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Full Length Research Paper

A comparative study of problem-based and lecture-based learning in secondary school students' motivation to learn science

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Problem-based learning (PBL) is an innovative method involving problem-first learning via work in small group and independent study. With its promises, PBL is gaining popularity in higher institutions. The purpose of this study, therefore, is to compare PBL and lecture-based learning (LBL) in Senior Secondary School (SSS) students' motivation to learn science. Eight-hundred and ten (810) science SSS II students were used. Students' interest inventory (SII) was used for data collection. The Statistical Package for Social Sciences (SPSS) software (version 9.0) aided data analysis using mean (X) and standard deviation (SD). The difference between two means was calculated using t-test, and the significance level was set at alpha 0.05. The findings show that PBL enhanced students' motivation to learn Biology more than the LBL. It also proved that PBL-students, though particularly the boys, are more inclined to taking responsibility of their own learning. Thus, this study having proved that PBL is equally useful at secondary school level, it is expected that some fresh perspectives on applications of PBL on secondary school students would issue from here.

Key words: Intrinsic motivation, active-learning, constructivism.

INTRODUCTION

Techniques for improving students' motivation form major topics of debate among educators. Conventional strategies, typified by lecture-based learning (LBL), are believed to have done little due to their passive, teacher-centered nature. In the recent years, educators are advocating a shift from passive sitting and listening to a more active and dynamic learning experience (Wilson and Corpus, 2005).

PBL is a student-centered instructional strategy in which students collaboratively solve problems and reflect on their experiences (Wikipedia, 2010). It stems on constructivist principles (Duffy and Cunningham, 1996). These principles posit that learning is achieved by the active construction of knowledge supported by various perspectives within meaningful contexts. The strength of constructivism lies in its emphasis on learning as a process of personal understanding and the development of meaning in ways which are active and interpretative. In this domain, learning is viewed as the construction of meaning rather than as the memorization of facts (Jonassen and Reeves, 1996).

PBL places emphasis on thinking skills, that it integrates knowledge, skills and behaviours, promotes the sharing of learning within a group (Aspy et al., 1993; Koh et al., 2008). Though, PBL hinges on problem-solving, the ultimate goal is learning. PBL is about facilitating students' learning through solving real-life and authentic problems and integrating knowledge across discipline. It is process oriented; requires self-directed, problem-driven learning; and takes a holistic approach to teaching/training and learning through reflection (Wikipedia, 2010). The characteristics of PBL are summarized by Wikipedia as:

1. Learning driven by challenging, open-ended, ill-defined and ill-structured problem;
2. Students generally work in collaborative groups;
3. Teachers take on the role as "facilitators" of learning.

Student-centered instruction is a potential method for enhancing intrinsic motivation among students (Hancock et al., 1995). PBL, as a student-centered instruction,

attempts to engender active learning by using methods such as cooperative learning, open-ended assignments, critical thinking exercises, simulations and problem solving activities (Felder and Brent, 1996). This approach leads to students being more challenged and being given more choice and control over instructional activities, which can enhance intrinsic motivation (Wilson and Corpus, 2005). Proponents of PBL suggest that it promotes positive attitudes towards the learning environment, with students studying for meaning rather than repetition of the instructors or materials (Coles, 1985; Bridges, 1992; Albanese and Mitchell, 1993). Matching contexts has been found to enhance relevance and facilitate recall (Keller, 1983; Godden and Buddeley, 1975). The closer the resemblance between the situation in which something is learned and the situation in which it will be applied, the more useful it is perceived and the more effort the learners will put into the learning tasks. Relevance is a major factor in motivation

