Enzyme Course: Contents, Coverage and Students' Feedback on Course and Teacher

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ABSTRACT— ***This study focuses on the first semester course on Enzymes, as taught in the Department of Biochemistry and Biotechnology of the Kwame Nkrumah University of Science and Technology, Kumasi, Ghana. The course outline and detailed course content have been provided, likewise the instructor's mode of delivery of lectures. The study provides an avenue for students' evaluation of one of the core courses taught in the first semester, Enzymes I. The evaluation was done by two different final year groups of two programmes, Department of Biochemistry and Biotechnology (34 students) and Department of Food Science and Technology (17 students). The respondents evaluated the course content (scope and relevance), instructor's mode of delivery and ranking of instructor. Both groups of students found the course content to be adequate and relevant, and identified some topics as interesting or otherwise. The overall performance of the instructor was rated very high. The study has brought out the views of students on a course and its mode of delivery, which would assist in the future revision of syllabus, as part of the continuous quality assurance programme.***

Keywords— Enzymes, course, evaluation, syllabus, quality assurance

1. INTRODUCTION

The Department started as part of the Faculty of Applied Sciences of the Kwame Nkrumah University of Science and Technology, but later became the Department of Biochemistry. Due to the expanding frontiers of biochemistry, it became necessary to widen the scope of coverage in biotechnology, hence, the changing of the name to the Department of Biochemistry and Biotechnology. At the same time, due to the inroads made by the Department in food science, plans were put in place to nurse a Department of Food Science and Technology, which started in 2004 and produced its first graduates in 2008.

The Biochemistry programme, in the first two years, provides a foundation, focusing on the basic molecules of life, cell structure and body functions. This enhances in-depth understanding of physiology, microbiology and biochemistry. On completion of this foundation, students who opt for Clinical Biochemistry, can advance their clinical knowledge through the study of subjects, such as Clinical Biochemistry, Immunology, Endocrinology and Metabolism of Health Risk Toxicants. The theoretical aspects of some of the courses of the programme are supported by the provision of laboratory sessions in which students become skillful in some scientific methodologies.

In the final year, there are two modules on enzymes; Enzymes I and Enzymes II, for the first and second semesters, respectively. Students of both the Department of Biochemistry and Biotechnology and Department of Food Science and Technology, offer Enzymes I.

1.1 *The course contents of Enzymes I are*:

A historical perspective on enzymology.
General properties of enzymes.
Enzyme technology and applications of enzymes.
Isolation and purification of enzymes.
Classification and nomenclature of enzymes.
Enzyme kinetics.
Factors affecting enzyme activity.

1.2 *Detailed content*

1.2.1 Historical perspective

A brief review of how various scientists had carried out studies on the nature (catalytic and protein), mode of action, kinetics, separation and purification of enzymes. The roles played by Kirchoff, Berzelius, Payen and Persoz, Pasteur, Buchner, Sumner, Willstater and Northrop are highlighted. The discovery of ribozyme by Altman and Cech and modification of the definition of enzymes, to include non-protein molecules. The lock and key model of Fischer, as well as the induced fit model of Koshland. Enzyme kineticists like Brown, Michaelis and Menten, likewise Briggs and Haldane, are featured.

1.2.2 Enzyme technology and application of enzymes

An introduction to enzyme technology, involving the production, separation, purification, stabilisation and packaging of enzymes to allow their efficient and beneficial use, for a wide range of purposes. Some attention is paid to the roles of Takamine and Rohm in enzyme technology.

Starting from their own environment, students are made to recount the different ways enzymes are used domestically, industrially and medically.

1.2.3 Enzyme isolation and purification

Given the wide usage of extracted enzymes, there should be conscious effort to produce, particularly industrially and medically useful enzymes. The various raw materials to use, ranging from microbial systems and multicellular organisms, like higher plants and animals. Students are made to identify some commonly used enzymes and how such enzymes are isolated and purified. Having made a choice of the raw material for the enzyme, then follows the techniques for the separation; homogenisation and fractionation, as well as the various precautions to take. The need for the evaluation of the success and efficiency of the various steps of separation and purification.

1.2.4 Enzyme classification and nomenclature

Students are also made to realise that before 1955,enzymes were named subjectively, based on criteria which enzymologists chose. However, through the deliberations of the Enzyme Commission, whose first report came out in 1961, all enzymes were grouped into six classes, with sub-classes and sub-sub-classes. Also recommended, were some systematic ways of naming enzymes according to some well-defined patterns.

