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Improving pre-service science teachers' reflective practice through problem-based learning approach at colleges of education in Ghana

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Abstract: The purpose of this study was to facilitate science teacher trainees' reflective practices in science through the use of problem-based learning approach. Stratified Random Sampling technique was used to select 20 prospective science teachers from two colleges of education in the Volta Region of Ghana to respond to the research instruments. Interviews and document/content analysis were employed to gather data from the respondents. Data generated from the study were analyzed qualitatively using thematic approach. It was found that reflective practices of science teacher trainees were improved through writing of reflective journals, self, peer and mentor evaluations of PBL lessons with accompanying feedbacks. However, some mentors lack expertise in coaching pre-service science teachers to be reflective practitioners due to inadequate training. It is recommended that constant in-service training on how to effectively coach teacher trainees to be reflective, must be organized for mentors to sharpen their skills.

Keywords: Problem-based learning, reflective practice, teacher trainees, mentors, feedback, collaboration

INTRODUCTION

The desire to produce quality and effective teachers to teach in Ghana's basic educational institutions had culminated in a series of educational reforms. One of these reforms is the 2007 Educational Reforms following the recommendations made by the Report of the President's Committee on Review of Education Reforms in Ghana in 2002 (Report of the President's Committee on Review of Education Reforms in Ghana, 2002). Accordingly, the then teacher training colleges were upgraded to colleges of education with child-centred and innovative curricula to offer diploma/degree programmes to students (Mereku, 2019; National Council for Tertiary Education [NCTE], 2013; Report of the President's Committee on Review of Education Reforms in Ghana, 2002) in order to improve upon the content knowledge of prospective teachers and to expose them to modern teaching and learning strategies that require critical thinking and problem-solving skills (Amakyi & Ampah-Mensah, 2014).

One of the innovative approaches that was introduced into the curriculum of teacher trainees with the help of the mentoring universities in partnership with Transforming Teacher Education and Learning (T-TEL) which is a UKaid support programme from the government of Britain is Problem-Based Learning (PBL) approach as the implementation of PBL in teacher training curriculum better prepares the trainees to be more innovative and relevant in their teaching professions (Borhan, 2014).

Problem-based learning is a learner-centred teaching approach that can be effectively used in teaching a wide variety of subjects including science. According to Borhan (2014), PBL which is aligned with social constructivist framework has become one of the promising innovations for teaching and learning in schools because PBL is a pedagogy that incorporates different learning styles and intelligence of students into the teaching and learning process and thus provides learners with opportunities to collaborate with others in small group settings in order to learn actively, be motivated intrinsically, interact with their peers and share ideas towards solving real-life problems under the guidance of a facilitator (Akinoglu & Tandogan, 2007; Austin, 2016; Bas, 2016; Chung et al., 2016; Fukuzawa et al., 2017; Ginting, 2017; Pratiwi et al., 2018; Roessingh & Chambers, 2011; Simone, 2014; Syofyan & Siwi, 2018).

When students learn science actively in collaborative small groups, they do not act as passive recipients of knowledge from their teachers but rather interact with material resources and peers to share ideas to develop knowledge and science process skills such as observation, measuring, classifying, communication, interpreting and hypothesizing. Learning science thus becomes meaningful as students participate in the science processes by manipulating the resources that are provided to construct their own knowledge during the teaching and learning process (Boateng, 2014; Hofstein & Mamlok-Naaman, 2007; Idiege et al., 2017; Rauf et al., 2013). This results in the grasping of the scientific concepts and demystification of science as a difficult subject (Dah, 2020).

A learning approach to develop reflective practice in pre-service teachers is problem-based learning (Koh & Tan, 2016). During PBL, teachers and learners are given the chance to reflect in action and on action as teachers facilitate the process to help learners construct knowledge through social interaction with their peers. This affords teachers the opportunity to either think critically to resolve problems as they occur during the teaching and learning process or after the teaching and learning process by developing a repertoire of experiences that would enable them to resolve the problem when it happens again (Amakyi & Ampah-Mensah, 2014; Koh & Tan, 2016).

According to Amakyi and Ampah-Mensah (2014), reflective practice in teacher preparation is a pedagogical approach which promotes autonomous learning that aims to develop students' understanding and critical thinking skills which can be exhibited during PBL sessions. Because when student teachers continuously look into their own actions and experiences with regards to teaching and learning, they grow professionally (Priya et al., 2017) as this has been proven to be a meaningful way of learning about teaching (Loan, 2019) and will help teachers to understand the needs and capabilities of

their learners (Habib, 2017) in order to assist them reflect on their abilities and thus learn better because reflection is one of the most important attitudes science teachers and students need for effective teaching and learning of science (Dah, 2020).

