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Developing A Tutorial Learning Package (TLP) for Academic Achievement in Enzymology for Biochemistry Undergraduates at Salem University, Nigeria

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Abstract
The purpose of the present study was to improve students' overall performance, critical thinking, and application of enzymological concepts in Biochemistry. It describes the implementation of a student-centred method via the use of a tutorial learning package (TLP) in enzymology at Salem University, Nigeria. The use of a TLP strategies in an undergraduate enzymology course was rated very high by students as the instructor/ teacher was only a facilitator of learning. Most activities (i.e. free discussion, problem-solving(PS) group) were evaluated by the students through written questionnaires and informal conversations indicating good acceptance and approval of these methods. Good student scores in the biochemistry exams with the treatment group indicated that these activities are also working as valid educational tools. In addition, mean scores for the semester examination were significantly higher ($P < 0.05$) in the student-centred with TLP compared with the traditional teacher centred method. The shift from teacher-centred delivery to a student-centred model led to a positive change, in which the learners drove the process and were guided, not directed, by the teacher. The use of TLP is therefore proposed as a novel pedagogical apothegms, that could be replicated at least in part, in other courses and in other places so as to compare findings.

Keywords
Enzymology, Tutorial Learning Package, Achievement, Biochemistry

Introduction

Biochemistry is a powerful multidisciplinary toolkit which lends itself to countless scientific fields (Boyer, 2003) .The job of nurturing and connecting high-school students to the world of biochemistry and molecular biology could be very tasking and extremely challenging. This is why biochemistry is given the sobriquet " *king of boring"* by students (Se et al, 2008). Enzymology is a critical aspect of biochemistry that deals with the study of enzymes, their kinetics, structure, mechanism and function, as well as their relation to each other (Voet et al,2008). This aspect of biochemistry constitutes a core course in the curricula of biochemistry programmes at the undergraduate and postgraduate level. In fact it can be said that " *no enzyme, no biochemistry*" . Attempt at teaching this interesting course has become a nightmare to students having low grade or even outright failure in the semester final grade.

The paradigm of university teaching in enzymology is still traditional teacher centred learning in which the teacher transmits knowledge (what the teacher believes is important) to the students, who passively absorb and then use the knowledge as needed. As a result of the mathematical and molecular nature of the course, many students battle to link the theoretical concepts with calculations. Thus, it is not surprising that undergraduate students were unable to correctly explain inherent concepts after completing a semester course in enzymology (Spruijt *et al*,2014).

Many authors are convinced that students learn more effectively if the knowledge and skills they acquire are inserted and contextualized in relevant real-life, problem based situations (Granger *et al*,2012, Chen *et al*, 2015). Also, PBL is a student-centred instructional strategy that engages students in active learning and critical thinking (Cortright et al,2005, Azer et al,2013). It is generally regarded as an effective learning strategy and an active process of personal cognitive construction (Se et al,2008) . This implies that the individual students are ultimately responsible for their own learning, while professors (or preceptors) play the role of "learning facilitators" (Glew,2003). The participation of well-prepared and PBL-committed professors is also a critical factor for the excellence of learning ((Epstein,2004). Generally, in student centred courses, students come prepared with information learnt from completing the preparatory assignment in predetermined work teams, in which the problems were solved through good communication between team members (Allen and Tanner, 2002). The student-centred study has several advantages, such as providing an informal environment for better linking the theory with the exercise, improving communication skills and critical thinking , increasing intrinsic motivation, and facilitating cooperation among students via learning to respect each others view.

The present study was initiated to improve students' overall performance, critical thinking, and application of enzymological concepts. The attempt to achieve this goal was started by instituting a tutorial learning package, involving "2-small-group discussion," and a "free response question" session. These activities aimed to engage students by giving them the opportunity to express themselves, verbally and in writing, and offer feedback as part of a formative assessment. These approaches help students to document their strengths and weaknesses with the aim of improving their performance in the course.

Material and method

Course Description

This study was conducted in the Enzymology (BCH 301) course at the Salem University (SU), Lokoja, Kogi State, Nigeria.The course is always mounted during the harmattan (or first) semester of every session which is from late September to early February when the semester examinations are taken. From the inception of the university, the investigator has been teaching the course for over five years now. The 15 students registered in the 2012/13 session and the 16 students registered in the 2013/14 session respectively constituted the sample size and subjects for the study.

The course involves a single module of 12 units which are listed below:

- Classification & Nomenclature of Enzymes 2 lectures
- Factors affecting enzyme action-pH, Temperature ,Ions, etc 1 lecture
- Active sites of enzymes 1 lecture
- Mechanism of enzyme catalyzed reactions 2 lectures
- Enzyme kinetics & the estimation of kinetic parameters-Km, Vmax, Ki,etc
  4 lectures
- Enzyme inhibition studies 1 lecture
- Mutation and Enzyme activity 1 lecture
- Suicide and Designer enzymes 1 lecture
- Allosteric/regulatory enzymes 1 lecture
- Zymogen activation, digestive enzymes,etc 1 lecture
- Production, isolation,purification & characterization of enzymes 3 lectures
- Characteristics, structures & function of Vitamins and coenzymes.2 lectures

The course is graded out of 100%—40 from 2 continuous assessments involving written test and online assignments and 60 from the final semester examination which consists of 5 questions and students are required to answer 3 questions that carries equal marks of 20 each. For this study, the cumulative semester scores being the primary method of assessment, are used as the measure of performance in this course.

