal instruction in secondary schools, it therefore indicates that the teaching of physics in secondary schools is not effective as it should be. If the teaching of physics is not effective as it should be, there will be the need to assess the level of PCK among secondary school physics teachers, since literature have shown that PCK is one of the factors underpinning the performance of effective teachers in the classroom which is built over time and experience. The concept of PCK is however a tacit construct, hence specifying and measuring this construct has proven elusive and controversial therefore it will require a careful and systematic analysis in order to obtain useful results.

Several studies have been done on teachers PCK mainly outside Nigeria (Aydeniz & Kirbulut, n.d; Balboa & Stiehl, 1998; Botha & Reddy, 2011; Lankford, 2010; Rizk,2009; Sarkim,2004; Wong & Lai, n.d among others) majority of these studies have more actively focused on two or three components out of the six components of PCK that was used in this study, also empirical evidence on how to examine PCK among science teachers in Nigeria is very scarce, thus this study is aimed at contributing towards the growth of empirical study in assessing physics teachers PCK in secondary schools.

Research Questions

From the issues raised in the problem of the study, the following research questions were raised to guide this study:

(i) What is the level of PCK held by secondary school physics teachers?

(ii) Is secondary school physics teachers' level of PCK influenced by their qualification, teaching experience and specialization?

Research question 1 was answered directly while research question 2 was hypothesized and tested as hypothesis 1.

Hypothesis 1

Secondary school physic teachers' level of PCK is not significantly influenced by qualification, teaching experience and specialization.

Methodology

The study adopted the survey research design. The population for this work comprised of all physics teachers in both public and private senior secondary schools in Edo South Senatorial district, Edo State. The researchers employed stratified random sampling technique in selecting 80 physics teachers across the seven Local Government Areas in Edo South Senatorial District. The stratification was done by school location (urban and rural), school type (public and private), sex of teachers (male and female) qualification (qualified and unqualified), area of specialization (physics specialist and non-physics specialist) and teaching experience (experienced and novice teachers). The researchers ensured that subjects (teachers) in each of the subgroups were adequately sampled and represented in the study so as to allow adequate representation of the specified groups of the target population. The instrument used for the study is the Questionnaire on Physics Teachers Pedagogical Content Knowledge (QPTPCK). The QPTPCK consist of seven sections: section A, B, C, D, E, F and G. Section A seeks the personal data of the teachers; Section B consists of 20-items (which are two-tier multiple choice items), 10 item each for force and motion; Section C consists of 9 items that elicited physics teachers knowledge of students; Section D consists of 6 items that finds out physics teachers knowledge of curriculum; Section E consists of 16 items and 1 open ended questions that elicits physics teachers knowledge of instructional methods; Section F consist of 8 items and 2 open ended questions that elicits physics teachers knowledge of assessment and Section G consists of 1 open ended question which elicits physics teachers knowledge of orientation (purpose) of teaching the concepts of force and motion. The QPTPCK was developed following the slight modification of the components of PCK as specified by Magnusson et al (1999) which is the conceptual framework of this study. This slight modification is the explicit addition of section B (content knowledge) which was not clearly explained satisfactorily in their model. However the items in the QPTPCK were developed by the researchers after a critical review of several literatures on PCK and other relevant materials related to this study.

The instrument was validated by an expert in measurement and evaluation and also by an expert in science education. The reliability of the QPTPCK was done using 20 physics teachers who were not involved in the study. The reliability coefficient of 0.80 was obtained using the cronbach alpha technique; this high alpha value indicated that the instrument was reliable for the study. To ensure that the relevant information was obtained, the teachers were given up to one week to complete the items in the QPTPCK, doing this ensured high rate of returns. The statistics used for the analysis of the data collected were the means and the t-test of independent samples

Results

The research question and the hypothesis raised for the study were carefully analyzed and tested respectively as follows:

Research Question 1: What is the level of PCK held by secondary school Physics teachers?

A summary of the mean scores of secondary school physics teachers PCK is presented in table 1 below:

Table 1: Mean score of secondary school physics teachers PCK

Variable	N	Minimum Score	Maximum Score	Mean Score	Decision
PCK	80	72.00	158.00	129.39	Average

The level of PCK among secondary school physics teachers was determined using the following range scores:

(i) 0 – 99 (i.e Between 0 – 49% of the total score) for poor or low PCK
(ii) 100 – 141 (i.e Between 50 – 70% of the total score) for moderate or average PCK
(iii) 142 – 202 (i.e Between 71 – 100% of the total score) for excellent PCK.