Since teachers are the implementers of the curriculum, the execution of PBL in their training programmes will adequately prepare the pre-service teachers to be more advanced and relevant in their teaching professions (Borhan, 2014) as they serve as facilitators that guide and coach learners to construct knowledge, apply it to solve problems in their daily lives as well as reflect on their practices for improved student learning outcomes (Amakyi & Ampah-Mensah, 2014; Boateng, 2014; Chung et al., 2016; Fukuzawa et al., 2017; Hofstein & Mamlok-Naaman, 2007; Idiege et al., 2017; Rauf et al., 2013; Sergiovanni, 2005; Simone, 2014). Thus, the introduction of PBL under the Supported Teaching in Schools (STS) module where trainees are expected to plan, teach and hold reflective sessions on problem-based lessons individually, with their co-mentees and mentors in their schools of attachment under the guidance of their mentors in collaboration with College STS Co-ordinators and tutors as part of the teacher preparation process to make teacher trainees creative and to acquire knowledge and skills relevant to their future careers (Borhan, 2014).

In the implementation of PBL, there are some obstacles that are usually encountered by teachers. These challenges include planning PBL lessons, alignment of curriculum to PBL cases, the nature of the case for PBL, assessment of learning outcomes in PBL, requirement of extra resources to execute PBL in large class settings, inadequate content and pedagogical content knowledge of facilitators to carry out PBL lessons, formation of groups for PBL lessons, ability of learners to collaborate with one another during PBL lessons (Amakyi & Ampah-Mensah, 2014; Fukuzawa et al., 2017; Koh & Tan, 2016; Loughran, 2002; Priya et al., 2017; Simone, 2014). These challenges require that prospective teachers experience PBL lessons in the course of their training and are supported and groomed effectively to acquaint themselves with how to reflect in practice, on practice and for practice during PBL lessons (Amakyi & Ampah-Mensah, 2014) in order to be effective practitioners of PBL to improve upon student learning outcomes after their training course. However, the development of reflective practices in pre-service teachers using the PBL method has been relatively under-researched (Koh & Tan, 2016) in Ghana hence, a study into facilitating science teacher trainees' reflective practices in science through the use of problem-based learning approach. Consequently, the researchers sought to find out how the reflective practices of pre-service science teachers were enhanced during the implementation of PBL approach in teaching science in their internship programme.

METHOD

Research Design

According to Creswell (2009), qualitative research is a means for exploring and understanding the meaning individuals or groups ascribe to a phenomenon and is linked to specific research problems, method of data collection, analysis and interpretation. The researchers adopted qualitative approach in carrying out the study since data were generated through interviews and document/content analysis and analyzed thematically in order to explore and understand the views and experiences of the participants. Haradhan (2018) stated that the purpose of qualitative research is to describe and interpret issues from the viewpoints of individuals and to generate new concepts and theories. Qualitative researchers are thus interested in people's beliefs, experiences and meaning systems from the perspectives of the people.

Participants

Two colleges of education in the Volta Region of Ghana with a total number of 130 student teachers offering Bachelor of Education with their specialism in Upper Primary Education were conveniently selected for the study. These teacher trainees were considered for the study since they will be teaching science compulsorily in the basic schools after their training. The colleges were coded A and B to ensure anonymity and confidentiality of the data that were generated from the research participants.

Stratified random sampling technique was used to select 10 trainees from each of the two colleges. Thus, 20 student teachers were selected in totality to respond to the research instruments. Stratified random sampling method was used because the researchers wanted to ensure precision, representativeness and gender equity in the sample size. Therefore, 10 male trainees and 10 female trainees were chosen as subjects of the study from the colleges. The mentors of the students were, however, purposively selected to respond to the research instruments.

In selecting the students, the list of students pursuing the upper primary specialism in the two colleges were obtained from their assessment officers. Two strata comprising of males and females were formed in each of the schools. Students in each of these strata were made to indicate their participation by randomly picking shuffled pieces of paper with the inscriptions Yes or No from a box. Students who picked Yes were involved in the studies. The participants in the study were given codes to promote their anonymity in respect of ethical considerations. Every male trainee was given Y and every female trainee was given X and hence in College A, the male respondents were coded as AY1, AY2, AY3, AY4 and AY5. The female respondents were labelled as AX1, AX2, AX3, AX4 and AX5. In College B, the male students were coded BY1, BY2, BY3, BY4 and BY5. The female respondents were labelled BX1, BX2, BX3, BX4 and BX5. The mentors were however coded AYT1, AYT2, AYT3, AYT4, AYT5, AXT1, AXT2, AXT3, AXT4, AXT5, BYT1, BYT2, BYT3, BYT4, BYT5, BXT1, BXT2, BXT3, BXT4 and BXT5.

