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Article in *Universal Journal of Educational Research* · March 2020

DOI: 10.13189/ujer.2020.080346

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# Assessment of Effectiveness of Problem Based Learning Pedagogical Approach in Radiography Education in a Tertiary Institution in Ghana

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*Received January 7, 2020 ; Revised February 18, 2020; Accepted February 24, 2020*

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**Abstract** A newly accredited department to train Radiographers in the college of health sciences, University of Cape Coast, Ghana was motivated by the great success story of graduating Doctors from the medical school of the same college that uses Problem-Based Learning (PBL) as the main pedagogy. Therefore, the new Radiography department decided to use PBL as the main mode of pedagogy for the training of the radiographers. This study seeks to evaluate the effectiveness of the PBL mode of pedagogy from students' perspective so that lessons can be learnt thereof. A questionnaire was used to gather responses from 272 students (190 males, 82 females) reading diagnostic imaging technology (Radiography) and diagnostic medical sonography programmes. The results showed 100% response rate from the respondents. On whether students prefer PBL to traditional lectures, 32.5% agreed, 63.2% strongly agreed with only 2.2% and 1.5% who disagreed and strongly disagreed respectively and 0.7% neither agreed nor disagreed. Also, 52.2% and 36.4% of the respondents agreed that PBL develops competence and confidence in self-directed learning, 37.5% and 55.5% respondents further strongly agreed to the same set of statements. However only 4.4% and 2.6% respectively disagreed with the same set of statements with 2.2% and 3.3% respectively neither agreed nor disagreed. Majority (59.1%) of the students identified inadequate resources to carry out the PBL activities as their main challenge with PBL. Therefore, from the students' perspective, PBL mode of pedagogy is appropriate for radiography education, it is high-quality and has significantly impacted on students clinical understanding, retention of information, presentation, health promotion and skills development.

**Keywords** Problem Based Learning, Pedagogy, Students Perception, Radiography, Imaging Technology, Health Promotion

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## 1. Introduction

Radiologic Technology (medical imaging) is the technical science that deals with the use of x-rays or radioactive substances for diagnostics or therapeutic purposes in medicine. Radiologic Technologist is the general term used to describe a professional that uses x-rays (radiography) or radioactive substances (nuclear medicine) to produce images of the internal parts of the body for interpretation by a specialist Radiologist. It also involves the use of x-rays or radioactive sources for the treatment of disease (radiation therapy) [1].

In addition to the use of x-rays and radioactive substances, Radiologic Technologists can now use high-frequency sound waves (Diagnostic Medical Ultrasonography) and magnetic field and radio waves (Magnetic Resonance Imaging) to create images of the internal anatomical structures of the human body.

To become a registered Radiographer, one must complete an accredited radiography training programme. These professional programmes are run by tertiary colleges or universities. There are only four radiography training schools in Ghana. The last three institutions were accredited within the last 4 years [2].

Ghana as a developing country has very few Radiographers and health professionals which is the

general trend in Africa in general [3]. The name Radiographer is synonymous to Radiologic Technician (diagnostic or therapy) or Diagnostic Medical Sonographer. The number of registered Radiographers in Ghana is about 334 [4] to a population of about 30 million; one radiographer to about 90,000 people which is woefully inadequate. The acute shortage of Radiographers in Ghana is because the country used to have only one undergraduate radiography training institution which graduated an average of about 30 students a year since its inception in 2002 [5]. The second school to be accredited in year 2015 to start the training of Radiographers in Ghana is the department of Imaging Technology and Sonography at the University of Cape Coast (UCCDITS). The first cohort of students will graduate in June 2020.

The school of medical sciences of the university of Cape Coast, a typically resource challenged new medical school in Ghana, right from its inception adopted the PBL mode of pedagogy and it is the only medical school out of the five government owned medical schools in Ghana to adopt the PBL as its main mode of pedagogy [6]. The feedback from the registrar of the Ghana Medical and Dental council which is the statutory regulatory body for the practice of medicine and dentistry in Ghana has officially declared the Medical Doctors graduating from the University of Cape Coast as among the very best in Ghana even though the medical school has been in existence for only 12 years [7].

Therefore, taking cognizance of the pervasive lack of resources and lecturers to start the new Radiography programme, and also by the motivation of the impact the young medical school (which had same challenges with availability of resources) has chalked in medical education in Ghana, the newly established UCCDITS to train Radiographers in the same College of Health and Allied Sciences of the university of Cape Coast took the decision to make PBL the core (about 90%) mode of Pedagogy in the new department with didactic lectures forming only 10% .