1.2.5 Enzyme kinetics

Rate enhancement in the presence of enzymes through lowering of activation energy. The use of the Arrhenius equation and plot to determine activation energies of catalysed and uncatalysed reactions. The initial rate of enzymatic reactions vrs substrate concentration, for non-regulatory and regulatory enzymes. The derivation of initial rate of enzymatic reactions using the equilibrium approach and the steady state approach. Measurement of initial rate using direct and coupled reactions. The kinetic parameters, Km and Vmax. Drawbacks in the use of the Michaelis-Menten plot. Transformation of the hyperbolic equation to linear forms like Lineweaver-Burk, Eadie-Hofstee and Hanes' equations and plots.

For enzyme inhibitors, the two broad classes are indicated; reversible and irreversible. Examples of the irreversible inhibitors are given, based on their mode of action. The three types of reversible inhibitors; competitive, non-competitive and uncompetitive. The mode of action of each type inhibitor; its effect on Km and Vmax, and how each of them can be presented graphically.

1.2.6 The application of the inhibitors; both artificial and natural.

Use of irreversible inhibitors for identification of important amino acid residues of enzymes or proteins in general. Overcoming of methanol and glycol poisoning with ethanol, use of disulphiram (antabuse) as an alcohol deterrant. Use of sulphanilamide and pyramethamine as antimetabolites of p-aminobenzoic acid and folic acid, respectively. Other antimetabolites are methotrexate, warfarin and dicourmarol, the latter two being vitamin K analogues. Other types of

inhibitors are kcat inhibitors and transition state analogues. Use of some enzyme inhibitors as weedicides, as examplified by glyphosate (to inhibit the shikimic acid pathway for the formation of aromatic amino acids) and sulphonylureas, for the inhibition of acetohydroxyacid synthase pathway in plants for the formation of the branched chain amino acids. Also considered are natural inhibitors, universally distributed, like the protease inhibitors, Kunitz inhibitors and Bowman-Birk inhibitors in legumes, like soy bean; and ovomucoid and ovoinhibitor in egg white.

1.2.7 Factors affecting rates of enzymatic reactions

Substrate concentration, enzyme concentration, temperature and pH.

The author has been teaching the course since 1990. His pet area in the study of enzymes is clinical enzymology, in which assays of enzymes are used for diagnosis and prognosis of pathological conditions. He is currently using enzyme assays as part of the parameters for characterizing sickle cell disease persons, and has several publications on the subject; [1, 2]. He also carries out studies on stroke patients, in which levels of enzymes like AST, ALT and GGT are measured. His studies on the pharmacological and toxicological profiling of natural products also involves the use of enzyme assays, as reported in another publications [3]. He is also the chairman of the Clinical Analysis Laboratory, a medical diagnostic set-up he has helped his Department to operate since April 2003, for teaching research and income generation.

2. METHODS

2.1 Rationale and mode of students evaluation of the course and the instructor

A three-member panel of the National Accreditation Board (NAB) was in the Department in August, 2011, as part of NAB's mandate of evaluation of institutions. There were so many benchmarks that are used for the evaluation of departments, for quality assurance. In the early 2000s, the University, in anticipation of the external quality assurance measures being put in place by the NAB, instituted its own internal quality assurance procedures. Therefore, an internal Quality Assurance Programme Unit was set up, headed by a Professor. At the end of each semester, students who offer each course, are asked to evaluate the lecturers, based on the following criteria;

Course presentation

Lecturer's bearing in class

Mode of delivery

Pedagogy

Learning environment.

It was one observation the NAB made in its evaluation that prompted this study, in order to address the shortfall, using these two programmes. Aside this, Dawley and Havelka [4] had indicated that a designed curriculum should not be considered a *fait accompli*, remaining the same every year. Rather, it should be an open-ended, ongoing, and iterative process of regular curriculum development and innovative change that should continue throughout the life of a course or programme. As regards the evaluation of course quality and teacher competence, this can be done in several ways, but according to Anderson *et al*. [5], a standard method used in most institutions is evaluating courses and their teachers via student questionnaires, either using paper-and-pencil approaches or online systems.

The current evaluation used two groups of fourth year students who were taught separately, but each of them had a two-hour theory class for each week, without any practical. In the introductory lecture for every year group, students are given an overview of the course, and provided with relevant reference books and textbooks. The mode of assessment is also explained to the students. Class attendance is made part of the continuous assessment, contributing 5%.

