BASIC SCHOOL SCIENCE TEACHERS' KNOWLEDGE FOR TEACHING BASIC ELECTRONICS

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ABSTRACT

The study was conducted to investigate basic school Integrated Science teachers' Pedagogical Content Knowledge (PCK) levels and the challenges they face teaching basic electronics. A mixed-method approach using the sequential explanatory design was adopted for the study. Data was collected using a questionnaire and an interview guide. Initially, the questionnaire, which had both task-based and open-ended items was used to collect data from seventy-four (74) purposively selected Basic School Integrated Science Teachers (BSIST) who taught at Primary 6 and Junior High School (JHS) 2. Subsequently, a semi-structured interview guide was used to collect data from six purposively selected Integrated Science teachers who had moderate PCK levels. The quantitative data was analysed using frequency counts and simple percentages, while the thematic analysis was used to analyse the qualitative data. Results obtained from the study show that 90.5% of the BSIST have low PCK for teaching basic electronics. The results also show BSIST face challenges such as limited content knowledge, large class sizes, and limited-time in teaching basic electronics. Due to the low PCK levels and challenges BSIST face, low students' academic achievement in basic electronics is to be expected. The study, therefore, recommends the development of basic school Science teachers' knowledge base for teaching basic electronics through professional development programmes that consider their differing needs.

Keywords: PCK, Integrated science teachers, basic electronics, challenges, basic schools.

INTRODUCTION

Research into teachers' knowledge has persisted over the past three decades. Fischer, Borowski, and Tepner (2012) remarked that the knowledge a teacher processes is an essential precondition for efficacious teaching; it is the basis for determining teachers' competencies in general, and to be specific, the standard for teacher education. Küçükaydin and Sağir (2016) emphasized that teachers' competencies are reflected in pedagogical implementation, which in turn determine students' behaviour and learning. A report by Bawakyillenuo, Akoto, Ahiadeke, Aryeetey, and Agbe (2013) on Ghana's industrial sector shows low levels of science and technology literacy and involvement. This situation emanates from students' perception of Science as an unattractive and difficult subject at the basic school level, which leads to a lack of interest in its study after basic education (Ampaih-Ghartey, 2010; Little, 2010).

As teacher quality is a determinant of students learning (Akanbi, Omosewo & Ilorin, 2018), it is not farfetched to implicate teacher instructional quality for the low levels of scientific and technological literacy. Research is directed towards the improvement of Science instruction by looking at the knowledge base of teachers in relation to their quality of teaching. Teacher Pedagogical Content Knowledge (PCK) has been identified as having significant impact on Science teaching effectiveness (Kind, 2009). Research further shows that Science teachers with

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high PCK levels in a particular topic enact better lessons while those with low PCK levels teach with difficulties (Baumert, Kunter, Blum, Brunner, Voss & Jordon, 2010; Sakpaku, 2016).

The genesis of research into the knowledge base of teachers and its impact on students learning is attributable to Shulman (1986). Shulman revealed seven knowledge bases of a teacher concerning subject matter related teaching. Since then, several studies have been conducted to determine the knowledge bases of Science teachers (Guerriero, 2017; Magnusson, Krajcik, & Borko, 2001; Munby, Russell, & Martin, 2001; Grossman, 1990). Pedagogical Content Knowledge (PCK) has since been described as the knowledge base that transforms all the other knowledge bases of a teacher into teaching. Shulman (1987), described PCK as:

> The knowledge needed for the most regularly taught topics in one's subject area, the most useful forms of representation of those ideas, the most powerful analogies, illustrations, examples, explanations, and demonstrations, the ways of representing and formulating the subject that make it comprehensible to others (p. 9).