It is important to note that, the non-availability of specialist Radiologists in most Regional and district hospitals in Ghana, to interpret and report on imaging findings and the emergence of very sophisticated imaging technologies which allows for diagnosis that was formerly unthinkable makes the training of the future professional Radiographer must be very prepared to take up the challenge beyond the 'hard' skills, and be able to make the effective impact on the complex clinical demands in healthcare delivery in Ghana and beyond. This requires an additional set of skills such as effective communication, compassion, critical thinking and collaboration. There is therefore the need for advanced high-quality training of the Radiographer to be more involved and improve on their clinical understanding of the clinical condition of the patient to be imaged. In this regard, the competent judgment of the radiographer who may need to understand the clinical implications of the imaging findings to the

patient who had undergone a special diagnostic imaging modality is very important. The future Radiographer with a better understanding of the clinical situations and conditions can be a very effective health promoter and play the health promotion advocacy role much better in the deprived health facilities they may be working in the future. Among some of the emerging challenges in health education are the emergence of new technologies, information explosion and exponential increase in scientific information and new approaches to diagnostic investigations.

Problem based learning (PBL) also known as explorative learning is an approach to innovative learning that is structured. Here the learner focuses on a problem which he/she has identified and which involves genuine intellectual effort [8]. The students learn course content through solving cases that mimic real life situations [9], and in the case of UCCDITS the PBL scenario was mainly a clinical one with a blend of medical imaging technology problem solving. This concept of learning experience was introduced in North America in the 1960s [8,9,10]. This method of pedagogy was developed for medical education initially but has now been adopted by different disciplines for use effectively [11]. As a result, PBL fosters active learning [5,10]. It is believed that, the shelf life of knowledge is lessening each year according to Goodall, [12], a member of the NHS lifelong learning policy team. This means that practitioners learning how to practice radiography today will find that much of the knowledge and many of the skills they have upon qualification will be insufficient to sustain them through their working life. They will need to be comfortable with the principles and practice of lifelong learning [13]. Other advantages of PBL according to Barrows and Tamblyn [14] are that learning is self-determined and acquired through "digging" or study, and thus, the student becomes an active participant in the learning process. The authors opine that this provides motivation to the student and most importantly, what the student learns is better retained, because the student alone determines what is important to his/her own study, and seeks out the information him/herself. The end rewards are internal: the desire to learn for personal or professional growth, not for teacher-dispensed rewards [14].

The structure of the UCCDITS PBL curriculum utilised the Maastricht '7-Jump' [15], a framework for structuring discussion and study around a trigger such that learners go about the PBL process in small groups of not more than 8-10 students in a group. At each meeting the study group appoint a chair to lead proceedings and two scribes to take notes. There is always a lecturer present at each meeting to facilitate the meeting [13,14]. Students undertake a PBL session through a three-step process as follows: step 1: first meeting and first appraisal of scenario, identification of all unknown words and terminologies, formulate a problem statement, brainstorm on unknown words in scenario and develop learning goals in which learners consume assigned

materials (readings, videos, images etc.) the meeting ends by specific research roles assigned to each member. Step 2: second meeting, reading of minutes of first meeting by scribes and readiness assurance to apply new knowledge. This is achieved by all group members discuss learning goals and their research findings and assigned roles, members have the opportunity to apply new knowledge through group problem-solving followed by a group discussion and coming to a consensus on group answers to each question and learning goals. Preparation of PowerPoint presentation slides and selection of members to present. Step 3: third and final meeting on the given scenario is a PowerPoint presentation by representatives of each group and scored [15,16]. After each group presentation they are questioned by the other listening groups whereby they ask relevant questions and critique the presentation if they find any ambiguity. Good questions asked is rewarded by the scoring faculty. At the end of all the presentations it is followed by a faculty-led class debriefing, where groups have the opportunity to make appeals as long as they can advance valid arguments to support their answers. The faculty may also give a short and usually focused lecture, aimed at clarifying misconceptions that become apparent during the debriefing process.

The PBL assignments should consist of knowledge-application of clinical scenarios with potential to generate controversy. Only then can vibrant discussions and deeper learner engagement with content may occur [19]. This is particularly true when groups eventually become a strongly bonded and highly motivated learning teams capable of using their collective brain power to propose practical solutions to real-life problems [20]. The PBL scenario always contained a health promotion talk and advocacy focused around the disease condition or other triggers contained in the scenario. PBL can be applied to teaching single topics or entire courses in higher education [21] and is suitable for both undergraduate and graduate level education [19,20]. A key ingredient for the success of PBL is that it has to be specific for content and structure to ensure that it discriminates in detail across disciplines such as radiography education which plays a lot of emphasis on radiographic anatomy (normal and pathological), imaging findings as well as imaging procedures and techniques to achieve objective.