Course Demography

The BCH 301 course is taught majorly as a core course to biochemistry students who are in their third year (often called part 3 or 300 level in SU).The course is a prerequisite to a future course in the final year known as Advanced Enzymology (BCH 402). This implies that failure in enzymology automatically exclude a student from taking BCH 402.The gender ratio favours the female in the ratio of three to two. Almost all the students live in urban city and are very fluent in English language which is the medium of instruction in Nigerian institutions.

Teacher centred learning Strategy

The students in the class of 2013/14, were taught using the traditional teacher centred lecture in BCH 301,Since the course structure and content was not radically different from what it was in the last three sessions, and students in this class were not given a form of treatment involving a learning package, they were therefore made to serve as the control group.

Tutorial learning package (TLP) for student centred learning

The TLP consists of 24 questions carefully drawn from past SU exam paper and from selected texts in biochemistry (Lehninger,2008, Jain *et al.*,2005.; Voet *et al.*,2008.). The aim is to get the students involved in every section of the work with particular emphasis on mechanism of enzymes reaction and enzyme kinetics where students actually encounter difficulty. This was designed in such a way that students will work from simple enzymological concepts such as amino acid residues present in enzyme active site and their role to mechanism of enzyme action by acid-base / covalent catalysis. The mechanism of chymotrypsin by covalent catalysis and HIV protease by acid-base catalysis were discussed extensively and the students who were divided into 4-groups were assigned to work on the mechanism of different enzyme(with serine residue at the active site) and acid –base catalyzed form. Further work was done on michaelis-menten kinetics for single substrate catalyzed reactions using the steady state assumption as well as the mathematical application of the derived equation. The evaluation of kinetic properties such as K_M and Vmax graphically was illustrated in the class session and the groups were further to work on their TLPs using actual numerical values. This pattern was also followed for all topics covered. Owing to the inherent time demanding nature of activity based learning, the investigator created an additional 90-min session to complement the normal 4-contact hours of 2-lectures per week for BCH 301.

Free question session. At the end of each TLP session, students were invited to respond to free response questions related to the course. They were allowed to respond individually or as a group with any materials available at their disposal. The essence of this session was to develop students' ability and critical reasoning with confidence. It further create an opportunity for students to express themselves.

Small-problem solving group using TLP. Immediately after each free question, the group leader guided the small-group discussions of problem solving in enzyme kinetics from the TLP.Here students in each were assigned numerical exercise on different forms of enzyme inhibition -competitive, non-competitive and uncompetitive respectively(with the non-competitive repeated with another exercise in the TLP)- to work on graphically using the Lineweaver-Burke plots (as well as Hanes and Eadie-Hofstees plots as home work). The investigator closely monitored the progress made by the students by circulating the classroom to provide individual assistance and encourage the groups as may be necessary. Students compared their findings with their course mates within and across groups and got feedback from the teacher about misconceptions and correct answers.

Pre-semester tests and examination session

The pre- semester test is a short answer fill in the blank questions after finishing about 60 -65 % of the course content. It is usually a 60-mins exercise held 2 times per semester. The result is pooled with the semester exam scores to make the overall semester achievement scores that were used in the analysis of student performance.

The examination is a 2 1/2-hour session of 5 questions optional for students to answer 3 questions of 20mks each.

Feedback Survey

A survey using a series of five-point Likert-scale questions was administered to gather feedback from every student at the end of the course (Gravestock and Gregor-Greenleaf, 2008). The questionnaire consisted of two categories: the student centred structure and the instructor's evaluation by the students about the course. The responses are expressed as mean and standard deviations shown in tables 2 and 3 respectiviely.

Statistical analysis.

Achievement scores from exam scores were expressed as means and SD. To compare each participant's score in performance from the 2013 and 2012 classes, Statistical Package for Social Sciences (version 13.0) software (SPSS,Chicago, IL) was used for statistical analyses with an independent sample *t*-test at 95% confidence interval ($P< 0.05$). For results of Likert scale-based questionnaires, significant deviations of student responses to questions from the neutral score of *3* were analyzed using a one-sample Wilcoxon sign-rank test, *P* values of _0.05 were considered to be of statistical

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significance.

Result and discussion

Table 1 : Sequence of weekly activities offered to each group in the study

Activity	Control group	Demonstration group
Lecture	Yes	Yes
TLP	No	Yes
Free questions	No	Yes
Small PS-group	No	Yes
Class quiz	Yes	Yes
Pre-Semester CAs	Yes	Yes
Home work	Yes	Yes

Table 1 shows the sequence of activity offered to each group in the study.