The importance of motivation to students' learning had been underscored by Cote and Levine (2000). In their study on "attitude versus aptitude", attitude proved to be the clear winner. Intelligence, as measured by the culture-fair intelligence test, had a negative correlation with skills acquisition and academic achievement. Motivation is a significant predictor of academic performance (Tavani and Losh, 2003) which leads to conclusion that intrinsic motivation is a major factor in determining academic success (Wilson and Corpus, 2005). Extrinsic motivation involves either reward or threat of something of negative consequence in order to lead to a desired behavior, while the intrinsic format derives from a genuine interest to learn (Viadero, 1999). Intrinsic motivation is important to both students and teachers because of its effect on learning outcomes. If intrinsic motivation is beneficial to students' learning outcomes, then it stands that educators should strive to cultivate and enhance the intrinsic motivation of students; teachers must consider the motivational aspects of the course they teach (Chapman, 2000). Intrinsic motivation is not constant, it can change based on the learning context such as instructional design, classroom design and atmosphere (Pintrich, 2002).

Studies indicate that one of the attractions of PBL is that it promises to provide additional motivation for students (Barrows, 1996; Chapman, 2000). An examination of the current state of intrinsic motivation among secondary school students shows that they are often unmotivated due to a perceived lack of relevance of their class work and that the problem tends to be worse in passive learning environments (Bouris et al., 1998). Harvard medical students taking the PBL curriculum were more likely to describe preclinical years as "engaging, difficult and useful" than their counterparts in the LBl who often described their experience as "irrelevant, passive and boring" (Albanese and Mitchell, 1993: 63). In their meta-analysis of the results of PBL assessments, Vernon and Blake (1993: 556) concluded, "with respect to program evaluation, data on student attitudes (from surveys), class attendance and student mood, or distress were consistently more positive for PBL than for traditional courses or curricula". A survey comparing student participation and engagement in PBL and non-PBL sections indicate a positive relationship between PBL and students' motivation to learn (Eck, 2000). This higher level of interest is not inherent to PBL process; higher motivation emanates from well designed PBL problems Chapman (2000). Mackinnon (1999) in a study proved that collaborative nature of PBL is one major source of student self esteems, greater satisfaction in learning, reduced classroom anxiety, and increased motivation for learning. Ommundsen (1999) in a case study examined the ability of PBL to improve student motivation, found that PBL led to positive student comments on questionnaires, especially in relation to student enthusiasm. Furthermore, study by Vita (2001) shows that culture determines individual's motivation derived from preference for thinking, relating to others, perception, organization and processing of information. Gender stereotyping is a cultural factor, predominant in African society. Eboh (2000) expressed this as 'gender inequality against women', and Okeke (2003) described it as 'social pressure and hidden curriculum' that disadvantage girls in Nigerian classrooms. Achuonye (2006) observed that societal expectations on females hinder them from participating effectively in classroom activities. PBL is gaining wide acceptance in a number of professional fields notably medicine, and architecture, aviation, social work, nursing, law and even education (Forsythe, 2003; Aspy et al., 1993; Barrows and Tambyln, 1980). Similar finding has been reported in the Far East, by Lai and Chu (1997) and Tse (1997).

PBL is beginning to make inroads into secondary school. For instance, Cialdella et al. (2002) demonstrated that younger students were more likely to realize improvements in motivation when a shift was made from traditional instructional method to cooperative learning activities. The middle school students in the study sometimes took advantage of freedom of learning environment by displaying inappropriate behaviour. The authors suggested two possible reasons for the age-based discrepancy: The older students were not used to freedom in an academic setting and therefore did not know how. This study is an attempt to try out PBL in Nigeria's secondary school, to examine the difference, if any, between PBL and LBL among Nigeria's secondary school students' motivation to learn; and whether gender stereotyping has any effect on PBL class.

Hypotheses

To guide the study, the following hypotheses were formulated:

1. There is no significant difference in the student's motivation to learn among those exposed to PBL and those exposed to LBL.
2. There is no significant difference in the motivation to engage in self-directed learning activities of students exposed to PBL and those exposed to LBL.
3. There is no significant difference in the motivation to engage in self-directed learning activities of students based on gender (male or female).