Shulman (1987) conceived PCK as a special amalgam of teachers' content knowledge and pedagogical knowledge. Researchers have proposed two theoretical models to explain the origin and development of PCK (Borowski, Carlson, Fischer, Henze, Gess-Newsome, Kirschner & Driel, 2012). The first, is the integrative knowledge model, which intersects other knowledge categories (educational, disciplinary, and contextual knowledge) into a specific knowledge (PCK) (Gess-Newsome, 1999). The second is the transformative knowledge, which is, a separate and unique category of knowledge (Magnusson, Krajcik, & Borko, 2001). Fernandez (2014), through an illustrative analogy by Gess-Newsome, described the integrative model as a mixture and the transformative model as a compound. Thus, the substances of the mixture can be easily separated by physical methods while in the case of a compound, the starting substances cannot be separated, and the initial properties cease to exist.

Teacher training programmes in Ghana are predominantly based on the integrative model where teachers are exposed to the components of PCK separately. For example, in the general Integrated Science course offered at the Colleges of Education in Ghana, the methods of teaching courses are separated from content courses for teaching Science (Institute of Education, 2014). But in practice, teachers are expected to draw knowledge from these areas to teach particular Science concepts.

The conceptualization of PCK has taken numerous forms for the past three decades (Kind & Chan, 2019). In this study, however, PCK is conceived as the knowledge formed from the integration of Content Knowledge (CK), Pedagogical Knowledge (PK), and Knowledge of Learners (KL) during a particular lesson. A Science teacher's CK refers to the teacher's understanding of facts, concepts, theories, principles, relationships, processes, and procedures. McConnell, Parker, and Eberhardt (2013) add that CK is fundamental to effective teaching since it is the basis for clear explanations, analogies, and for identifying relevant and accurate examples of concepts taught. Teachers with proficient CK can teach in ways that help students construct knowledge, pose appropriate questions, suggest alternative explanations, and propose additional inquiries (Windschitl, 2009; Thames and Ball, 2010). Ozden's (2008) study indicated that, "CK had positive effects on PCK and influenced effective teaching" (p.637). Dorwu's (2015) study affirmed that pre-service teachers who had inadequate CK eventually had low PCK to teach topics effectively. However, many Science teachers do not possess adequate understanding of the content of the concepts they are asked to teach (McConnell et al., 2013).

Subject matter knowledge (CK) is not sufficient in itself for effective or good teaching (Kind, 2009; Abell, 2008; Carlson & Francis, 2007). Shulman's (1986; 1987) conception of PCK places CK and PK as important ingredients for the attainment of instructional ends. The development of a Science teacher's PK is dependent on the amount of CK he/she possesses (Kapyla, Heikkinen & Asunta, 2009; Rollnick, Bennett, Rhemtula, Dharsey, & Ndlovu, 2008; Magnusson, Krajcik, & Borko, 2001). Kaypla et al. (2009) found out that graduate teachers who majored in Biology taught photosynthesis and plant growth with fewer misconceptions and inaccuracies, and used more practical strategies and fieldwork compared to those who did not major in Biology. Rollnic et al. (2008) also indicated that Chemistry teachers who had less subject matter knowledge of the mole concept did not know pedagogical strategies needed to teach the concept.

PK translates CK into PCK; however, the selection of CK and PK is dependent on the teacher' contextual knowledge (Gess-Newsome, 1999). Contextual knowledge (CKx) is knowledge about such factors as age, ability, gender, physical environmental issues, and the cultural background of the learners (Morine-Dershimer & Kent, 1999). One of the critical components of a Science teacher's CK_X is Knowledge of Learners (KL). In this study, KL is used in place of CK_X and it refers to teachers' knowledge of how students learn. Unfortunately, Science teachers do not have knowledge of learners' pre-conceptions and learning difficulties in the topics they are to teach resulting in adverse PCK results (De Jong, 2010; Ijeh, 2012; Juttner & Neuhaus, 2012; Morrison & Lederman, 2003). Morrison and Lederman (2003) added that in-service teachers were aware of the importance of knowing the prior knowledge of learners but they lacked the gamut of strategies and techniques that could be used to diagnose learners' ideas. KL is necessary to adapt CK and PK to suit the learning characteristics and needs of learners (Shulman, 1986; Juttner and Neuhaus, 2012).