The lecture is mainly through the use of white board, as blackboard and chalk has been phased out from our College since 2005. Students are free to ask questions in the course of the lecture. Before any day's lecture, a review of the last lecture is made, with what the instructor describes as "Matters arising from the last lecture." Here, students are given the opportunity to ask questions from previous lectures. Then follows, 'My issues for today', in which the instructor brings in issues related directly or indirectly to the topic being treated. It is after these that the substantive topics for each lecture is tackled.

Another common practice to engender full participation, is giving students simple questions, which they have to answer on sheets of paper. This takes at most five minutes, and the instructor goes round to mark the answers of students who finish the exercise early. The majority, however, do self-assessment.

Because NAB raised the issue of omission of the evaluation of the course content by the students, at the end of the last lecture for the first semester, the author decided to let the students evaluate the course outlined above, based on several questions, including the course content.

The students had no prior knowledge of the survey and the responses were to be anonymous, so no name or index number was included. There were in all, nine questions, which were as follows;

- How do you see the course content?
- Do you see the course as relevant?
- Which topics do you see as irrelevant? Why?
- Which areas do you find most interesting?
- Which area is the least interesting?
- Which topics do you think can be added to enrich the course?
- How would you rate the overall performance of the lecturer?
- What aspect of the lecturer's presentation did you like?
- What aspect of the lecturer's presentation did you dislike?

3. RESULTS

Table 1: Respondents' remarks on course content

Remark	***Frequency***
Very good, Ok, good	20 (5)
Fascinating	3
Interesting	3 (3)
Educative and detailed	2

Scores of Food Science students are in parentheses

Apart from the responses in Table 1, some solitary comments were as follows; excellent, fantastic, standard, very informative, broad, requires more time, too broad and demanding, contents too bulky.

Relevance of course

The responses were as follows; yes- 26 (11), very relevant - 7 (4), most definitely – 1, really important – (1). One of the respondents added that the course should have been done earlier.

Table 2: Topics respondents deem irrelevant

Topic	***No. of respondents***
History	15 (3)
Enzyme kinetics	2 (2)
Enzyme nomenclature and enzyme kinetics	- (2)
None	8 (7)
No response at all	7 (-)

Scores of Food Science students are in parentheses

Table 2 gives a summary of topics students deemed irrelevant. Two students of biochemistry and three of Food Science indicated all topics are important and relevant. Reasons offered by some of the students who saw history as irrelevant were; it does not have any impact on what one is supposed to know, it makes the materials covered bulky, it was boring. Two of the four who indicated enzyme kinetics felt the topic was abstract.

Table 3: Number of students indicating most/least interesting topics

Topic	***Most interesting***	***Least interesting***
Application of enzymes	17 (4)	- (-)
Enzyme kinetics	6 (3)	13 (7)
Enzyme nomenclature	8 (3)	2 (2)
Enzyme inhibition	- (2)	1 (1)
Enzyme technology	5	- (-)
Isolation, purification, application	- (2)	2 (-)
History	2 (2)	9 (3)
All topics	- (2)	- (-)

Scores of Food Science students are in parentheses

Topics to be added

No suggestion at all – 25 (13)
Microbial production of enzymes should be treated in details.
Enzyme technology in petroleum industry to control oil spillage
Enzyme biotechnology – 1 (1)
Application of enzymes in medicine and agriculture
Purification of enzymes for commercial purposes
Practical sessions on isolation of enzymes – 1 (1)
Applications to food should be elaborated – (2)