Data Collection Tools

The researchers employed interview and document analysis to gather data from the subjects. The interview guides for the trainees consisted of semi-structured items focused on support provided to teacher trainees to be more reflective during the implementation of PBL and reflective practices of prospective teachers before, during and after executing PBL lessons. The interview guide for the mentors emphasized support provided to teacher trainees to be reflective during PBL sessions. The guide/framework for analyzing the reflective journals of trainees focused on the topic/problem dealt with during PBL, the category of PBL lesson (taught individually, taught with co-mentee and team teaching/mentees and mentor) and the reflections on lessons taught. Data was collected from 14th to 26th March, 2022 with the research instruments by the researchers.

To address the issue of trustworthiness or rigour in qualitative research, the researchers adopted Guba's construct which correspond to the criteria of credibility, transferability, dependability and confirmability in conformity to the positivist investigator as cited in Shenton 2004. To address issues of credibility as in line with Shenton (2004), the researchers implemented appropriate and well recognized research methods in data gathering and analysis, developed early familiarity with the culture and environment of the participants through preliminary visits before the first data collection dialogue took place, used stratified random sampling technique for the subjects to eliminate bias in the selection of the participants and to ensure representative sample of the broader group, triangulation through the use of different methods such as individual interviews for teacher trainees and mentors as well as analysis of reflective journals by the students and the use of different types of informants in order to verify individual view points and experiences, no participant was coerced to take part in the study and the researchers established good rapport with them to allow the subjects offer honest information in relation to the problem, iterative questioning which allowed the researchers to probe into issues to elicit detailed data was employed, there was peer scrutiny of the study by colleagues and academia during presentations where feedbacks were provided and incorporated into the study, the researchers also engaged in reflective commentary to evaluate the study in order to determine the effectiveness of the techniques that have been employed, participants were allowed to check for the accuracy of the information they provided by reading through the transcripts of dialogues they partook in, there was an examination of previous research findings to assess the degree to which the study results were congruent with those of past studies and there was a detailed description of the phenomenon under study to convey the actual situation thereby promoting credibility of the study.

In positivist work, the concern often lies in demonstrating that the results of the study can be applied to a wider population since the findings of a qualitative research are specific to a small number

of individuals and environment (Shenton, 2004). To address the issue of transferability and to ensure that the readers of the research can be confident in conveying to other situations the results and conclusions presented in the study, the researchers have provided background data to establish the context of the study. Additionally, detailed description of the phenomenon under investigation was provided to allow readers have proper understanding of the occurrence thereby enabling them to compare the instances of the situation described in the research report with those that they have seen emerge in their case. Furthermore, the researchers have also conveyed to the readers about the boundaries of the study. Thus, information about the number of participants involved in the study, the data collection methods that were employed, the length of data collection session and the time period over which data was collected were given to the participants at the outset in line with Shenton (2004).

Dependability was achieved by the researchers through the use of overlapping methods such as independent interviews for the students and mentors and content analysis of the reflective journals of students. Moreover, there was in-depth methodological description of the processes in the study for it to be repeated by future researchers.

To deal with confirmability, there was triangulation through the use of different methods such as individual interviews for teacher trainees and mentors as well as analysis of reflective journals by the students and the use of different types of informants to reduce the effect of investigator bias. The researchers have also recognized the shortcomings in the study methods and their potential effects. Additionally, there was detailed methodological description to allow the integrity of the research results to be scrutinized. Furthermore, the researchers used diagrams to demonstrate 'audit trail' for any observer to trace the course of the research step-by-step through the decisions made and the procedures described in line with Shenton (2004).

Data Analysis Procedure

Data generated with the interview guides and document/content analysis were analyzed using thematic approach. Inductive, experiential and essentialist form of thematic analysis was employed because the codes and themes were derived from the contents of the data (Braun & Clarke, 2006; Braun & Clarke, 2012). The researchers adopted the six phase approach to thematic analysis which hinged on familiarizing yourself with the data, generating initial codes, searching for themes, reviewing potential themes, defining and naming themes as well as producing the report (Braun & Clarke, 2006; Braun & Clarke, 2012). In familiarizing with the data, the researchers immersed themselves in the data by reading and re-reading the data, noting initial ideas and transcribing the data. Generating initial codes began the systematic analysis of the data. The researchers coded interesting features of the data in a systematic fashion across the entire data set as well as collating data relevant to each code. In searching for themes,

the researchers collated codes into potential themes and gathered all data relevant to each potential theme. In reviewing potential themes, the researchers checked if the themes work in relation to the coded extracts and the entire data set as well as generated a thematic map of the analysis. In defining and naming themes, the researchers engaged in ongoing analysis to refine the specifics of each theme, the overall story the analysis tells as well as generating clear definitions and names for each theme. The themes that emerged include: writing of reflective journals, assessment of trainees' performance as well as reflection in action, on action and for action.