Gess-Newsome (2013) suggested PCK as "*the knowledge of, reasoning behind, planning for, and enactment of teaching a particular topic in a particular way for a particular reason to particular students for enhanced student outcomes*"(p.3). This affirms the topic-specific nature of PCK. The lack of such knowledge makes it difficult for teachers to identify and understand student difficulties, the selection of the most effective instructional strategies, analogies, demonstrations, or multiple-representations needed for the desired change in behaviour in learners after Science instruction (Kind & Chan; 2019; Kang, Donovan & McCarthy, 2018; Fayez, Sabah & Oliemat, 2011). Thus, teachers with inadequate PCK for teaching specific topics teach such topics with difficulty.

Many basic school Science teachers in Ghana have challenges teaching the concept of basic electronics (Appiah, 2015; Dorwu, 2015; Sakpaku, 2016). In Sakpaku's (2016) study, 86.7% of basic school teachers assessed had low PCK level for teaching basic electronics. Dorwu (2015) also reported that Science teachers with poor PCK may have inadequate CK in a particular concept. Such an outcome is expected because after the inclusion of the concept of basic electronics in the 2002 educational reforms for basic schools (CRDD 2007; 2007b; 2007c; 2012), there was no concomitant introduction of the content in the Diploma in Basic Education (DBE) curriculum until the 2012 DBE Science curriculum innovation (Institute of Education, 2012). Therefore, basic school in-service Science teachers who graduated from the accredited Ghanaian Colleges of Education before 2015 did not study basic electronics as part of the curriculum content and were not exposed to the pedagogical strategies for teaching it.
The possibility of teaching experience (Abell, 2008) closing the gap is murky since the majority of Science teachers still express the view of teaching basic electronics with difficulty (Sakpaku, 2016). Generally, and for Science in particular, professional development programmes

organised for teachers are generic in nature and do not target the specific content areas in which teachers have challenges teaching (Atta & Mensah, 2015; Razzaq, 2012). Professional development programmes for Science teachers fail to expose them to experiences needed to obtain in-depth understanding of basic Science concepts (Loughran, Mulhall, & Berry, 2008). The possibility that teachers will close knowledge gaps they had in college through professional development programmes is slim. Further, the numerous abstract concepts in basic electronics like voltage, current, potential difference, resistance, capacitance et cetera, pose pedagogical challenges for teachers; as such they tend to skip teaching the topic. In the DBE Science curriculum, basic electronics was introduced as part of the Science content course and taught only in the 2nd semester of year 2 (Institute of Education, 2014). However, there was no provision for its teaching in the Science methods course. Thus, its teaching depended upon the ingenuity of the Science methods tutor. This phenomenon according to Kosso (2007) may result in the training of Science teachers who may know (scientific) facts (CK) without an understanding of how they fit together (PCK). With the assumption that PCK develops with teaching experience (Abell, 2008), Science teachers may have developed a certain level of PCK for teaching basic electronics. The question remains to be answered whether Science teachers have the necessary PCK for teaching basic electronics.

For the past 3 decades since the inception of studies into Science teachers' PCK, instruments have been constructed in other parts of the world to assess teachers' PCK in the field of Science and Technology (Lange, Kleickmann & Möller, 2009; Rohaan, Taconis & Jachems, 2009). There are some specific ones on assessing Physics, Chemistry, and Biology in-service and pre-service teachers' PCK on specific topics (Mesci, 2016; Bektaş, 2015; Bahçivan, 2012). In Ghana, PCK studies seem to largely revolve around the influence and relevance of PCK to classroom practices, teacher preparations, and teaching other disciplines apart from Science (Azure, 2015; Boateng, 2015; Pinamang, & Cofie, 2017; Eshun & Mensah, 2013). In literature on Science education in Ghana, PCK studies appear to focus on PCK relative to its development, influence on Science teachers practice, and its impact on student achievement (Siemoh, 2015; Eshun 2014; Amoah, 2017). In Ghana and specifically, the Sekyere East District, there seems to be no research conducted to determine the PCK levels of basic school Science teachers relative to basic electronics and the challenges they face teaching the topic. This study sought to fill this gap in the literature. The following research questions guided the study:

1. What PCK levels do Basic School Integrated Science teachers have for teaching basic electronics?
2. What challenges do basic school Integrated Science teachers face in teaching basic electronics?

