An assessment of resource availability for problem based learning in a Ghanaian University setting

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Abstract

Purpose – The purpose of this paper is to assess the differences pertaining to the resources presently accessible for problem-based learning (PBL) among six colleges of Kwame Nkrumah University of Science and Technology (KNUST) in Ghana.

Design/methodology/approach – Data for the study are the cross-sectional type drawn from 1,020 students. Poisson and zero-inflated Poisson (ZIP) models were implemented on the data to ascertain the variations regarding the extent of resources available for PBL across the colleges of the university.

Findings – The study outlines the specific resources accessible for PBL across college levels of KNUST. On aggregate, 25.7 per cent reported that their respective colleges have sufficient resources, while 74.3 per cent indicated otherwise. The ZIP model exhibited superiority over the Poisson model, when compared under a Vuong test. As per the ZIP model, none of the colleges appeared to differ significantly in terms of having sufficient resource for PBL.

Practical implications – Findings are applicable to informed decision-making which targets achieving quality education through the use of PBL. Access to sufficient resources that meet the needs of colleges or departments of a University is emphasized.

Originality/value – The application of Poisson and ZIP models to aggregated count data in a PBL setting is novel.

Keywords Universities, Education, Resources, Colleges

Paper type Research paper

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Introduction

With the pursuit of making university education an environment for higher-order learning and creative thinking, many educationists have advocated for the introduction of educational strategy that integrates school learning with real-world phenomena. Largely, emphasis has been given to problem-based learning (PBL) in this regard. PBL is an approach to instructional delivery in education which is conceived as student-centered where learners are actively exposed to real world phenomena (Correnti and Marconi, 2014; Wilkerson and Gijselaers, 1996). In PBL, ill-structured problems serve as the first stimulus and structure for learning (Wilkerson and Gijselaers, 1996). The PBL strategy allows students to work in groups and a teacher facilitates the groups during a tutorial process (McPhee, 2002; Hmelo-Silver, 2004). Overton (2010) emphasized that PBL fails to work when tutorials consist of large group of students. Typically, PBL tutorial consists of a group of students, usually 8 to 10, and a teacher, who facilitates the lesson (Deo, 2013).

Presently, PBL is considered to be an effective instructional strategy in education in that it allows long-term retention and skill development (Strobel and van Barneveld, 2009). Research indicates that graduates from this form of education consistently achieve better and progress faster in their careers than graduates from comparable traditional classroom-based education (Acs distance education, 2015). As a result, many universities particularly those in the developed part of the globe have incorporated PBL into their curriculum. Though universities in the developing parts of the world, especially African countries, happen to use programs that, in part, appear in the form of PBL, not much can be said about these universities. Literature in the setting of Ghanaian universities, in particular, is limited.

Implementing PBL in schools and universities is a challenging task that requires resources, together with significant planning and organization (Wood, 2003; Azer, 2011). It also has implications for staffing and demands a different approach to timetabling, workload and assessment (Wood, 2003). Infrastructural resources required in PBL include library, books, computers, internet access, tutorial rooms, magazines, brochures, newspapers, television, telephones and study space (Wood, 2003; Mathews-Aydinli, 2007; Deo, 2013). These resources represent an extensive source of information for learners and are accessed prior to and during tutorial sessions. When using PBL, two main types of human resources are needed: first a "facilitator" who is well trained in PBL processes and has acquired competencies in facilitation and management of group dynamics and secondly, a "content expert" or "subject expert" who possesses specialization in the discipline concerned (Deo, 2013). The tutor or facilitator guides the learning process and conducts a thorough debriefing at the conclusion of the learning experience (Savery, 2006).

Presently, universities in Ghana are using PBL approaches. At the Kwame Nkrumah University of Science and Technology (KNUST), PBL approaches have been identified as one of the approaches essential to learning outcomes. The overwhelming number of students enrolled in recent years demands an urgent review of the PBL environment of the university. Moreover, most administrative activities and the deployment of programs like PBL are at the discretion of College administrators. However, there is an absence of documents describing the resources available or accessible for PBL at the college level. Given this exposition, the objective of this study is to assess the resources presently available for PBL at KNUST and, most importantly, investigate their distributions across the college levels. In this study, we defined PBL resource as the basic physical and organizational structures and facilities needed for the successful operation of PBL.