The time allocated for the PBL cycle vary depending on the content and the explorative learning that students are supposed to engage in. It may also hinge on the resources that are available for students to use during the PBL cycle. Donner & Bickley [23], found that in resource poor environments such as Ghana, PBL process may not be effective in driving learning. These can be in the form of special equipment that make learning relevant to current contextual trends. Some researchers in medical education intimate that PBL has inherent problems that weakens the benefits that learners are supposed to get from participating

in the process especially in a professional programme like radiography training [12,22].

The rationale and vision for the radiography curriculum at UCCDITS was to create an integrated and problem-based curriculum, using instructional technology to enhance collaborative and self-directed learning, research training, improving student communication and technical skills and strengthening support to teaching faculty.

There are very few departments in Universities across Ghana that are using the PBL as a pedagogy to transfer knowledge. In the case of radiography training, UCCDITS is the first and only school in Ghana to adopt this curriculum. This study sought to evaluate the effectiveness of PBL from the students' perspective for inferred feedback and lessons to be learnt to improve the curriculum thereof. The subject specific of content and structure of the PBL will therefore be assessed in a resource constraint environment as in UCCDITS. We aimed to answer the following:

1. Students' perception of the PBL and acceptability of the curriculum
2. whether PBL sessions are providing an opportunity for a more in-depth understanding of radiographic concepts.
3. Students' have any serious negative feedback or concerns
4. Students have enough time and resources for self-directed learning.
5. Students are able to formulate problem statements and identify the themes/problems inherent in the scenarios, and can follow the steps of the PBL process
6. Whether the general learning outcomes are desirable
7. Students perceived benefits from the PBL activities

These are some of the key questions we the lecturers and innovative faculty of the Radiography training programme at the Department of Imaging Technology and Sonography, University of Cape Coast, Ghana wanted to investigate.

## 2. Methodology

### 2.1. Study Area

The University of Cape Coast is one of the major public universities in Ghana offering tertiary education to over seventy thousand students [25]. The University offers graduate and post-graduate programmes in the arts, business and sciences. Among the four colleges of the University is the College of Health and Allied Sciences. The Department of Imaging Technology and Sonography, under the school of Allied Health Sciences in the College had its first intake of students in 2016/2017 academic year, becoming one of the four tertiary institutions in Ghana that offer undergraduate Bachelor of Science degree

programme in radiography.

**2.2. Study Population**

The study involved 272 students in their second, third and fourth year at the department of Imaging Technology and Sonography, University of Cape Coast (UCCDITS) and were made up of 190 males and 82 females. The department has adopted components of the PBL pedagogy into the traditional lecture-based curriculum generally used in the School of Allied Health Sciences. Every PBL cycle, within the UCCDITS, these students are presented with problem scenarios covering relevant areas of courses to be taught where they are guided to employ the PBL approach to solving the inherent problems. It must be emphasized that each of these students went through purely didactic lectures during their first year at the university where they read general university-wide courses and were only introduced to PBL in the second year through to the final year in their field of study.

**2.3. Study Design**

This study employed a cross sectional design. All students in second, third and fourth year of study at the UCCDITS were included. A purposive sampling was done while employing a census approach. The study was conducted towards the end of the semester of study when the students had completed the full semester activity.

**2.4. Inclusion Criteria**

All consented Level 200, 300 and 400 students (i.e. Year 2,3 and 4 students) who have all been exposed to the PBL mode of pedagogy in the department.

**2.5. Exclusion Criteria**

All Level 100 (first year) students, because they do not take part in PBL activities of the department. They are mainly reading general university wide courses which are delivered mainly by didactic lectures.

**2.6. Data Collection**

The collection of data was based on primary data using a pre-structured questionnaire administered to students by faculty to complete. For this study, questionnaires were administered to consented students who met the inclusion criteria of being in Level 200 – 400 and had been exposed to the PBL activity in the department. The questionnaire included both opened and closed-ended questions. Each student completed the study questionnaire.

**2.7. Data Analysis**

The data obtained was entered and analysed using the Statistical Package for Social Science (SPSS v.23.0). Proportions were presented for categorical variables.

**2.8. Ethical Clearance**

Ethical clearance and permission to undertake the research was sought from the University of Cape Coast Institutional Review Board. Respondents gave informed consent and were assured of confidentiality as names and other personal information were not included in the study. There were no risks to the participants. Participants were also informed about their rights to withdraw from the study at any stage as participation in the study was voluntary.