METHODOLOGY

The sequential explanatory mixed-methods design was employed in carrying out this study in the Sekyere East District (SED) in the Ashanti Region of Ghana. The target population for this study was all basic school Integrated Science teachers who had at least three years of teaching experience in 41 primary and 33 junior high schools (JHS). From this, 74 basic school Integrated Science teachers (BSIST), comprising, 41 basic 6 and 33 JHS 2 Integrated Science teachers were purposively sampled. Later, a sub-sample of 6 BSIST (3 primary 6 & 3 JHS 2 Integrated Science teachers) who had taught in the same class for more than 3 years, were sampled and interviewed. The criterion for selecting the sub-sample was based on the assumption that teachers' PCK develop with teaching experience (Abell, 2008).

The instruments used to collect data were a semi-structured questionnaire and semi-structured interview guide. In line with the design used, data was first collected using the questionnaire and analysed. Subsequently, six selected respondents were interviewed. The questionnaire consisted of three parts. The first part consisted of five items and collected background information on respondents such as their age, academic qualification and teaching experience. The second part, consisted of 10 task-based items (Pedagogical Content Knowledge Reflective items), adapted from Eshun (2014). The tasked-based items with their rating rubrics were developed to collect and rate respondents PCK levels. The content of this part of the questionnaire was based on the Primary 6 and JHS 2 Integrated Science curricula and required participants to critically reflect on two teaching scenarios; where learning is promoted in one and hindered in the other. After reading each scenario participants were required to answer questions based on their reflections to determine their PK, CK, and KL, the sum of which is their PCK scores. The ratings were categorized as Low, Moderate, or High PCK levels. The last part of the questionnaire consisted of six open-ended items on challenges teachers face teaching basic electronics. The semi-structured interview guide consisted of five items and data collected was used to triangulate findings obtained from the open-ended part of the questionnaire and also to determine other challenges BSIST face in teaching basic electronics.

Face and content validity were ensured through scrutiny by six post-graduate students and later by three senior lecturers from the Department of Basic Education. The instruments were also pilot tested in a nearby Municipality (Ejisu-Juaben Municipality) with respondents who have similar characteristics as those in the study area. After the pilot testing, two raters, trained by the researcher, rated responses of the task-based items of the questionnaire. Cohen's Kappa was used to determine the inter-rater reliability. The Kappa value, $\kappa = 0.785$ (95% CI,0 .300 to 0.886), $p < 0.000$) revealed a substantial agreement between the two raters (Landis & Koch, 1977). This implied a high level of reliability of their ratings (Altman, 1999). The pilot testing of the instruments helped to re-structure and refine the content of the scenarios.

The questionnaire was self-administered. The researcher read and explained the requirements of each item on the task-based part to the respondents before they completed the questionnaire. Each respondent used an average of 30 minutes to complete each questionnaire. The return rate was 80.4%. This is above a response rate of 50% deemed adequate for analysis and reporting of surveys (Mugenda & Mugenda, 2003). The interview sessions were held after the PCK levels of respondents were determined. Each interview session lasted a minimum of 20 minutes. Data from the task-based section of the questionnaires were analysed using frequency counts and percentages and presented in tables. Responses from the open-ended items were coded and themes generated. The themes were further analysed using frequency counts, which were converted into simple percentages. Also, the recorded interview sessions were transcribed verbatim and read over many times to enable the researcher to get acquainted with the data. Afterwards, the transcribed interview data was coded based on the themes obtained from the open-ended items of the questionnaire. Therefore, the challenges BSIST face in teaching basic electronics was determined from the themes generated and confirmed with related excerpts from the transcribed interview data.

The researcher gained access to respondents by seeking written permission from the education authorities in the Municipality. Distinctive codes were assigned to each respondent and this facilitated their identification for interviews. Prior to this, respondents' consent had been obtained and they were assured of confidentiality and anonymity.

RESULTS AND DISCUSSION

The results of the study are presented in line with the research questions that the study sought to answer.