Literature review

The origination of PBL has been credited to the School of Medicine at McMaster University in Canada (Lee and Kwan, 1997). Moreover, other institutions such as Michigan State University in the USA, Maastricht University in The Netherlands and Newcastle University in Australia are also well recognized regarding the introduction of PBL (Barrows, 1996). The flaws of traditional medical education led to the introduction of PBL. It is claimed that PBL fosters several desirable learning outcomes: it helps students to construct an extensive and flexible knowledge base, become effective collaborators, acquire problem-solving skills, become intrinsically motivated to learn and develop self-directed learning skills (Barrows, 1985, 1996; Norman and Schmidt, 1992). PBL was formerly conceptualized as a rigorous, structured approach to learning that is tailor-made for medical education and based on considerable experience and research (Barrows and Tamblyn, 1980). However, since its introduction, several variants have been developed by different universities to suit their local needs. Moreover, presently, PBL is seen in use not only in medical domains but also in a variety of academic disciplines such as biology (Szeberenyi, 2005), biochemistry (Osgood *et al.*, 2005) and chemistry (Barak and Dori, 2005) for example. Owing to this, the definition and conception of PBL has been considered in general terms rather than limiting it to the medical domain. Boud and Feletti (1997) defined PBL as an approach to structuring the curriculum which involves confronting students with problems from practice which provide a stimulus for learning. According to Savery (2006) PBL is an instructional (and curricular) learner-centered approach that empowers learners to conduct research, integrate theory and practice, and apply knowledge and skills to develop a viable solution to a defined problem. Similarly, Correnti *et al.* (2014) described PBL as a student-centered pedagogy which actively engaged learners in real-world problems. Hmelo-Silver (2004) also defined PBL as an instructional method in which students learn through facilitated problem solving that centers on a complex problem that does not have a single correct answer.

The process of facilitating PBL starts with the design or selection of ill-structured problems (Schmidt, 1983). This is recognized as a crucial factor in the success of learning in the PBL environment (Kukkamalla *et al.*, 2011; Savery, 2006). Hmelo-Silver and Barrows (2006) explained ill-structured problems as complex problems that cannot be solved by a simple algorithm. The University of Delaware provides sample problems that fit into the disciplines of biology, chemistry/biochemistry, criminal justice and physics available at www.udel.edu/inst/resources/. Also, Schmidt (1983) presents a medical example of such problems in his paper. Research indicates that facilitators' industrial experience and exposure to real-world phenomena leads to the design of credible problems (Tik, 2014). In PBL, the tutor or facilitator guides the learning process and conducts a thorough debriefing at the conclusion of the learning experience (Savery, 2006). Deo (2013) indicates that a typical PBL tutorial consists of a group of students, usually 8 to 10 and a teacher, who facilitates the lesson. According to Overton (2010), PBL sessions with large number of students in a lecture theatre fail to work.

Once problems are designed and presented to students, they are allowed to work in collaborative groups to discover what they need to learn to solve a problem (Hmelo-Silver, 2004). In this context, students must define the problem, identify and acquire the skills and knowledge needed to solve it and work through to the solution. Schmidt (1983) provided a step-by-step procedure which the study group needed to follow while working through the problem. This is outlined as follows:

- *Step 1*: clarify terms and concepts not readily comprehensible;
- *Step 2*: define the problem;
- *Step 3*: analyze the problem;
- *Step 4*: draw a systematic inventory of the explanations inferred from Step 3;
- *Step 5*: formulate learning objectives;
- *Step 6*: collect additional information outside the group; and
- *Step 7*: synthesize and test the newly acquired information.

As study groups endeavor to go through these steps, they have to access information by using several learning resources or materials. For instance, to formulate learning objectives, which happens to be Step 5, Wood (2003) indicated that students have to use triggers or trigger materials from the problem case or scenario. Wood (2003) considered the following as examples of trigger materials:

- paper-based clinical scenarios;
- experimental or clinical laboratory data;
- photographs;
- video clips;
- newspaper articles;
- all or part of an article from a scientific journal;
- a real or simulated patient; and
- a family tree showing an inherited disorder.

According to Overton (2010), when using PBL, students need to have ready access to any relevant resources in the library, internet and so on. The studies of Wood (2003); Mathews-Aydinli (2007); Azer (2011) and Deo (2013) largely focused on infrastructural and human resources. The authors suggested several infrastructural resources required in PBL, and these included library, books, computer, internet, tutorial rooms, magazines, electronic materials, brochures, newspapers, television, telephones, over-head projectors, white boards, flip charts and study space (Wood, 2003; Mathews-Aydinli, 2007; Deo, 2013). Using PBL also has implications for staffing and demands a different approach to timetabling, workload and assessment (Wood, 2003). Overton (2010) acknowledged that the major resource implication for the use of PBL was time – time to develop and trial good problems and time to train staff and to tutor the students. The author further indicated that PBL takes more staff time than traditional methods because the group sizes have to be restricted. Deo (2013) claimed that two main types of human resources are needed when using PBL: first, a "facilitator" who is well trained in PBL processes and has acquired competencies in facilitation and management of group dynamics and, second, a "content expert" or "subject specialist" who possesses specialization in the discipline concerned.