**3. Results**

A total 272 students were recruited for the survey out of which 190 (69.9%) were males and 82 (30.1%) were females. The results showed a 100% response rate from the participants. Also, the students were asked whether they were aware of the radiography profession before they entered the university and the results showed that majority (65.4%) had not heard of the radiography profession as against 34.6% who had heard of the profession.

**3.1. Satisfaction with Programme of Study**

In response to the question as to whether or not the students are satisfied with their programme of study, 163 (59.9%) out of 272 agreed that they are satisfied. Another 35 (12.9%) strongly agreed with 21 (7.7%) and 12 (4.4%) who disagree and strongly disagree respectively and 41 (15.1%) students neither agree nor disagree as shown in Figure 1. Thus, majority of the students were happy with their programme of study compared to few who were not happy.

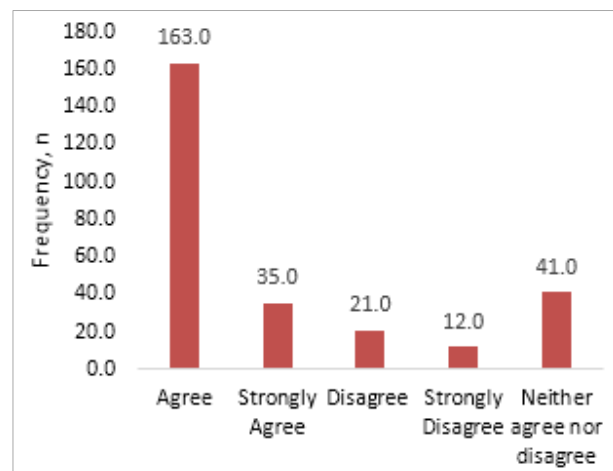


Figure 1. Satisfaction with the programme of study

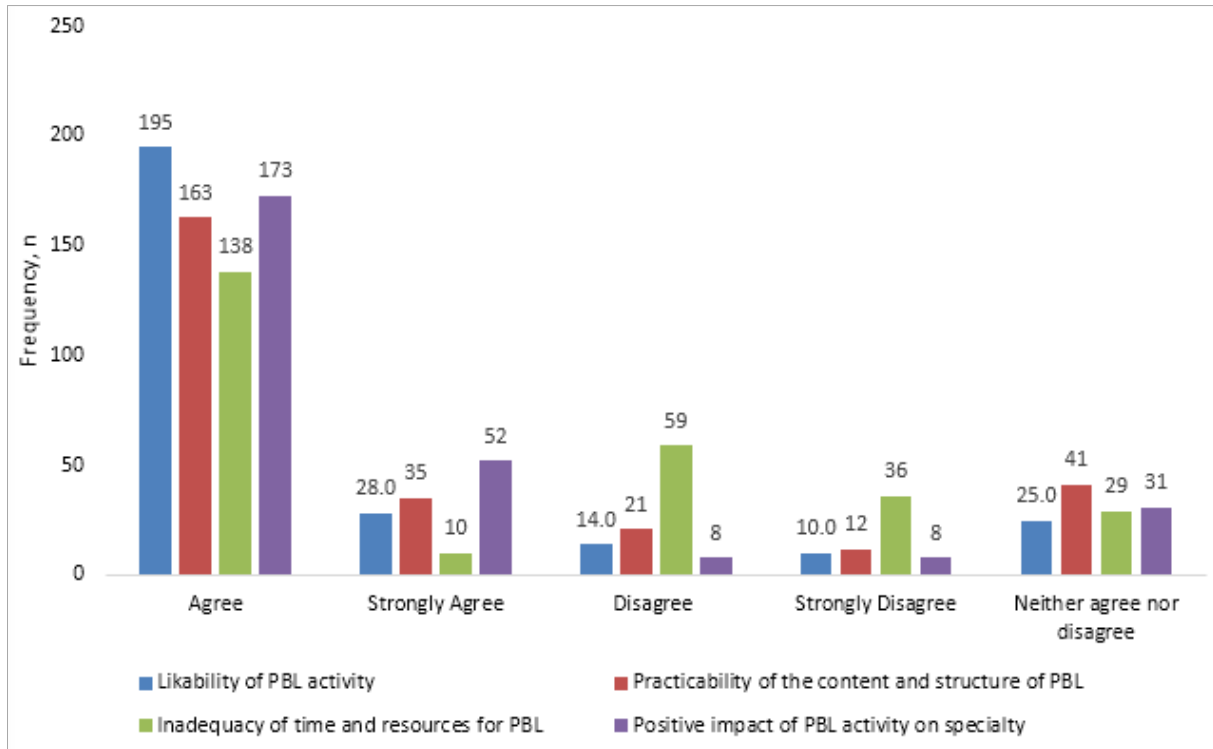


Figure 2. Students perception about PBL activity

3.2. Students Perception of PBL activities

Figure 2 illustrates students’ general perception about PBL activity in the department. The results showed that 195 (71.7%) agreed they enjoy the PBL activity, and 28(10.3%) strongly agreed to the same statement. However, 14(5.1%) and 10(3.7%) of the students disagreed and strongly disagreed respectively, that the PBL activities were interesting with 25 (9.2%) neither agree nor disagree.

On the practicability of the scenario, the content and structure of the learning goals as well as questions elicited from the PBL activity, 163 (59.9%) students agreed and 35 (12.9%) strongly agreed that, the content and structure of the clinical scenario as well as the learning objectives are practicable. However, 21(8.8%) and 12(4.4%) respectively disagreed and strongly disagreed with 41(15.1%) neither agree nor disagree.

Students were asked whether the allocated time and resources to carry out the PBL activity were inadequate. We had majority, 138(50.7%), of students agreeing with another 10(3.7%) strongly agreeing that there is NOT enough time and resources to carry out the PBL activities as compared to 59(21.7%) who disagree and 36(13.2%) strongly disagree with 29(10.7%) neither agree nor disagree.

A majority, 173(63.6%) agreed that PBL activity has impacted positively on their field of study with 52(19.1%) who further strongly agreed to the same statement. However, same number of students, 8(2.9%) disagreed and strongly disagreed that PBL activity has made a positive impact in relation to their programme of study. We had 31