Table 1 shows that the mean score of secondary school physics teachers PCK was 129.39 which falls within the average level category. This implies that majority of secondary school physics teachers have an average or moderate level of PCK in Edo south senatorial district.

Hypothesis 1: Secondary school physics teachers' level of PCK is not significantly influenced by qualification, teaching experience and specialization.

Table 2: Descriptive table on the mean scores of teachers PCK based on qualification, teaching experience, and specialization

Variable		N	Mean Score	S.D
Qualification	Qualified	35	133.17	13.14
	Unqualified	45	126.44	15.90
Teaching Experience	Less Experienced	55	127.69	11.82
	Experienced	25	134.12	13.17
Specialization	Physics Specialist	59	129.71	13.80
	Non-Physics Specialist	21	128.48	18.49

Table 2 is the summary of the descriptive table showing the mean scores of PCK of physics teachers based on qualification, teaching experience and specialization. To test if there is a significant difference in the mean scores, the t-test analysis of independent samples was used. The summary of the table on the t-test statistics is presented in table 3:

Table 3: t-test analysis on mean scores of physics teachers PCK based on qualification, teaching experience and specialization.

Variable	Mean Diff	df	t value	Sig. (p value)	Decision
Qualification	6.73	78	2.02	0.04	Significant
Teaching Experience	6.43	78	2.52	0.02	Significant
Specialization	1.23	78	0.32	0.75	Not Significant

$\alpha = 0.05$

Testing at Significant level of 0.05, table 3 revealed that only the mean difference in specialization of teachers was not significant while for that of teaching experience and qualification of teachers, the mean difference were significant. Therefore, it can be said that secondary school physics teachers' level of PCK is significantly influenced by qualification and teaching experience but it is not significantly influenced by specialization of physics teachers.

Discussion of Findings

This study revealed that secondary school physics teachers had average level of PCK, this finding is in agreement with the findings of Wong and Lai (n.d) and Lee et al (2007) whose studies revealed that science preservice teachers had average or moderate PCK, but however in disagreement with the findings of Aydeniz and Kirbulut (n.d), Botha and Reddy (2011), Sarkim (2004) which all reported that preservice science teachers have limited PCK in Turkey, South Africa and Indonesia respectively. This finding also disagrees with the study of Lankford (2010) where it was revealed that Biology teachers had excellent PCK in teaching of osmosis and diffusion in secondary schools in United States of America., however in Lankford study; all the 6 teachers used for the study were experienced teachers. Also the finding of this study also disagrees with the findings of Balboa and Stiehl (1998) where they found out that the 10 professors used for the study had excellent PCK.

The average (moderate) PCK possessed by physics teachers as found in this study is not sufficient enough to promote conceptual understanding of physics concepts among students. Science education researchers do argue that excellent PCK promotes excellent teaching which in turn may lead to students better understanding of the concepts been taught in science classrooms. Hence there is the need for physics teachers to have excellent PCK so as to help students develop conceptual understanding of physics concepts they are been taught in schools.

Comparing the PCK levels of the various subgroups that was used for the study; it was revealed that qualification and teaching experience have significant influence on the level of PCK of teachers, while specialization of physics teachers had no influence on the level of PCK held by teachers. In terms of experience, this finding corroborates the findings of Rizk (2009) whose study revealed that non-experienced secondary science teachers had poor PCK and Lackford (2010) study which revealed that experienced biology teachers had excellent PCK in the teaching of Osmosis and diffusion. This finding on the influence of experience on PCK of teachers is not suprising; as opined by Gudmundsdattin (1987) PCK is not a fixed body of knowledge but instead an ability that can be developed through reflection, application and experience in teaching. This statement is further supported by the study of Rovengo (1992) whose finding revealed that novice teachers PCK was inadequate to support teaching. This however does not mean that the novice teachers cannot teach, but they might not have an armamentarium of representations at their disposal. A novice teacher often relies on unmodified subject matter knowledge most often directly extracted from the text or curriculum materials and may not have coherent framework from which to present information. (Cochran, Deruiter & King, 1993). The result of this study may suggest that novice teachers are sometimes not developmentally ready to assume the roles required of them as good physics teachers. This study is able to confirm existing literature reviews that assert that PCK is a specialized knowledge that grows with years of teaching experience. Buttressing this, Kind (2009) opined that PCK is a useful concept use for describing and contributing to our understanding of professional practices which clearly develops over time. However, the teacher training programme is supposed to provide a framework on which the novice teachers can build their PCK.