It was indicated that time and resource implications in PBL should not be underestimated when using PBL (Overton, 2010). However, most institutions often fall short in terms of resource availability in PBL. For instance, Overton (2010) averred that many institutions may be short of the space that helps PBL work well – flat seminar rooms with movable furniture. A recent study from the Malaysian setting, based on the perception of students, found insufficient levels of resources in PBL (Zin *et al.*, 2013).

Materials and methods

Survey data

The analysis of the present study is based on data extracted from the KNUST-based Building Stronger University (BSU) phase two project. BSU is a program under the Danish International Development Agency (DANIDA) to strengthen the research and educational capacities of universities in selected DANIDA priority countries. This project is a cross-sectional survey of 1,145 participants who are workers and students of KNUST. The survey was conducted in the year 2014 with well-structured questionnaires built from a proposed matrix for mapping PBL in selected DANIDA priority countries. The working survey participants were educational managers, teachers and information technology (IT) experts of the university.

In this study, data on the student participants were mainly used. The student participants were 1,020, representing 89.0 per cent of the entire sample. Students were drawn from 33 programs (levels 200 and 300 and first-year postgraduate) across the six colleges. These colleges were College of Science, College of Agriculture, College of Architecture, College of Health and Allied Sciences, College of Arts and College of Engineering. Because some colleges had large departments, a probability–proportion-to-size method was used to select the programs among the six colleges. Anticipating a follow-up survey, second-year and third-year undergraduate and first-year postgraduate students were considered as the target population. This allowed for a follow-up survey and other research investigations into PBL at KNUST. The data collected were quantitative.

Ethical issues

Permission was sought from all participants before any audio recordings, and written information of any kind were collected. They were informed of the purpose of survey and what the information was to be used for in the developmental agenda of KNUST.

Methodology of data analysis

Data analyses in this study were based on graphical and numerical approaches. Graphical procedures such as clustered and stacked bar charts were used to perform descriptive analysis. Also, count regression analyses were conducted. In this context, the standard Poisson regression model and the zero-inflated Poisson (ZIP) regression models were used. When applying these models, data were first aggregated into counts based on the responses of students from the various colleges. Our interest was in the frequency of individuals who thought that their colleges had sufficient resources for PBL, and any response which opposed this was conceived as zero. Consequently, students who indicated that their colleges had insufficient resources for PBL contributed to the counts of zeros. The Poisson model assumes that data are equidispersed (Mouatassim and Ezzahid, 2012). However, this model produces inappropriate results in the case of over-dispersed data and data with too many zeros. The zero-inflated models are able to incorporate over-dispersion and excess zeros (Zeileis *et al.*, 2008). In both models, the aggregated responses from students about whether their colleges had sufficient resources for PBL was used as the outcome variable, while college and level of study were considered explanatory variables. The Poisson and ZIP models were non-nested, so, for that reason, the Vuong test was used to compare them. The test-statistic of the Vuong test is asymptotically distributed N(0,1) under the null hypothesis that the models are indistinguishable (Vuong, 1989). Data preparation and graphical procedures were computationally handled in Ms Excel, and the count regression models were executed using R.

Findings

This section presents the results obtained by analyzing the data retrieved from the KNUST-based BSU Project. In total, data on 1,020 students from College of Science, College of Architecture, College of Agriculture, College of Engineering, College of Health and Allied Sciences and College of Arts of the KNUST were used. The students were asked to indicate the human and infrastructural resources presently available for PBL within their respective colleges. The responses from students in that respect are presented in Figure 1. From the figure, the available infrastructural resources accessible for PBL were internet, general library and study space (Figure 1). Lecturers or teachers constitute the only human resources. Generally, more than half of the students from all the colleges indicated that they had access to the internet, general library and lecturers in the PBL setting. From the figure, 17.0, 33.4 and 45.0 per cent of the students from College of Science, College of Architecture and College of Engineering, respectively, responded that they had access to study space. However, with the students from College of Agriculture, College of Health and Allied Sciences and College of Art, no responses about having a study space for facilitating PBL were reported.