Table 2: **Students ratings of the TLP exercise**

Item	Mean ±	SD
The TLP package was better at fulfilling the learning objectives	4.31 ±	1.02
The TLP enabled me to better understand Concepts	4.50 ±	1.57
The TLP was more interesting than the traditional Strategy	4.56 ±	1.83
The TLP ensured greater student participation	4.50 ±	1.52
The TLP helped me to be more focus in the course	4.44 ±	1.34
More TLP should be organized for other courses in the future	4.75 ±	1.88
The TLP helped me to achieve better in my semester Examination	4.56 ±	1.68

N= 16 . Ratings were scored on a 5-point likert scale, where 5= strongly agree, 4= agree, 3= neutral, 2= disagree and 1 = strongly disagree.

At the end of the semester, the 16 students enrolled in the course completed an inventory containing statements to be rated on a 5-point likert scale, 1 (strongly disagree) to 5 (strongly agree), and a few questions requiring brief written responses. As is evident in Table 2, the students' ratings indicated an overall positive endorsement of the exercises. Students' written remarks were predominantly positive as well. Several students noted that initially they were apprehensive, skeptical, and even critical of the exercises, but that eventually they enjoyed the exercises.

Table 3 : Students' ratings of Instructor's performance in BCH 301

Item	Mean ±	SD
The clarity of the instructor's expectations of learning.	4.50 ±	1.52
The instructor's ability to communicate the course content effectively.	4.56 ±	1.68
The instructor's ability to inspire interest in the subject.	4.31 ±	1.02
The fairness of the instructor's assessment of learning	4.38 ±	1.45
The instructor's concern for students' learning	5.00 ±	1.48
The overall quality of the instructor's teaching.	4.44 ±	1.35

N= 16 . Ratings were scored on a 5-point likert scale, where 5= Excellent, 4= Good, 3= Adequate, 2= Poor and 1 = Very poor.

The 16 students enrolled in the course completed an inventory containing statements to be rated on a 5-point likert scale, 1 (Very poor) to 5 (Excellent), and a few questions requiring brief written responses. As is evident in Table 3, the students' ratings indicated an overall positive rating of the instructor's performance. Students' written remarks indicated a number of encomium for the investigator as majority noted that the institution of TLP has demystified the *hydra-headed* enzymology to a *level headed* enzymology. All are unanimous in the endorsement of a TLP for other mathematically based courses such bioenergetics, protein chemistry, methods in biochemistry among others.

Table 4: Independent t-test to compare the examination performance of control and experimental group

Group	N	Mean	S.D	df	t_{cal} *	$P_{0.05}$
Control	15	52.93	7.20	29	3.624	2.045
Experimental	16	62.69	7.29			

*Statistically significant at $P < 0.05$.

Discussion

The goal of the present study was initiated to improve students' overall performance through critical thinking and application of enzymological concepts to numerical exercises.

In the present study, the results showed that the institution of a TLP was an effective and efficient method to promote active learning in biochemistry students attending an enzymology course. Over 80% of the students reported that the method was good and satisfying in helping them to monitor their own learning and evaluate their success in achieving the course objectives. Moreover, the responses of students in this study indicate that most of the students preferred the modified student-centred method to the traditional teacher centred strategy. This is particularly instructive because the TLP promote active learning by making the students to concretize the concepts learnt in class through carefully directed problem solving approach. Chen et al (2015) noted that student- centred instruction can be a highly effective tool for developing students' mastery of important skills: self-study, investigation, and presentation as well as promoting the development of a cohesive learning team. This study was able to confirm that apart from the TLP arousing the curiosity of students in the small group of four, their innate abilities

in applying the course concept to mathematical problems which was hitherto difficult with the teacher centred strategy were elicited through critical thinking. It was therefore not surprising that a significant difference ($P < 0.05$) existed in student performance for the treatment group than the control.

A number of investigators have advocated for the use of activity-based learning in the teaching noting that it is capable promoting camaraderie among peers, making them accountable for their own learning and helping students to discover things for themselves among others (Cortright et al,2005; Ericsson, 2006 ; Deslauriers et al, 2012 and Zachary et al, 2015). The unanimous positive response by students in rating of the exercise and the instructor's performance attest to the almost wide acceptability of the TLP initiated by the investigator which is predicated on the fact that apart from student-centred learning include students' accounting for individual and team work, there is provision for immediate feedback to correct learning errors or validate the rationale that formed the basis for the exercise. This was done by the investigator in circulating round the classroom to provide necessary assistance to individuals and deserving groups. The observation significant difference in the grade distribution is a further confirmation that student-centred learning contributes to increased student learning and student performance is largely a function of the teaching method adopted.

Conclusion

The combination of activities in a student-centred course as reported in the use of TLP (as reported in this work), with the experience acquired along the years, has made great improvements of the teaching and learning of enzymology with a very strong potential in the academic achievement of biochemistry undergraduates at Salem University. The use of TLP could be replicated as a novel pedagogical apothegms, at least in part, in other courses and in other places so as to compare findings.

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