The findings of this study in terms of qualification is in agreement with the study of Sarkim (2004) where it was reported that teachers who exhibited high PCK agreed that their training during their teacher education programme helps them in terms of applicability of teaching skills and knowledge for effective teaching, this thus contributes to the successful development of their PCK. However, this finding is not surprising in the sense that it is expected for qualified teachers to have a better PCK than unqualified teachers; as majority of the qualified teachers have been exposed to the various components of PCK as used in this study during their training in the teacher education programme, unlike the unqualified ones who may not have been exposed to some of the components of PCK during their training in tertiary institutions and when they come across it in the teaching field, they may ignore or look down on these components of the PCK, since they don't really know the implications or are not equipped for it, thus they may just teach the way that suits them. The qualified teachers' PCK may have started to develop

after they have been exposed to teaching practice where they may have had their pitfalls in the teaching field; hence in the teaching career, they may easily adjust to the new challenges unlike their unqualified counterparts who just enter into the teaching profession without adequately preparing for it, thus may be with time and experience as this study have revealed their PCK may begin to develop, but however it will increase for those who are interested in the teaching profession. In as much that qualification (education training) is important in developing teachers PCK, it does not make them automatic experts, it can only place them on a trajectory field. The teacher training programme is supposed to provide a framework on which a would-be teacher can build his PCK (Grossman, 1990).

The researchers were amazed that specialization of physics teachers has no significant influence on their PCK. There is the need for further study to confirm this finding because in a study carried out by Sanders (1993) it was revealed that teachers when teaching a topic outside their subject specialty sometimes acted like novice teachers. This is not however the case in this study, as it was revealed in this study that physics teachers irrespective of specialization have the same level of PCK. The reason for this in this study may be that majority of these non-specialist physics teachers used in this study are either qualified or experienced. If so, since this study have showed that qualification and experience of a teacher contributes positively to teachers PCK, this might be responsible for the non-specialist teachers to have a PCK level very close to that of the specialist physics teachers as seen in table 2.

Conclusion and Recommendations

The overall findings of this study revealed that secondary school physics teachers have average level of PCK and this level of PCK differs by teachers qualification and experience but however do not differ in terms of specialization. Based on the findings of this study, the following recommendations are made:

(i) The need for follow up courses or training for physics teachers cannot be overemphasized, thus there should be the organization of workshops, seminars and any other form of inservice training programmes (conferences, further training etc.) for physics teachers. Doing this will help physics teacher to be informed of the various misconceptions in physics concepts and thus efforts will then be made in correcting these misconceptions. Furthermore the organization of these programmes will help improve physics teachers PCK in physics teaching; as such programme will expose the teachers to the various components of PCK as used in this study; having knowledge of these components of PCK will help or support teachers in improving their PCK which in turn will enhance the effectiveness of teaching physics in classroom.

(ii) The teachers of methodology of physics teaching in teacher education program should try as much as possible to expose the student-teachers to the various components of PCK during their course of teaching in order to enable the pre-service teachers see how the interaction of these components of PCK improves the teaching of physics. When being exposed to these various components of PCK the pre-service teachers will become conscious of it when executing their teaching tasks, this will in turn enhance their PCK.

(iii) Government or school proprietors should employ only qualified physics teachers, since this study has shown that qualified teachers have higher level of PCK than unqualified teachers. Since the qualified teachers must have been exposed to the various components of PCK, this will promote a better understanding and teaching of physics in classroom because the qualified teachers will not undermine any of the components of the PCK, since these various components improved or enhanced their PCK in total, unlike the unqualified teachers who are not being exposed to the various components of PCK, thus there is the likelihood that they may undermine some component of the PCK in the course of their teaching and this will in turn affect the level of their PCK.

(iv) Also novice teachers should be allowed to observe or be mentored by experienced teachers for some time before being allowed to teach in a classroom independently. Doing this will allow the novice teacher to have the confidence in classroom teaching which in turn helps to develop their PCK because they must have observed or be

mentored by experienced teacher hence their fears or likely pitfall must have been overcome during this process of observing and been mentored by experienced teachers.

(v) Authors of physics textbooks should give detailed explanations of physics concepts in their book; as oftentimes teachers rely so much on textbooks as the source of their knowledge. The authors should try as much as possible to review their books in line with the new challenges and needs as they arise, so as to enable physics teachers to be informed of these and hence be updated.

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