(11.4%) neither agreed nor disagreed.

3.3. General Perception about Benefits and Negatives of PBL Activity

Table 1 shows the students’ general perception about PBL benefits and the shortcomings. It is remarkable to note that, 68.1% and 23.1% respectively agreed and strongly agreed that PBL improves learning ability with only 4.4% and 2.2% respectively who disagreed and strongly disagreed with 1.8% neither agree nor disagree. In a similar way, 145(53.3%) and 100(36.8%) respectively disagree and strongly disagree that PBL does not improve decision making skills. Conversely, 12(4.4%) and 9(3.3%) respectively agree and strongly agree that PBL does not improve decision making skills with only 6(2.2%) neither agree nor disagree. Furthermore, majority, 150(55.1%), of the students strongly agree that PBL improves problem solving skills with a further 99(36.4%) of the students who agree. However, 9(3.3%) and 5(1.8%) respectively disagree and strongly disagree and 9(3.3%) neither agree nor disagree. Most students acknowledged that PBL helped them to develop competence and confidence in self-directed learning with very high numbers who agreed or strongly agreed to this statement as can be inferred from Table 2. Additionally, majority, 150(55.5%) of the students strongly agree that PBL improves presentation skills with 99(36.4%) agreeing to the same statement and only 9(3.3%) and 5(1.8%) respectively who disagree and strongly disagree to the same statement with 9(3.3%) neither agree nor disagree. Again, we had 176(64.7%) students who

strongly agree that PBL encourages students to take up leadership responsibilities and a further 74(27.2%) who agree to same statement with only 8(2.9%) and 7(2.5%) respectively who disagree and strongly disagree with 7(2.5%) neither agree nor disagree. Table 1 also shows that students enjoy PBL as the main mode of pedagogy compared to the traditional lectures as 88(32.5%) agreed, 172(63.2%) strongly agreed with only 6(2.2%) and 4(1.5%) respectively who disagree and strongly disagree whereas 2(0.7%) neither agree nor disagree. The general perception

of students on the research and health talk component of the PBL activity shows that majority of the students acknowledged that, the health promotion aspect of the PBL activity is laudable and has made them capable to research and give health talks. 150(55.1%) and 148(54.5%) strongly agreed that the health promotion aspect is laudable and has made them capable to deliver health talks respectively while 9(3.3%) and 7(2.6%) think otherwise 9(3.3%) each neither agree nor disagree.