In producing the report, the researchers were given final opportunity to do analysis of the data to produce a vivid and compelling story that is based on selected data extracts in relation to the research question, research problem/topic and relevant literature.

RESULTS

The findings and discussions are presented below based on the research question posed.

Research Question: How were the reflective practices of pre-service science teachers enhanced during the implementation of PBL?

Incorporating PBL into the prescribed participatory teaching and learning methods within the Ghanaian common core science curriculum for Basic one to Basic nine (BS1-BS9) necessitates that science teachers embrace knowledge, skills and attitudes relevant to promoting reflective practice during PBL sessions. Table 1 below displays responses from student teachers, along with corresponding codes, regarding the reflective practices they utilized during their PBL lessons.

Table 1. Reflective practices adopted by science teacher trainees during PBL lessons

Codes	Responses
AY_1	Initially, I was having a challenge with how to form the small groups to include the different kinds of learners for PBL lessons. But when my mentor assisted me with the capabilities of the pupils in science, I was able to form the groups.
AY_2	When I was planning my PBL lesson on the solar system, I thought of a model on the solar system to facilitate the understanding of the concept by the pupils.
AY_3	After teaching a PBL lesson, I fill my reflective journal.

AY_4	After I was shown the video about how I facilitated the PBL lesson by my mentor and I self-reflected, I realized my lapses and ready to improve upon them subsequently.
AY_5	Before I teach a PBL lesson, I plan how to go about it.
AX_1	I have learnt a lot from my mistakes and ready to improve upon them after filling the reflective journal on my PBL lesson
AX_2	I asked my co-mentee about my strengths and weaknesses after teaching a PBL lesson and he outlined them to me.
AX_3	After self-evaluation of my PBL lesson, I recognized that I should have involved the pupils in the lesson more than I did.
AX_4	How to ask probing questions was initially a problem to me. But after my co-mentee and mentor guided me, I was able to do it with ease.
AX_5	After I have delivered my lesson, my mentor could not critically analyze my lesson to provide honest feedback that will spark self-reflection in me. She only said the delivery of the lesson was okay.
BY_1	When I was delivering a PBL lesson on health and sanitation to my P4 pupils, I thought of downloading and showing the pictures of micro-organisms that make us sick to the learners but unavailability of internet connectivity prevented me from doing so.
BY_2	Selection of problem cases to reflect real life learning experiences was a challenge to me initially but when my mentor helped me, I was able to do it.
BY_3	I have learnt a lot from my colleague when he acted as a critical friend by pointing my flaws during the facilitation of the PBL lesson to me.
BY_4	My mentor guided me to think about how I delivered the PBL lesson and the possible adjustment that I could do to make the lesson better next time.
BY_5	I feel I can better facilitate PBL lessons more effectively after my mentor engaged in a reflective session with me with the help of the scoring rubrics

BX_1	After teaching a PBL lesson on diseases in humans to my P4 pupils, I realized that I should have looked for a microscope and slides on the causal agents of these diseases for pupils to see.
BX_2	When I was facilitating the lesson, I realized that some groups needed extra content support and I had to interact with them to provide that support to them.
BX_3	When I wanted to teach a concept on generation of electricity to my pupils, I thought through the concept and realized that I needed to improvise electric circuit board to help me deliver the lesson.
BX_4	When I was filling my reflective journals on my PBL lesson, I noticed that if I want to engage in PBL lesson next time, I must give more opportunity to the pupils to comment on their learning experiences.
BX_5	I fill my reflective journal on my PBL lesson to identify my strengths and weaknesses.

Ensuring that student teachers apply the concept of PBL acquired from their tutors during their internship programmes, and effectively reflect in action and on action in the course of the implementation of PBL lessons, is crucial for their professional growth. However, this goal cannot be accomplished without adequate support for teacher trainees in selecting problem cases, selection and utilization of resources/improvisation of teaching and learning resources and deploying the right pedagogy for PBL lessons among other factors. Table 2 below presents responses from mentors along with corresponding codes regarding their practices to enable prospective science teachers to be reflective during the execution of PBL lessons in their schools of attachment.

Table 2: Support provided by mentors to mentees to be reflective during the implementation of PBL.

Codes	**Responses**
AYT_1	Initially, my mentee was having a challenge with how to form the small groups to include the different kinds of learners for PBL lessons. But when I assisted him with the capabilities of the pupils in science, he was able to form the groups.