Rating of lecturer

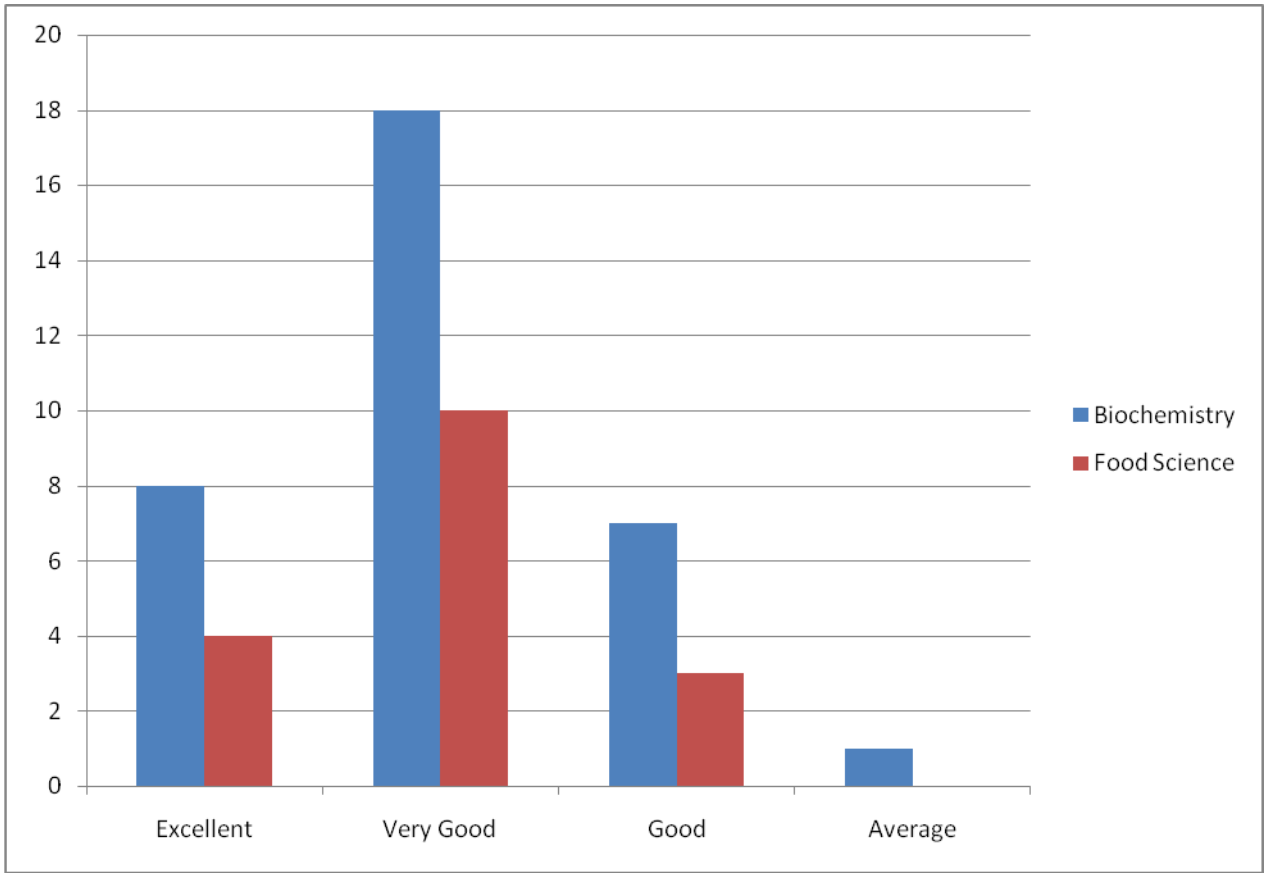

Fig 1: Grades given to instructor by respondents

For a quantitative score of the ratings, to allow the comparison between the two groups of students, the ratings were given numerical values from 0 (poor) to 5 (excellent). The maximum cumulative grade point for the 34 Biochemistry students was 170, and for the 17 Food Science students, 85. The actual cumulative score from the Biochemistry students was 135/170, and for Food Science, 69/85, giving percentages of 79.4% and 81.1%, respectively. Thus, the Food Science students graded the lecturer slightly higher than their counterparts.

Table 4: What students of both programmes like about lecturer's presentation

Biochemistry
Relating theory to practical life applications -8
Ability to link enzymes to other courses -7
Ability to present lectures in simple understandable way – 4
Good in-depth knowledge of course content – 3
Tries to explain every point he makes, making lectures interesting.
Makes class lively and interesting.
Has control over the course and knows what to teach
Food Science
Clear explanation of topics. – 4
Isolation and purification of enzymes. - 3

Other comments were; Lecturer goes according to course outline, Enzyme applications, Enzyme kinetics, linking theory to practicals, well abreast with course content, his review of previous lectures with 'Matters arising' and interactive nature of class

Table 5: Aspects of lecturer's presentation they dislike

Biochemistry	***Food Science***
No comment – 19	No comment – 7
Talks too much -3	The nature of his questions and marking scheme. – 5
Enzyme kinetics -4	Enzyme nomenclature and kinetics. - 2
Enzyme inhibitors -2	No powerpoint presentation.
Does not allow any break in two-hour lecture.	No practical sessions, so we do not have experience on enzyme extraction and purification.
History on enzymes.	Sometimes, too much linkages are made to other areas; this puts me off.
Marking attendance before lecture.	
Sometimes lectures too fast.	
Sometimes it is difficult to follow what he says	