Basic School Integrated Science Teachers' PCK Levels for Teaching Basic Electronics

This study sought to determine the PCK levels of basic school Integrated Science teachers for teaching basic electronics. The integrative model of PCK used in this study conceives PCK as an amalgamation of CK, PK, and KL components into a specific knowledge domain. CK was rated on a scale, which had a maximum score of 18 points, PK on a scale with a maximum score of 68 and KL on a scale with a maximum score of 24 points. Therefore, the PCK was measured on a scale of 0 to 110 points, 0 being the minimum point and 110 being the maximum point attainable by each respondent. The PCK components for each respondent were categorized on three levels- insufficient, basic and proficient. The range of score points of respondents' PCK component levels are shown in table 1.

Table 1. **Scale Ranges for PCK Components**

Ranges /components	CK	PK	KL
Insufficient	0 – 6	0 – 22	0 – 8
Basic	7 – 12	23 – 45	9 – 16
Proficient	13 – 18	46 – 68	17 – 24

The PCK levels and PCK components' levels of BSIST for teaching basic electronics were analysed and are presented in table 2. The PCK levels of respondents were rated as low, moderate and high.

Table 2. **Frequency Distribution of BSIST's PCK Levels for Teaching Basic Electronics**

Categories of PCK Components' Knowledge levels	**PCK Components** CK		PK		KL		**PCK Levels**		**Categories of PCK Levels**
	№	%	№	%	№	%	№	%	
Insufficient	0	0	65	87.8	74	100	67	90.5	Low
Basic	37	50	9	12.2	0	0	7	9.5	Moderate
Proficient	37	50	0	0	0	0	0	0	High
Total	74	100	74	100	74	100	74	100	Low

The results, as shown in Table 2, indicate that 90.5% (67) of the respondents have low PCK levels for teaching basic electronics. The remaining 9.5% (7) of the respondents have moderate PCK levels for teaching basic electronics. Overall, the PCK level of BSIST is rated as low. The results in table 2 suggest that low competence in any of the topic-specific PCK components affects the PCK needed for effective teaching of that topic. Half of the respondent's attained proficient CK level but it could not significantly contribute to the attainment of high PCK by any respondent. This result confirms the study of Kind (2009), which reported that subject matter knowledge (CK) is not the only pre-requisite for good teaching (PCK). Emphatically, Science teachers' CK, is not sufficient in itself for effective teaching (Abell, 2007; Carlson & Francis, 2007). However, since no respondent attained insufficient CK level, it contradicts McConnell's et al., (2013) finding that many teachers of Science do not possess adequate understanding of the content of the concepts they are asked to teach. The trends in the results also refute the assertion that a teacher's CK competence translates into PK competence as indicated by Kapyla et al. (2009) and Rollnick et. al., (2008). However, some competence in CK and PK contributes to moderate PCK levels of respondents.

The low PK and KL competence of respondents, largely contributed to their low PCK levels attained. More than four-fifths of the respondents attained insufficient PK level. Respondents' insufficient KL levels suggest they may have the prior knowledge of learners' competence and difficulties but lacked the gamut of strategies and techniques that could be used to diagnose learners' needs during a basic electronics lesson (Morrison & Lederman, 2003).

Abell's (2008) asserts that PCK develops with teaching experience. However, results in this study suggest that over time, BSIST in the SED rather develop their CK to the detriment of their PK and KL for teaching basic electronics. It also suggests that teacher preparation of BSIST neglected the PK and KL needed for teaching specific topics like basic electronics. In the colleges of education, basic electronics as a content domain is taught in the DBE General Integrated Science course in the 2nd semester of the year 2 (Institute of Education, 2014). The content focuses solely on the CK component of the PCK for teaching basic electronics at the basic school level. This leaves the onus on developing the requisite PK and KL for teaching basic electronics with the in-service teacher. However, the PK and KL levels which respondents attained reveal that majority of them fail to develop the requisite PK and KL after graduating.