**Table 1.** Students' general perception about the benefits of PBL

Variable on PBL activity	Agree	Strongly Agree	Disagree	Strongly Disagree	Neither agree nor disagree
PBL improves learning ability	186(68.1%)	63(23.1%)	12(4.4%)	6(2.2%)	5(1.8%)
Content and structure of clinical scenario and learning objectives NOT enjoyable	9(3.3%)	8(2.9%)	110(40.4%)	141(51.8%)	4(1.5%)
Availability of time and resources to carry out PBL activity NOT adequate	136(50.0%)	112(41.2%)	9(3.3%)	4(1.5%)	11(4.0%)
PBL activity in relation to your field of study very relevant and enjoyable	98(36.0%)	159(58.5%)	8(2.9%)	5(1.8%)	2(0.7%)
PBL does NOT Improves decision making skills	12(4.4%)	9(3.3%)	145(53.3%)	100(36.8%)	6(2.2%)
PBL improves problem solving skills	99(36.4%)	150(55.1%)	9(3.3%)	5(1.8%)	9(3.3%)
Develops competence in self-directed learning	142(52.2%)	102(37.5%)	12(4.4%)	10(3.7%)	6(2.2%)
Develops confidence in self-directed learning	99(36.4%)	151(55.5%)	7(2.6%)	6(2.2%)	9(3.3%)
Enhances ability to speak in front of people	100(36.8%)	140(51.5%)	12(4.4%)	12(4.4%)	8(2.9%)
Improves Power Point presentation skills	99(36.4%)	150(55.1%)	9(3.3%)	5(1.8%)	9(3.3%)
Information researched and studied are retained better	132(48.5%)	110(40.4%)	3(1.1%)	17(6.3%)	10(3.7%)
Prefer PBL to the traditional lectures	88(32.5%)	172(63.2%)	6(2.2%)	4(1.5%)	2(0.7%)
Does NOT impede on time to read the subject	14(5.1%)	10(3.6%)	141(51.9)	103(37.9%)	4(1.5%)
Helps Students formulate learning goals on their own	150(55.1%)	99(36.4%)	5(1.8%)	9(3.3%)	9(3.3%)
Encourage students to assume leadership responsibilities	74(27.2%)	176(64.7%)	8(2.9%)	7(2.6%)	7(2.6%)
Clinical scenarios made me understand the problem of what I am to image better	186(68.4)	63(23.2%)	12(4.4%)	6(2.20%)	5(1.8%)
Knowledge in medical terminology and understanding disease conditions have made me enjoy my programme of study better	88(32.4%)	172(63.2%)	6(2.2%)	4(1.5%)	2(0.7%)
Research on disease conditions and medical terminologies has made me understand doctors request forms better	159(58.5)	98(36%)	8(2.9%)	5(1.8%)	2(0.7%)
The health promotion and advocacy component of the PBL is NOT laudable	9(3.3%)	5(1.8%)	99(36.4%)	150(55.1%)	9(3.3%)
The health promotion and advocacy component of the PBL has made me appreciate better health promotion in medical imaging education	120(44.1%)	80(29.4%)	20(7.4%)	20(7.4%)	32(11.7%)
The health promotion and advocacy component of the PBL has made me capable to research and give health talks	100(36.8%)	148(54.4%)	7(2.6%)	8(2.9%)	9(3.3%)

\* Source: Field data 2019

**Table 2.** Students' negative concerns about the PBL activity

Ranking of Concern	Type of negative Concern
<b>1st</b>	More resources required. For example, meeting rooms, internet, books, models, radiographs and images library.
<b>2nd</b>	Volume of work – if PBL and other assessments, then the interim assessment takes priority
<b>3rd</b>	Some group members didn't get along together- group cohesion was lacking.
<b>4th</b>	Non-contributors in group – some group members were opportunistic.
<b>5th</b>	'7-step' – difficult to follow leading to sometimes merging of steps.
<b>6th</b>	Insufficient self-study time.
<b>7th</b>	Lack of books in library and internet
<b>8th</b>	Quiet students – make little contribution to group activity.
<b>9th</b>	Learning objectives not always relevant - leads to wasted time
<b>10th</b>	Lack of friendship with members of other groups- Less interaction with other classmates who are not PBL group members.