METHODOLOGY

The study adopted a Solomon four-group experimental design. Using this design, the respondents (SSSII Biology students) were randomly assigned to two experimental groups (A and C) and two control groups (B and D). Pretest and posttest were administered to the groups A and B. Groups C and D received posttest only. Through a simple random sampling, four government senior secondary schools in Port Harcourt municipality were selected. All the eight-hundred and ten (810) SSS II science students (that is those offering three major science subjects namely Biology, Physics and Chemistry) from the four schools were used.

Students' Interest Inventory (SII), developed by the researcher, was used to collect data on students' perceived effect of PBL strategy on their interest to learn Biology. The PBL Biology problem was structured, in conformity with the "stop and think" questions in the 'focal problems' and "gained design formats" of Wales and Stager (1972) respectively, which according to Albanese and Mitchell (1993) are adequate for novices (people attending PBL class for the first time) such as the respondents in this present study. The topics were drawn from the SSCE Biology syllabus of the SSS II level as seen in the scheme of work at the time of the study. This inventory served as pretest and posttest.

Validation and reliability of instruments

The SII was given to two senior colleagues in the university to ascertain its validity. Modifications were effected to ensure that only the recommended items were administered on the students. To ascertain the reliability of the instruments, the researcher used the test-retest method, using Pearson-product moment correlation coefficient (r). The results of r = 0.9486 (approximately +1). This implied that the score was highly correlated and the items were reliable.

Procedure for data collection

(a) In each of the schools, the students were systematically assigned into four (4) groups: A, B, C, and D.
(b) The SII was given to only groups A and B. This served as pretest. Problem-based learning (PBL) package was presented to groups A and C. Lecture-based learning (LBL) was used on groups B and D.
(c) The students' interest inventory (SII) was also administered on the four groups: A, B, C and D. This served as post-test.

Problem-Based Learning Session (Treatment)

Induction and grouping: The first day was used for a low-key introduction to PBL process and familiarization of students with the researcher. The researcher briefly described the PBL process and its objectives; and a copy of the expected students' behaviour in PBL class was given to each of the students. Then the students were randomly assigned to discussion groups of ten (10) students each. In their groups, the students were asked to introduce themselves and appoint a leader and a record keeper.

Problem presentation and group discussions: Before presenting the problems, the researcher, reviewed the objectives of the lesson to guide the group's thought and discussion to ensure they do not go off track, and achieve the overall objectives of the instruction. This is in conformity with suggestions for successful implementation of PBL on novices given by Albanese and Mitchell (1993). In each group, the students were asked to seat in such a way that everyone can establish eye contact with everyone else in the group to ensure that conversation flows easily.

Thereafter, the researcher distributed copies of the PBL Biology problem to students. Each group discussion began with one of the students reading the PBL problem (reading the problem aloud was to keep the group focused as suggested by Pross (2003). The students discussed the problem, listing what they know, what they do not know and what they needed to know, which formed the learning issues. These learning issues stimulated them to proceed on a research process, in form of self-directed learning activities. In preparing for self-directed learning, students clarified and ranked learning issues; and delegated learning tasks to each member of the group. The researcher supported this process by questioning, probing, encouraging critical reflection, suggesting and challenging in helpful ways but only where necessary. Students and researcher discussed the resources needed for studying the learning issues, and their availability. The researcher encouraged the students to mention where they will be looking for the information and why. The next meeting was set in two days time.

Next meeting: When students reconvened, the researcher encouraged them to re-examine the problem learning by saying "Now that you have studied some issues on the problem, let us start over and see how you would change your thoughts and analysis of the problem". This re-examination gave them insights about what they should have hypothesized and what they should have asked. They, thus, explored the previous learning issues, integrating their new knowledge into the context of the problem; summarized their knowledge and connected new concepts to old ones through verbal presentations. At this point, the researcher asked the students to think of other situations where their new information could be used. Students continued to define new learning issues as they progressed through the problem. This eventually, helped them to understand that learning is an ongoing process, because there will always be learning issues to be explored. As part of closure, the researcher required students to communicate, orally their findings and to write a note on the topics covered to be submitted next week. This formed a review and synthesis of the new information learned, and subsequence integration into previous knowledge. Previous misconceptions were thus, identified and corrected.