The students were asked to indicate whether the resources available in their respective colleges were sufficient for running PBL. Figure 2 presents the responses provided by students according to their individual colleges. Exactly, 35.0 per cent of students from College of Health and Allied Sciences indicated that their college had sufficient resources for PBL. This happened to be the highest, followed by 28.0 per cent of students from College of Architecture. Conversely, on the whole, a large proportion of students from all the Colleges

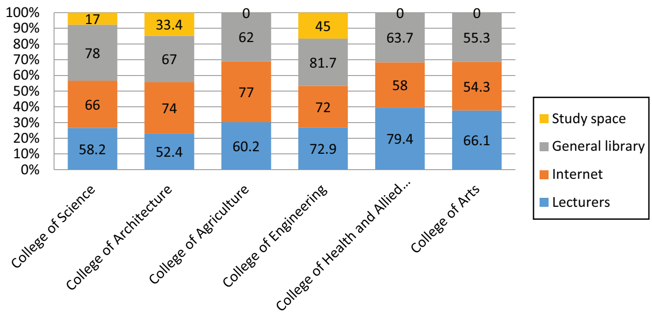

Figure 1.
Accessible resources for PBL stratified by college of study (percentage)

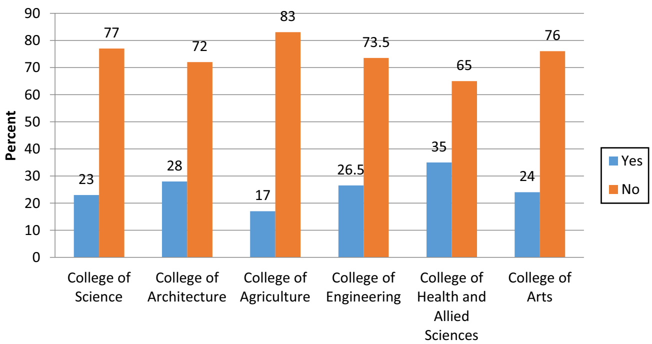

Figure 2.
Perceived level of resources for PBL stratified by the college

responded "no", indicating that the majority of the students disagreed that their colleges had sufficient resources for PBL. On aggregate, 25.7 per cent indicated that their various colleges had sufficient resources for PBL, while 74.3 per cent responded otherwise (Figure 3). Thus, the aggregated responses across colleges consisted of counts of too many zeros, compared to the counting numbers. In this regard, it is compelling to study the underlying principles contributing to both components; counts and excess zeros. Poisson regression and ZIP regression analyses were performed using college of study and level of study as predictor variables (Table I).

Table I shows the fit statistics of the standard Poisson regression and ZIP regression in explaining the aggregated number of perceived responses about the resources accessible for PBL within the colleges under study. From the log-likelihood test, the standard Poisson model corresponds to a *p*-value of 0.001. This indicated that the Poisson model was statistically significant at 5 per cent level, compared to a null or intercept only model. Similarly, the ZIP model fitted significantly better than the null model (*p*-value = 0.000). Though both models appeared to be significant, the Vuong test with test statistic of 2.137 and a *p*-value of 0.015 suggested that the ZIP model was a significant improvement on the standard Poisson model. Therefore, the ZIP regression was used to model the data, and the results obtained are presented in Table II. In this model, the count (Poisson) component rate ratios and 95 per cent confidence interval for each of the categories of the covariates are presented. A second portion corresponding to the zero-inflated component of the model is expressed in logit coefficients.

Following the ZIP model, the percentage of students from the College of Architecture who held the view that their college had sufficient resources for PBL were 79.0 per cent less than their counterparts from College of Science. For College of Agriculture, the proportion of students who indicated that their college had sufficient resources for PBL were 87.0 per cent less than College of Science. However, College of Engineering (7.0 per cent), College of Health and Allied Sciences (38.0 per cent) and College of Arts (1.0 per cent) recorded proportions higher than those of College of science. Despite these variations, *p*-values depict that none of

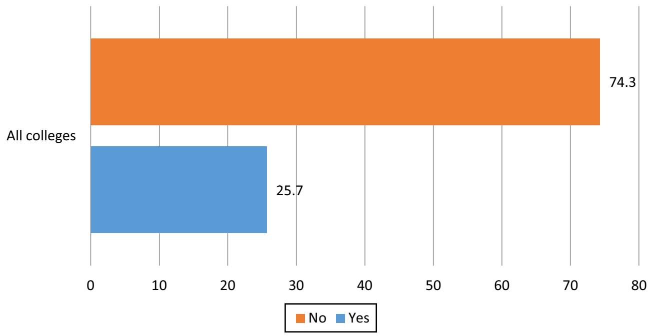

Figure 3.
Percentage frequency of aggregated college data

Test method	Statistic	Poisson	ZIP	Poisson and ZIP
Log-likelihood	*p*-value	0.001	0.000	
Vuong test	Test statistic			3.064
	p-value			0.015