### 3.4. General Negative Concerns Identified by Students

Table 2 shows in incremental order the general students' negative concerns about the PBL activity in the department. Inadequate resources to carry out PBL activities is the number one negative concern of students followed by the workload on students while some of the group members not getting along in the PBL group is the third negative concern of students. Lack of friendship with members of other groups which leads to less interactions with other classmates is the least negative concerns of students. The top 10 concerns were ranked as follows;

## 4. Discussion

The curriculum of the Department of Imaging Technology and Sonography of the University of Cape Coast (UCCDITS) is carefully structured to have a combined PBL activities and didactic lectures. The Radiography programme is a 4-year programme with the first year (Level 100) students reading university wide general courses. These general courses are well designed and are aimed at preparing freshly admitted students into the university for the transition from a 3 years senior high school education, to a university education in the Health Sciences. The PBL mode of pedagogy in the department starts only from the second year. The students are therefore in the position to share their opinion on the likability of the PBL mode of pedagogy and contrast with the purely lecture-based teaching they had in the first year. A timeless truth, in that health education is not completed in the training school: it is only just begun [11,24]. Again, most of what students are taught today may in ten years, would have been modified or changed, and the trouble is none of we teachers know which ones. Therefore, the health worker must be equipped with the skills to research to be abreast with current trends in their field of work. The function of health worker especially in Africa with our overburdened diseases is fast becoming more social and preventative

rather than investigative and curative [27]. Therefore, advocacy and health promotion and the ability of the future health worker to research and analyse the clinical basis of disease conditions to help promote preventive measures is very important. This is especially so because we have a very acute shortage of radiographers and other categories of health workers in Ghana as well as across Africa in general [2,3]. There is therefore the need to develop innovative ways of training health professionals that can do very well in the face of the huge challenge with availability of resources. As evident in the quality of Doctors trained using PBL as the main pedagogy at the University of Cape Coast medical school [7], we the faculty members of the new Radiography department (UCCDITS) assumed that, a PBL curriculum is the way to go to achieve maximum impact in the training of these Radiographers.

Problem-based learning (PBL), arguably the most widely experimented curriculum innovation that has generated a lot of disagreement and debate [26, 27, 28, 29]. Educational theory suggests that learning is enhanced if content: is perceived to be relevant, is embedded in the context of use, and actively involve the learner [32]. PBL motivate learning and improves retention. From the existing four types of PBL practice [31] the nature of the PBL we employ at UCCDITS can be classified as type IV or standard. This implies, the curriculum uses PBL as core mode of teaching with a mixture of regular didactic lectures to focus students for individual and group learning [13] [15] [16].

From our study out of a total of 272 students' respondents, the males were 190 (69.85%) and 82 (30.15%) were females. There are two times more males than females and so therefore, conscious and targeted efforts must be made to admit more females into the programme to bridge the gender gap. Radiography training at UCCDITS is a new programme in the University of Cape Coast. The general awareness of the radiography profession among senior high students in Ghana is very low as evident from the study, only 94(34.6%) have heard of the Radiography



profession before admission into the department. Most of the students in our department did not select radiography as their first-choice programme but rather, were only introduced to the radiography specialty pursuant to the general admission policy into the College of Health and Allied Sciences. Radiography was only later proposed to students thereof, who did not gain admission into their first-choice programme (usually medicine, Physician assistant studies, Pharmacy etc). Students' response to whether they are satisfied with their specialty of study after few years into the programme was very positive. Majority, 163 (59.92%) students agreed while 35(12.9%) strongly agreed that they were happy with their programme of study with 41(15.1%) neither agree nor disagree. However, 21 (7.7%) and 12(4.4%) respectively disagreed and strongly disagreed that they were happy with their programme of study. More work therefore has to be done in Ghana, to enlighten senior high school students about the Radiography profession so that we can have a lot of first choice applicants to the department.

Table 2 shows that, 161 (59.1%) of students perceived inadequate infrastructure and other resources to be a major challenge to the PBL activity while 35 (12.9%) students indicated the curriculum structure to be a major challenge and same number, 35 (12.9%) students said both poor infrastructure and curriculum structure are a major worry. Despite the many advantages of a PBL curriculum, resource implications sometimes pose a major challenge to this activity. Non availability of specially equipped tutorial rooms for the various PBL groups, lack of internet service and qualified faculty to facilitate the PBL session are a major limitation to the PBL activity especially in middle income countries like Ghana where funding of health education is very much inadequate [5,31]. Only 41 (15.1%) students perceived the PBL mode of pedagogy had no challenge.

As shown from Table 1, students had the option to indicate whether they agree, strongly agree, disagree, strongly disagree or neither agree nor disagree about statements of perceived PBL benefits to their education. On whether PBL improves their learning ability, 186 (68.1%), 63(23.1%), 12(4.4%), 6(2.2%) and 5(1.8%) students agreed, strongly agreed, disagreed, strongly disagreed and neither agreed nor disagreed respectively. On whether the content and clinical scenario are not enjoyable and did not meet their learning goals, 110(40.4%), 141(51.8%), 9(3.3%), 8(2.9%) and 4(1.5%) students disagreed, strongly disagreed, agreed, strongly agreed and neither agreed nor disagreed respectively. This shows that majority of the students were very happy with the PBL curriculum. Also, asked whether available time to carry out the PBL activity was inadequate, 136(50.0%), 112(41.2%), 9(3.3%), 4(1.5%) and 11 (4.0%) students agreed, strongly agreed, disagreed, strongly disagreed and neither agreed nor disagreed respectively. Conscious efforts therefore must be made to improve on the timetable

to free more time for student directed learning and also limit volume of work to very relevant ones in order not to overwhelm students with work.