Group facilitation: This study is characterized by large classes; therefore, student group leaders were used as facilitators. They were briefly trained to act as facilitators to enable the researcher monitor and control all the groups, by moving from one group to another, asking probing questions and dropping words of encouragement when and where necessary; interacting directly with students who are exhibiting some major behavioural problems such as frowning, sighing, withdrawal, sleeping, drawing, chatting, roaming, and general restlessness.

Assessment: Following completion of the PBL process, the groups were evaluated on the lesson objectives. Input was provided by the students, peers, and the researcher. Reasoning, group behaviour, knowledge level and self-directed learning ability were assessed. This provided students with positive reinforcement regarding their

Table 1. Comparison of motivation to learn Biology between PBL and LBL students.

Group	N	X	SD	SE	T-cal	df	T-crit	P	Remark
TLB	402	818.00	135.89	42.97					
PBL	402	1268.50	130.63	41.31	47.93	802	1.96	0.05	Significant

Table 2. Comparison of motivation to take responsibility of one's own learning by students and LBL students.

Groups	N	$\bar{X}$	SD	SE	T-cal	df	T-crit	P	Remark
TLB	402	1225.40	99.1	31.43					
PBL	402	658.70	45.23	14.30	104.37	802	1.96	0.05	Significant

Table 3. Comparison of PBL male and female students' motivation to engage in self-directed learning activities.

Groups	N	X	SD	SE	T-cal	df	T-crit	P	Remark
PBL F	192	556.40	39.95	12.63					
PBL M	210	669.00	63.78	.20.17	21.41	400	1.96	0.05	Significant

strengths as well as constructive feedback for rectifying any identified deficiencies. The SII instrument was administered on the students as posttest to ascertain the effect of each of the two strategies on their interest to learn Biology.

Data collected were analyzed using the statistical package for social sciences (SPSS) software (version 9.0). The raw data from the respondents were summarized using mean (X) and standard deviation (SD). The difference between two means was calculated using t-test, and the significance level was set at alpha 0.05

PRESENTATION AND DISCUSSION

The findings of the hypothesis that there is no significant difference in the motivation to learn among students exposed to PBL and that of those exposed to LBL; as shown in Table 1, PBL strategy enabled secondary school students to improve their motivation towards learning of Biology as a secondary school subject.

This favourable motivation is derived from the real-life nature of PBL problem and the collaborative tendencies of PBL strategy. The students perceived the real-life Biology problem and the group effort in PBL process as sources of their increased interest in learning Biology. This finding supports the views of Chapman (2000) and Eck (2000), that well designed PBL problems and collaborative nature of PBL are major sources of student self-esteem, greater satisfaction in learning, reduced classroom anxiety, and increased motivation for learning. It is also in line with the findings by Albanese and Mitchell (1993) that PBL, though difficult is engaging and useful. The difficulty experienced by the students was derived mainly from initial stage in the group formation process and human tendency to resist change. This agrees with the findings by Shmuck and Shmuck (1992). However, not everybody overcame the difficult phase (frustration phase); some students insisted poor interest in PBL strategy. This is an indicator of learning style as previously expressed by Burch (1997) and Barrows (1996) that some people cannot thrive well in PBL environment.

On whether or not significant difference exists in the motivation of PBL students and that of LBL students to engage in self-directed learning, Table 2 revealed that PBL enhanced students' interest in learning how to learn more than the LBL strategy.

Previous studies (Hmelo and Lin, 2000; Eversen and Hmelo, 2000) had revealed that this positive attitude towards self-directed learning hinges on students identifying discrepancies between what they know and what they need to know, prioritizing what they need to learn, make choices about the resources they will consult, work collaboratively with colleagues and organize their effort to address the learning issues in sufficient depth and breath.