AYT_2	When my mentee was planning his PBL lesson on the solar system I guided him to see how he could include models in the lesson to facilitate understanding by the learners.
AYT_3	I guided my student teacher to fill his reflective journal after teaching.
AYT_4	I used my android phone to record the PBL lesson of my mentee and allowed him to engage in self-reflection after the delivery of the lesson by observing the video.
AYT_5	Before my mentee engages in a PBL lesson, I guide him on how to go about it.
AXT_1	I guide my mentee to fill her reflective journal after presentation of PBL lesson.
AXT_2	I allow my mentees to do peer assessment whenever they teach PBL lessons.
AXT_3	My mentee realizes her flaws whenever she engages in self-reflection after PBL lessons and willing to improve upon her weaknesses.
AXT_4	How to ask probing questions was a problem to my mentee so when I detected that, I guided her and she was able to do it.
AXT_5	I guide my mentee to fill her reflective journal after delivery of the lesson.
BYT_1	I advised my mentee that he could download materials from the internet to aid him in the presentation of his PBL lessons.
BYT_2	Selection of problem cases to reflect real life learning experiences was a challenge to my mentee but when I guided him, he was able to do it.
BYT_3	I told my mentees that they should be critical friends of each other and critique the PBL lessons of each other.
BYT_4	I guide my mentee on effective management of time in the delivery of PBL lessons.
BYT_5	I engaged my mentees in reflective sessions with the help of scoring rubrics after delivery of PBL lessons.
BXT_1	I guide my mentee to reflect on her PBL lessons after teaching.

BXT_2	I guide my mentee to reflect when she is teaching a PBL lesson and see the adjustments she could make to promote teaching and learning.
BXT_3	I advised my mentee to be creative and improvise materials and equipment for the presentation of her PBL lessons whenever the conventional ones are not available.
BXT_4	I guided my mentee to think about the future experiences of her learners based on her presentation of PBL lessons.
BXT_5	I guided my mentee to fill her reflective journal on her PBL lessons to identify her strengths and weaknesses.

DISCUSSION

Across many professions, there is the need for individuals to reflect about the way they conduct their activities (Loughran, 2002). Reflective practice entails the ability to look into one's actions so as to engage in a process of continuous learning (Habib, 2017). Reflection becomes effective when it leads the teacher to make meaning from the problematic situations in ways that enhance understanding so that he/she sees and understands the practice setting from a variety of viewpoints (Loughran, 2002). Hence, the introduction of PBL approach into the curriculum of teacher training institutions since it enables prospective teachers to undergo reflective practices (Amakyi & Ampah-Mensah, 2014; Loughran, 2002; Priya et al., 2017; Sergiovanni, 2005) as one of the key challenges that pre-service teachers face is the possession of inadequate knowledge and skills to promote reflective practices during PBL sessions (Koh & Tan, 2016).

Enhancement of reflective practices of teacher trainees during the implementation of PBL is very essential as it prepares them for the world of work after their training. According to the prospective teachers from Table 1, the reflective practices that were adopted during the implementation of PBL include writing of reflective journals, reflection in action/practice, on action/practice and for action/practice, self-assessment, peer assessment and mentor evaluations through observations/the use of video recordings, scoring rubrics or checklists (AX1, AX3, AY4, BX1, BX2, BX4, BY3, BY5). These findings were confirmed by the mentors from Table 2 that mentees are guided to fill reflective journals, reflect in action, on action, for practice, to go through self, peer and mentor evaluations during the implementation of PBL as part of their preparatory course (AXT1, AXT3, AYT4, BXT1, BXT2, BXT4, BYT3, BYT5).

Writing of Reflective Journals

Writing of reflective journal after teaching a PBL lesson is very paramount to the success of the lesson as it enables the practitioner to undergo introspection to see the strengths and weaknesses that are associated with the lesson in order to take actions to improve upon the flaws of the lesson subsequently. According to the prospective teachers from Table 1, they filled their reflective journals after delivering PBL lessons to their pupils (AY3, AX1, BX5). One of them stated "I have learnt a lot from my mistakes and ready to improve upon them next time after filling the reflective journal on my PBL lesson" (AX1). Another pre-service science teacher asserted that "I fill my reflective journal on my PBL lesson to identify my strengths and weaknesses" (BX5). The mentors of the science teacher trainees affirmed these findings as they have stated from Table 2 that they guided their mentees to fill their reflective journals after teaching so that they could identify their prowess and flaws and work on their lapses to become better teachers. These findings are in agreement with the fact that reflective practice is a pedagogical approach in teacher educational institutes that allows teacher trainees to think about their teaching practices, analyze their methodologies and how to improve upon the practice for better learning outcomes (Amakyi & Ampah-Mensah, 2014; Loughran, 2002; Priya et al., 2017) and thus the need for maximizing reflection in our pre-service teachers through writing of reflective journals (Rice et al., 2012) as it improves meta-cognitive skills of students (Goodell, 2012).