Challenges Basic School Integrated Science Teachers Face Teaching Basic Electronics
Ghanaian Science teachers face numerous challenges in teaching Science (Parker et. al., 2018). The peculiar challenges to teaching basic electronics outlined in Table 3 were themes generated from responses obtained from the open-ended items in the questionnaire. The themes were coded and analysed using frequency counts and percentages.

Table3. **Challenges Faced by BSIST In SED In Teaching Basic Electronics (*N*=74)**

Challenges	Frequency	Percentage (%)
Limited content knowledge	64	86.5
Limited time factor	56	75.7
Large class size	44	59.5
Poor quality of professional training	13	17.6

Table 3 shows that limited content knowledge was the most pressing challenge of respondents. Some of the respondents' concerns relate to a lack of subject matter knowledge, as they were not taught the topic in their teacher preparation stages. Loughran et. al. (2008) affirmed that most teacher preparation programmes failed to expose Science teachers to adequate experiences to provide them with sufficient content knowledge and an in-depth understanding of basic Science concepts. In a confirmation of the above statement, one respondent, a 30-year-old teacher with 8 years teaching experience, indicated during the interview session that he was not trained as a Science teacher, therefore, does not have the content knowledge required to teach basic electronics at the JHS. He said:

> *I was taught basic electronics at the SHS levels during my Integrated Science course but at the training college, I didn't get the chance to study the topic again. That is why I find it difficult to explain some components...*[Teacher 2]".

Another respondent admitted that although he endeavours to improve his knowledge through self-tutoring, he skips teaching difficult concepts under basic electronics that he does not understand. In his words, he stated:

> *...the textbooks mention that transistors can be used as amplifiers or switches but the explanations they give are too technical…this makes it difficult to understand, so when it gets to that part I tell the kids it's not so important or questions will not be asked about them so that I can skip.* [Teacher 4, a 31-year-old with 7 years teaching experience]

Further concerns were raised about the scanty content knowledge in some government textbooks that prevents basic school teachers from gaining enough content knowledge to effectively teach the topic. In line with this Teacher 1, aged 33 with 8 years teaching experience, responded:

> *…the government textbooks don't go into details with the way they explain issues on basic electronics, this makes it difficult to understand most of the sub-topics under basic electronics to teach it well.*

Additionally, 56 (75.7%) of respondents cited time as a limiting factor in teaching basic electronics. Respondents indicated that there are many topics teachers are expected to cover within the academic year. Therefore, the use of inquiry-based teaching, which is the most effective teaching technique for teaching basic electronics, becomes practically impossible due to time constraints. One respondent commented:

> "*If pupils can pass their BECE well, teachers have to cover a lot of topics and because of that it is not prudent to spend too much time teaching basic electronics which most questions don't come from [sic]*" [Teacher 2].

Results from table 3 show that 13 (17.6%) of respondents indicated that the quality of professional training they received was poor. If that were factual, then the high rate of respondents who indicated limited CK is confirmed. This result could also be an indication that the respondents have no access to in-service training programmes geared towards addressing their PCK deficits in teaching basic electronics. Respondents who had some training on the teaching of basic electronics, indicated that their training was not detailed enough while others indicated that the training they received was not on the level they are teaching. For example, an excerpt from Teacher 6, a 32-year-old female respondent, who has taught for 6 years reads:

> "*The workshop I attended was not practical, they used a projector to explain things to us, so I don't even know how to properly connect a bulb to a battery…*".

This finding is consistent with the assertion of McConnell, et. al. (2013) that in most cases, professional development programmes ignore the variations in teachers' professional background and peculiar needs. Such workshops, seminars, in-service training or conferences, do not yield the desired results on the participants as revealed in this study.

From the interview sessions, participants raised the issue of getting the appropriate teaching and learning materials (TLMs) for teaching basic electronics as a daunting challenge since most of these TLMs cannot be improvised. They added that TLMs and the tools needed to construct them are also not readily available on the market for purchase. The respondents further indicated that, even if they have access to the tools and materials to construct circuits, they lack the necessary skills to construct them. To this one respondent said:

> "*Even if I get all the components and tools to make the circuits the textbooks suggest, I don't know how to join wires to the components using lead solder wire and the soldering iron…"*[Teacher 3, a 30-year-old male teacher with 5 years teaching experience].