On the issue of gender, the findings as shown in Table 3 proved that there is significant difference in the motivation to engage in self-directed learning activities in favour of male students. Girls were found to be less disposed to taking responsibility of their own learning due to cultural stereotyping in African society against female science students (Okeke, 2003). Female folks in Africa are generally viewed as weak/soft, low risk-takers, and must not be seen struggling or doing hard things (Eboh, 2000). Hence, we have more boys than girls in science, 'hard subjects' (Okeke, 2003), and boys are more eager to take risks or face challenges; if for no other reason, to

show that they are 'males'. This could explain why the female students in this study were not readily eager to take responsibility of their own learning.

CONCLUSION AND SUGGESTION

From the findings of this study, the following conclusions were drawn:

1. That students taught by PBL strategy are more motivated to learning Biology than their counterparts taught by the lecture-format.
2. That students taught by PBL strategy are more inclined to taking responsibility of their own learning than those taught by the conventional strategy.
3. That male students are more motivated than their female folks to learning how to learn-to-learn in PBL environment.

In the light of these major findings of this study, the following implications are eminent:

1. Ideological implication: Educators are not in doubt of the need for effective and efficient teaching and learning, particularly in this era of 'information unlimited', the making of critical thinkers and life-long learners. Rather, 'how' to achieve this meaningful learning has remained a subject of controversy. While, some believe on mere 'improved' conventional teaching methods, others advocate for innovative, active learning strategies, such as problem-based learning (PBL). The findings of this study stand as a bonus point for the innovative-active learning ideology. Also, amidst proponents of PBL are some arguments restricting the use of PBL to 'adult learners', (tertiary institutions), this study having proved that PBL is equally useful at secondary school level, it is expected that some fresh perspectives on application of PBL on primary and nursery pupils would issue from here. It is also expected that such arguments would yield a premise on which to base a hybrid format of PBL for various levels of learners, particularly in subject-oriented educational systems.
2. Theoretical implication: Behaviourists theories for many years dominated the field of instruction while cognitivists followed sluggishly behind. But in the recent times, cognitive psychology is beginning to take the lead, particularly in the areas of information processing theory and contextual learning theory. The findings of this study came as a boost to the current trend, putting into focus some Nigeria peculiarities such as gender-inequality, over-population, and poor learning conditions. Though PBL is gender-friendly, it is only, but to an extent, especially when it concerns accepting responsibility of one's own learning by the female folks. This study therefore initiates arguments on which point on the PBL-continuum could third world countries probably fit into; this is a socio-cultural dimension.
3. Implication for teaching and learning: The need for critical thinking cannot be over-emphasized especially in this era of unprecedented advancements in science and technology. But 'how' to achieve this creativity in learners have bordered teachers. Therefore, the findings of this study are expected to increase the awareness of Nigerian educators, curriculum planners and teachers on the current global trends in teaching strategies to enhance creativity in classroom. It is a boost to their understanding and reorientation towards the adaptation and application of PBL strategy to science and technology subjects. Not just emphasizing on individual subjects, but the need for a total integration of various subjects at all levels for a more meaningful learning.

Teachers have new roles as facilitators, coaches or managers of learning. They need to understand and practice this new role. The findings of this study are expected to trigger teachers to infuse such activities that would promote motivation for creative learning. Similarly, students are encouraged to become active, inquisitive, taking greater responsibility of their own learning, reading, not just to pass examinations, but also to demonstrate adequate critical thinking and interpersonal skills which they will draw from for the rest of their lives.

In the context of the above implications of the findings, the following recommendations are made that:

1. PBL, as an instructional strategy should be used not just at the tertiary institutions but also the secondary school level;
2. PBL is adopted as a strategy for enhancing motivation for learning in secondary schools;
3. PBL be use to teach critical thinking and interpersonal skills in secondary schools;
4. More studies on PBL in secondary school should be carried out on arts subjects;
5. Further studies be made from the gender perspective to properly ascertain the point on PBL continuum African community could be accommodated.

LIMITATIONS OF THE STUDY

Schools used for this study were all densely populated, yielding, at least, five discussion groups in each class. By this, it was practically impossible for the researcher, being the teacher-facilitator, to be in all the groups at the same time. Therefore, group leaders were trained and used as group facilitators.

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