Reflection in Action, on Action and for Action

Thinking about how to effectively plan a lesson, make modifications in the pedagogy in the course of teaching if the need arises and using the experiences gained to improve future presentations should be of prime importance to the teacher. Teachers must therefore reflect in action, on action and for action. Reflection in action/practice entails the thinking the teacher does in the course of facilitating learning in the classroom, reflection on action/practice involves the thinking processes of the teacher after the presentation of the lesson and reflection for action/practice refers to the thinking the teacher does about future experience based on the previous practice or experience (Amakyi & Ampah-Mensah, 2014) which are geared towards improved learning outcomes of the students. Prospective teachers from Table 1 have thus reflected in action, on action and for action (BX1, BX2, BX4, BY1) in order to promote teaching and learning in the classroom. According to one teacher trainee, "when I was facilitating the lesson, I realized that some groups needed extra content support and I had to interact with them to provide that support to them" (BX2). This finding is in agreement with Simone (2014) that during the implementation of PBL, the facilitator needs to provide content support to the learners to minimize their anxiety and provide them with a positive learning experience. The student teacher had just reflected in action to solve an emerging problem (Amakyi & Ampah-Mensah, 2014; Thomas & Geursen, 2012). Another teacher trainee stated "after teaching a PBL lesson on diseases in humans to my P4 pupils, I

realized that I should have looked for a microscope and slides on the causal agents of these diseases for pupils to see" (BX1). This prospective teacher had looked at her practices and had felt that if she had provided microscopes and slides on pathogens of diseases for her pupils, they would have learnt the concept more meaningfully. This teacher had thus reflected on practice to enhance the academic performance of her pupils. Another prospective teacher affirmed that "when I was filling my reflective journals on my PBL lesson, I noticed that if I want to engage in PBL lesson next time, I must give more opportunity to the pupils to comment on their learning experiences" (BX4). The trainee had thought about her future experience based on the previous experience in order to help her grow professionally and for her pupils learn better. These findings are in agreement with (Amakyi & Ampah-Mensah, 2014; Loughran, 2002; Priya et al., 2017) and were confirmed by the mentors from Table 2 as they stated that they guided their mentees to engage in reflection in action, on action and for action to ensure effective learning of the scientific concepts during PBL sessions (BXT1, BXT2, BXT4).

Assessment of Trainees' Performance

Self-assessment, peer assessment and mentor evaluations are integral part of PBL lessons for prospective teachers. This gives the teacher trainees the opportunity to critically analyze their practices to see their strengths and weaknesses and to grow out of their flaws. According to the teacher trainees from Table 1, they had undergone self-assessment, peer assessment and mentor evaluations in the course of executing PBL approach in their schools of attachment (AY4, AX2, AX3, BY3, BY4, BY5) and these assertions were corroborated by the mentors from Table 2 (AYT4, AXT2, AXT3, BYT3, BYT5, BXT2). As asserted by one teacher trainee from Table 1, "after I was shown the video about how I facilitated the PBL lesson by my mentor and I self-reflected, I realized my lapses and ready to improve upon them subsequently" (AY4). Another teacher trainee from Table 1 stated "after self-evaluation of my PBL lesson, I recognized that I should have involved the pupils in the lesson more than I did" (AX3). These assertions were confirmed by the mentors from Table 2 as they stated that they allowed their mentees to engage in reflective practice after delivering their PBL lessons to enable them grow professionally (AYT4, AXT3).

When students are reflective about their own teaching practices, it promotes professional growth as they are able to evaluate, judge and find ways to improve upon their performances (Amakyi & Ampah-Mensah, 2014; Chase & Robbins, 2012; Senese, 2012) and when videos support reflective practice, it leads to recognition of substantive classroom moments that helps in identification and understanding of the appropriateness of the decisions made in the classroom and results in a more effective interpretation of events (Marsh, 2018).

Peer assessment provides the opportunity to the colleagues of an individual to critically examine the practices of the individual and to make comments that will be geared towards the improvement in the practices of this person. The teacher trainees from Table 1 stated that they had experienced peer

assessment in PBL lessons during their practicum sessions (AX2, BY3). One teacher trainee affirmed that "I have learnt a lot from my colleague when he acted as a critical friend by pointing my flaws during the facilitation of the PBL lesson to me" (BY3). Another prospective science teacher stated that "I asked my co-mentee about my strengths and weaknesses after teaching a PBL lesson and he outlined them to me" (AX2). These proclamations were buttressed by the mentors as they stated that they allowed their mentees to engage in peer assessments after the delivery of their PBL lessons (AXT2, BYT3). According to Amakyi and Ampah-Mensah (2014), peer assessment is of immense importance in supporting reflective practice because of its focus on dialogue and shared interpretations of teaching and learning between students. As students engage in dialogue about teaching and learning, they learn from each other and use the feedback provided by peers to inform their own practices.