Students in very high numbers (some in excess of 63.2% strongly agreed that, the PBL mode of pedagogy helped them; develop confidence in self-directed learning and improved decision-making skills, improved problem-solving skills and enhanced ability to speak in front of people. Power Point presentation skills is one quality students noted has improved considerably. The clinical scenarios contained in the PBL made students understand better the clinical situation they are to image. This is consistent with study by Takayoshi 2016 [29], where PBL in radiography education markedly improved the self-efficacy of students in plain radiography. The PBL activity has encouraged students assume leadership responsibilities, knowledge in basic medical terminology and understanding of disease conditions have made students enjoy their programme of study better while research on disease conditions and medical terminologies has contributed to students' better understanding of Doctors request forms. The health promotion and advocacy component of the PBL students said was laudable as the health promotion and advocacy component of the PBL has made students appreciate better health promotion in medical imaging education and are capable to research and give health talks appropriately. This is because each PBL session involves a research and health promotion presentation on the disease condition or trigger contained in the scenario. This has helped students to undertake advocacy roles and give health talks in their communities especially in rural settings.

Table 2 ranks students' negative concern about PBL activities with the top three being insufficient resources, volume of work on students and lack of group cohesion respectively. This is in agreement with the work of Barrows and Tamblyn [14] who stated that the main disadvantage of PBL is lack of extensive learning resources to the student (books, reprints, slides, videotapes, and so on) so that he/she can easily pursue his/her own individual needs. This problem occurs because the curriculum must be unstructured in order to allow the student to spend time using the available resources, as he/she feels appropriate, in order to meet his/her own educational designs [8]. The least three challenges were respectively quiet students who make little contribution to group activity, learning objectives not always relevant which leads to wasted time and lack of friendship with members of other groups which leads to less interaction with other classmates.

The students' negative feedback about the PBL activity is worth of note, it is very important to make very stringent efforts to correct these negative concerns as much as possible. More resources have to be provided by the university to the department to improve on academic activities. Innovative ways to constitute PBL groups can be explored to make quiet and opportunistic students get more

involve such that the spirit of no one left behind can be fostered.

## 5. Challenges/Limitations

The study involved students are still in training, a prospective study involving these students when they are already practicing and to ascertain their competences and how the PBL mode of pedagogy they acquired at UCCDITS is helping them solve problems in the hospitals or institutions they find themselves. It will be good to evaluate the standards of Radiography students from UCCDITS with other students who had their training by the traditional lecture-based curriculum to ascertain the effectiveness of either pedagogy.

## 6. Conclusions/Recommendations

This study clearly demonstrates that, young students without any knowledge of the Radiography profession, can be introduced to the discipline and they can grow to appreciate the profession. Serious efforts must be made to undertake career fair outreaches to Senior High schools to enlighten them about the radiography profession and the prospects thereof. The Problem based learning approach as a pedagogical strategy in radiography education is practicable and has several advantages as it prepares the students for all uncertainties that awaits them as future health professionals.

A good scenario is key in a PBL session. The desired and essential learning objectives must be carefully crafted in order to achieve this goal. The success of PBL as a key pedagogical tool relies heavily on the quality of the scenarios and there is therefore the need for a very efficient scenario bank. Good quality scenario writing is a very tedious work which requires experienced and dedicated faculty to craft them. In the absence of adequate human resources, the PBL implementation can deteriorate. Without the necessary leadership and strong commitment from all faculty members, teaching may gradually drift to become more lecture-based learning. Medical Imaging departments can therefore liaise with clinicians and other basic science experts or engage some as faculty to support with the writing of good scenarios [34].

This study demonstrates that the PBL mode of pedagogy is effective and can be employed in Radiography education. It highlighted the importance to initiate a focused PBL centred curriculum which makes student centred learning the main mode of pedagogy in radiography education.

## Conflict of Interest

The authors declare that they have no competing interests.

## Data Availability Statement

The data used to support the findings of this study may be released upon application to the Head, Department of Imaging Technology & Sonography, University of Cape Coast.

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