Participants also cited poor academic abilities of pupils to stimulate their own learning as another limitation to the effective teaching of basic electronics. Teacher 3 stated:

> "*…the kind of pupils I have is also a serious problem. Hmmm, most of them can't express themselves well in English. Some can't even write or speak two good sentences on their own…*" For the same reason, Teacher 5 (32 years with seven years teaching experience) also said; *"… normally I teach the topic from form two to form three because with the form ones they usually have low-level understanding to learn this topic*".

CONCLUSIONS

The study was carried out to investigate the level of knowledge BSIST have for teaching basic electronics and the challenges they face teaching the content. The findings show that majority of BSIST in the SED have low PCK for teaching basic electronics. Although the findings revealed that respondents had basic and proficient CK levels, it did not translate into high PCK levels due to their insufficient PK and KL levels. In could be inferred that CK is not the only knowledge base needed for good teaching of basic electronics. The knowledge bases of PK and KL are equally necessary for developing the PCK needed for the teaching of basic electronics. The study also revealed challenges that respondents face in teaching basic electronic. Among the challenges, limited content knowledge, limited time factor and large class size were mentioned.

The study has brought to the fore deficiencies BSIST have teaching basic electronics, a recent innovative content introduced into the basic school Science curriculum. If basic school Integrated Science teachers are not exposed to the needed CK and PCK during initial teacher training and the appropriate professional development workshops organised for them during the period of in-service, they will continue to find it difficult teaching basic electronics as has been unearthed in this study. Basic school Science teachers have good subject matter knowledge in basic electronics but lack the skills to teach it to the understanding of pupils. Such teachers may resort to the traditional teaching methods, which inhibit students' ability to understand and concretize concepts in basic electronics.

The study also revealed the challenges basic school Science teachers face in teaching basic electronics. The curriculum framework of the basic school Science curriculum reveals that basic electronics is taught across the basic schools; from primary 1 to JHS 3. Consequently, these challenges may traverse these levels. Basic school Science teachers may skip basic electronics or teach it in ways that will inhibit comprehension. Eventually, low students' achievement in relation to the topic will be the result. As the concept spirally develops from primary one to the JHS level, if the prerequisite knowledge needed for further studies is poor, comprehension in higher levels will also be affected. Therefore, these challenges reveal critical issues that can affect students' interest in studying basic electronics at their current levels and at higher levels of Science education.

Finding a lasting solution to problems of this nature should be the priority of Science tutors in all Ghanaian Colleges of Education. The CK and PCK of basic electronics should be meticulously taught together and not as separate courses, to prepare teacher trainees to effectively teach basic school learners after the teacher-training programme. When this is effectively done, the nation will have learners who are interested in studying Science and related courses beyond the basic school level in Ghana and elsewhere.

RECOMMENDATIONS

Based on the above, I recommend that the SED Directorate of the Ghana Education Service should organize workshops and training programmes for Science teachers in the basic schools to develop their knowledge bases needed for the teaching of basic electronics. These professional development programmes should consider the different needs of basic school Science teachers. Thus, as much as it becomes necessary, equal weightings in terms of resources should be channeled to the development of basic school Science teachers' CK, PK and KL needed for teaching basic electronics.

Keen attention should be directed to finding solutions to the challenges basic which school Science teachers face to offset any limitations they have on the teaching of basic electronics in Ghanaian basic schools. In the light of this, the SED Education Directorate should endeavour to ensure headteachers of the various basic schools use part of their capitation and base grants to procure adequate and appropriate TLMs to facilitate the teaching of basic electronics. There should be supervision to ensure that teachers use the TLMs procured in their lessons to facilitate the understanding of basic electronics. Further, keen supervision of pupils' academic achievement in basic electronics should be constantly evaluated to ensure it develops as they rise through the educational ladder. Finally, the postings and classification of Science teachers in the SED should be based on their requisite background characteristics. Also, the curriculum developers of the DBE programme should consider innovations that will enhance the development of the PK and KL of basic school Science teachers in teaching basic electronics.

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