Teacher trainees undergoing their internship programmes must be guided on the rudiments of the teaching profession. They must be coached by the master craftsmen under whose care they have been entrusted on the appropriate pedagogies for teaching and learning in order to become better teachers in the future. According to the mentees from Table 1, they were guided by their mentors through analysis and evaluation of their PBL lessons which sparked reflective practice in them in order to become effective teachers after their training programme (BY4, BY5). One prospective science teacher stated that "I feel I can better facilitate PBL lessons more effectively after my mentor engaged in a reflective session with me with the help of the scoring rubrics "(BY5). Another teacher trainee asserted that "my mentor guided me to think about how I delivered the PBL lesson and the possible adjustment that I could do to make the lesson better next time" (BY4). These statements were confirmed by the mentors from Table 2 as they stated that they engaged the teacher trainees in reflective practices after the delivery of their PBL lessons (BYT5, BXT1). The most essential role of mentors in PBL is to facilitate teaching and learning activities by guiding student teachers (Akinoglu & Tandogan, 2007). This is achieved through coaching, modelling best practices to students and holding reflective conversations with them (Allison-Roan & Ramirez, 2012; Kriedemann & Paterson, 2018). As mentors observe lessons and coach student teachers through reflective sessions by providing constructive, honest and non-judgmental feedback on their practices, they grow professionally as they incorporate the feedback into their practices (Baecher & McCormack, 2012; Chase & Robbins, 2012; Kriedemann & Paterson, 2018; Senese, 2012; Weir, 2018).

Content analysis of the reflective journals of prospective teachers coupled with how students have undergone reflective practices during the execution of PBL approach revealed that participants of the study had reflected during the planning stage, execution phase and after the implementation stage of the PBL lessons either individually or collectively with their peers and mentors. During the planning stage, the reflective journals of students from Table 1 revealed selection of authentic PBL cases for PBL lessons, resource mobilization for PBL lessons, formation of groups to encompass the various diversities

in the classroom, facilitation of the PBL lessons and authentic assessment strategies that can be adopted (AY1, AY2, AY5, BY2, BX3). As stated by one trainee "when I was planning my PBL lesson on the solar system, I thought of a model on the solar system to facilitate the understanding of the concept by the pupils" (AY2). Another prospective teacher affirmed that "when I wanted to teach a concept on generation of electricity to my pupils, I thought through the concept and realized that I needed to improvise electric circuit board to help me deliver the lesson" (BX3). These pre-service teachers have thought of how to be resourceful in order to provide hands-on learning experiences for the pupils to learn meaningfully, retain the concept learnt, acquire science process skills and to demystify science as a difficult subject. This finding agrees with the fact that for students to learn science meaningfully and to demystify science as a difficult subject, they must participate in the science processes by manipulating the resources that are provided to construct their own knowledge during the teaching and learning process (Boateng, 2014; Dah, 2020; Hofstein & Mamlok-Naaman, 2007; Idiege et al., 2017; Rauf et al., 2013). Mentors on the other hand have asserted from Table 2 that they coached the teacher trainees during the planning stage of the PBL lesson for it to be successful (AYT2, AYT5, BXT3). For instance, one of the mentors from Table 2 stated that "I advised my mentee to be creative and improvise materials and equipment for the presentation of her PBL lessons whenever the conventional ones are not available" (BXT3).

During the implementation stage, participants thought about how to make adjustments in their methodology, time and effectively interact with learners to promote learning as they facilitate the PBL lessons (BX2, BY1) from Table 1. For instance, one trainee from Table 1 asserted that "when I was delivering a PBL lesson on health and sanitation to my P4 pupils, I thought of downloading and showing the pictures of micro-organisms that make us sick to the learners but unavailability of internet connectivity prevented me from doing so" (BY1). This finding is in conformity with Simone (2014) who stated that for teachers to be competent in their subject areas and pedagogy, they must know the resources that are available, how, why and when they should be used to enhance teaching and learning. Nevertheless, the unavailability of the internet connectivity prevented the teacher from achieving his goal. Mentors on the other hand from Table 2 have confirmed the assertions by the prospective science teachers that they advised the teacher trainees to evaluate their methodologies as they deliver the PBL lessons and to see where amendments can be made in order to promote the attainment of the desired learning outcomes (BXT2, BYT1).