Note: Level of significance is 5%

Table I.
Fit statistics of standard Poisson and ZIP model for PBL resources

Table II.
ZIP regression estimates for aggregated responses of resources for PBL

Variables	Count model coefficients (Poisson with log link) Rate ratios (RR)	95% CI for ratio rate		p-value
Intercept	1.04	0.50	5.63	0.361
College of Science				
College of Architecture	0.21	0.01	7.11	0.386
College of Agriculture	0.13	0.09	5.30	0.701
College of Engineering	1.07	0.21	5.72	0.882
College of Health and Allied Sciences	1.38	0.03	2.16	0.131
College of Arts	1.01	0.11	4.51	0.503
Level 200				
Level 300	0.67	0.02	3.86	0.299
Postgraduate	1.58	0.34	7.88	0.336
	Zero-inflation model coefficients (binomial with logit link)			
	Odds ratio (OR)	95% CI for odds ratio		p-value
Intercept	0.11	0.01	2.43	0.743
College of Science				
College of Architecture	0.30	0.13	3.35	0.441
College of Agriculture	1.03	0.39	6.02	0.024
College of Engineering	0.49	0.15	3.49	0.213
College of Health and Allied Sciences	0.29	0.06	3.08	0.116
College of Arts	0.96	0.09	4.41	0.344
Level 200				
Level 300	0.73	0.22	2.19	0.637
Postgraduate	0.41	0.23	1.97	0.804

Note: Level of significance is 5%; Reference categories: College of Science and Level 200

the categories of the covariates (Colleges and Study levels) on the count component appeared to be significantly associated with the aggregated number of students who indicated that their colleges had sufficient human and infrastructural resources for PBL.

Of the zero-inflated component, the College of Agriculture was significantly associated with the odds of the perceived insufficient resources for PBL. Students from the College of Agriculture were three times more likely to indicate that their college had insufficient resources for PBL than those from college of Science.

However, the likelihood of students from the College of Architecture responding that their college has insufficient support for PBL was decreased by 0.21. Correspondingly, the odds of students reporting that their college did not have sufficient resources for PBL were low for College of Engineering [Odds ratio (OR = 0.49)], College of Health and Allied Sciences (OR = 0.49) and College of Arts (OR = 0.96), when compared to College of Science.

Regarding the level of study, level 300 was associated with lower odds of zero counts (insufficiency) than level 200. Also, students at the postgraduate level were 0.59 times less likely to report that their college had insufficient resources for PBL compared to level.

Conclusion

In this paper, access to human and infrastructural resources in six Colleges of KNUST was considered as a crucial issue prior to seeing complete implementation of PBL into the university's curriculum. The colleges considered were College of Science, College of Architecture, College of Agriculture, College of Engineering, College of Health and Allied Sciences and College of Arts. The study showed that students in the colleges mentioned had access to common PBL resources primarily internet, lecturers and a general library. Additionally, students from the College of Science, College of Architecture and College of Engineering had access to study space. These findings concurred with the studies of Wood (2003); Mathews-Aydinli (2007); Azer (2011) and Deo (2013). Collectively, 25.7 per cent of the students indicated that their various colleges had sufficient resources for PBL, while 74.3 per cent responded otherwise. When compared statistically, none of the colleges appeared to differ significantly in terms of having sufficient resources for PBL. The indication was that the colleges were perceived to be under-resourced. This concurs with a study done in a Malaysian institution by Zin *et al.* (2013). Overton (2010) discussed resource implications in PBL and cautioned that these implications should not be underestimated. The author emphasized that large group of students in tutorial meetings, inadequate study space and insufficient staff time; and time to develop and trial good problems, to train staff and to tutor the students did not provide successful PBL environments. The present study justified the perception that the PBL environment of all the colleges of KNUST were under-resourced, and this brought to light that students of the university may experience suboptimal learning outcomes. This underscores the importance of drafting policies for PBL resources based on the needs of each department or college with realistic themes such as ensuring sufficient resources. Recognizing these, KNUST and other institutions that share a similar culture should assess their student/college to resource ratios, such as student-to-lecturer ratio, student-to-computer ratio, student-to-study space ratio, time allocation, for example, and these should meet the global standards to realize the intended learning outcomes of PBL. Moreover, KNUST should consider doing more by introducing contemporary resources that can help students to learn and perform practical tasks in a modern academic environment.

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