After implementing PBL, student teachers went through self-assessment, peer assessment and mentor evaluations which revealed their strengths and weaknesses associated with the lessons with accompanying feedback as presented in Table 1 (AX2, AX3, AX4, AY1, BY2, BY4). According to AX3, "after self-evaluation of my PBL lesson, I recognized that I should have involved the pupils in the lesson more than I did". Another teacher trainee stated "I asked my co-mentee about my strengths and weaknesses

after teaching a PBL lesson and he outlined them to me" (AX2). Another prospective teacher affirmed "my mentor guided me to think about how I delivered the PBL lesson and the possible adjustment that I could do to make the lesson better next time" (BY4). The mentors from Table 2 supported the assertions of the student teachers that they went through self, peer and mentor evaluations with accompanying feedbacks as publicized in their reflective journals (AXT1, AXT2, AYT3, BYT5). These findings are in agreement with (Amakyi & Ampah-Mensah, 2014; Chase & Robbins, 2012; Priya et al., 2017; Senese, 2012) that PBL practitioners need to undergo self, peer and mentor evaluations which will spark reflective practices in them in order to be effective PBL practitioners.

As the feedbacks were assimilated and accommodated into their existing knowledge base, it has enabled them to grow jobwise. According to the participants from Table 1, even though they encountered some challenges initially in the selection of problem cases, formation of groups to encompass the different diversities of learners, selection and improvisation of teaching and learning materials, facilitation of PBL lessons and authentic assessment techniques to be adopted during PBL, they overcame these challenges when they reflected on the lessons through self, peer and mentor evaluations (AY1, AX4, BY2). According to AX4, "how to ask probing questions was initially a problem to me. But after my co-mentee and mentor guided me, I was able to do it with ease". To BY2, "selection of problem cases to reflect real-life learning experiences was a challenge to me initially but when my mentor helped me, I was able to do it" and to AY1,

Initially, I was having a challenge with how to form the small groups to include the different kinds of learners for PBL lessons. But when my mentor assisted me with the capabilities of the pupils in science, I was able to form the groups.

The mentors from Table 2 on the other hand confirmed that their mentees went through self, peer and mentor evaluations after the delivery of their PBL lessons to reflect on their practices and consequently become expert practitioners in the future (AYT1, AXT4, BYT2). These findings are in conformity with (Cengiz & Karatas, 2015; Cimer & Cimer, 2012; Denton, 2018; Goker, 2016; Lew & Schmidt, 2011; Prabha, 2016; Priya et al., 2017) that reflective practice enables practitioners to learn from their own professional experiences, analyze these experiences and change their practice where necessary.

Subsequently, mentors play crucial roles in guiding prospective teachers to be reflective about their choice of subject matter, pedagogical and technological strategies for improved learning outcomes of students during PBL sessions. Nevertheless, some mentors lack expertise in coaching teacher trainees to be effective reflective teachers. As stated by one of the trainees from Table 1, "my mentor could not critically analyze my PBL lesson to provide honest feedback that will spark critical self-reflection in me. She only said the delivery of the lesson was okay" (AX5). Clearly, this mentor either lacks the proficiency in pointing out the strengths and weaknesses of the lesson to the prospective teacher for him/her to

incorporate the constructive feedback into subsequent lessons in order to grow professionally or she was reneging on her core mandate of shaping the prospective teacher to be a reflective practitioner. Mentors should, therefore, focus on high quality preparation of teacher trainees (Dunne, 2007).

CONCLUSION

Problem-based learning is an innovative and child-centred approach introduced into the curriculum of colleges of education in Ghana by T-TEL in partnership with the mentoring universities. This constructivist approach requires that learners collaborate with one another in small group situations to generate knowledge and skills by interacting with resources, peers and facilitators.

Teachers need to be reflective practitioners as it enables them to grow professionally. One of the pedagogies that facilitates reflective practice in teachers is PBL approach. During PBL, teachers are offered the opportunity to reflect in practice, on practice and for practice about the appropriateness of their content, pedagogical and technological knowledge and how they impact learning outcomes of students for possible adjustments.

Since prospective teachers are learning the rudiments of teaching, they must be groomed properly as they would replicate the knowledge, skills and values they have acquired from their mentors when they become fully fledged teachers. However, some mentors lack the expertise in guiding teacher trainees to be effective reflective practitioners as a result of inadequate training. It is, therefore, essential that mentors are provided with sufficient in-service training in order to model appropriate reflective practices to teacher trainees.

Recommendation

1. The success of mentoring programmes depends on how teacher trainees are nurtured with the relevant knowledge, skills and values by their mentors. Since knowledge, skills and values acquired by individuals degenerate over time, it is prudent that mentors are constantly trained in order to effectively support prospective teachers entrusted to their care to be better teachers.

Limitations of the Study

1. Employing convenient sampling technique to select the two colleges of education in the Volta Region of Ghana for the study coupled with the fact that small sample size (15% of the population) was used to respond to the research instruments, prevents the generalization of the findings to all the colleges in the Volta Region of Ghana.
2. The study is limited by the fact that the views of science teachers in the colleges of education in the Volta Region were not explored on how they nurtured reflective practice in teacher trainees using PBL for them to replicate same during their school attachment programmes..

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