4. DISCUSSION

This study has focused on the course contents of Enzyme I; the mode of delivery of the course by the instructor, and the evaluation of both the course and the instructor by the students of two different programmes within the same Department. Almost all the comments about the course content from the two groups (Table 1) were positive. Even the three comments out of 51 that appeared dissenting, should not be seen in a negative light. They are the candid opinion of three students who found the course content to be too broad or bulky. On the relevance of the course, though the respondents are of two different programmes, none of them made any adverse comment at all, as all of the responses were affirmative. All the students of the two programmes saw the course to be relevant; there was not a single dissenting view. This is an attestation that the course, as outlined is generally acceptable by the students. It is rather the course contents that some of the students thought some of the topics were irrelevant. Of the topics covered, those that were deemed irrelevant (Table 2) were history, enzyme kinetics and enzyme nomenclature but the most detested was the history of enzymology.

As regards topics that were least interesting, again, enzyme kinetics and history are the top two (Table 3). Therefore, in the future, the coverage on history should be made as brief as possible since it appears the details covered could have made the volume of material covered too bulky, as pointed out by some of the students. While twenty of the students found enzyme kinetics to be least interesting, nine of them saw this topic as the most interesting. Indeed the group of students who did not like this topic are presumably those with poor numeracy skills, so have developed some phobia for anything involving mathematical equations, graphs and deductions from these. Several authors and authorities had observed, students of life sciences are often unable to manipulate or appreciate numbers and equations, to use scientific notation or to explain and make predictions from data presented in graphs, charts and tables [6, 7].

A way out is to identify those students who show this weakness and offer them extra tutorials. Enzyme kinetics is pivotal in enzyme studies and so does not deserve such a low rating, despite students' apprehension. It has to be further noted that the number of topics that were listed to be most interesting was more than those said to be least interesting (Table 3). Then, even for those topics that were regarded by some of the respondents to be least interesting, some other students found them to be most interesting, except that the latter group was in the minority. The challenge, therefore, is for the instructor to adapt his style of delivery to water down some of the misconceptions and apprehensions of students of the dreaded topics, to get the balance swing from the negative to positive perception. According to Voet and Voet [8], one of the most important aspects of good teaching and learning resides in teacher enthusiasm. Teachers must make any teaching/learning style their own, must enjoy the process and convey this enthusiasm to the student in order for their style of teaching to be effective. Admittedly, there are different pedagogies, but individual instructors adopt and adapt instructional ideas that suit them and their situation [9]. The mode of delivery was tailored to promote active learning and metacognition [10] through a quasi-student-centered rather than a purely traditional teacher-centred approach.

Gibbs [11] mentions some key elements that numerous research studies have identified as being associated with "good teaching" and that are most likely to engender a deep approach to learning, the development of conceptual understanding, and problem-solving ability in students. These elements include; students' intrinsic motivation, by showing a need to know something; students being active, rather than passive, in the learning process and students having existing conceptual knowledge and experiences, which they bring to bear in the learning of new concepts.

These attributes espoused by Gibbs are reflected in the range of the students' responses, as captured by this study. The author's style of teaching very much, falls in line with White's approach, borne out from the experiences gathered from his teachers [12]. White recounts "As a student, I resented teachers who held their notes in one hand, copied them on the blackboard with the other, while talking with their backs to the class, and then later expected their students to reproduce that information in closed book examinations. Why should students have to memorize material that the instructor could not reproduce from memory?" On PowerPoint presentation, White added, " Lecturers can conceal their deficiencies by using PowerPoint slides, overhead transparencies, and photocopied handouts". For pedagogical reasons, White preferred to use what he called stone-age technology—chalk on slate—and lecture with a minimal dependence on notes.

As pointed out by one of the Food Science students (Table 5), the author does not use PowerPoint presentation. Nonetheless, the thrust of the author's style is to foster active learning, in which students solve problems, answer questions, formulate questions of their own, discuss, explain, debate, or brainstorm during class [13]. Above all, the performance of the students in the end-of semester was good, as all students passed (results not shown).

The course, as outlined above, is rigorous and in-depth, exposing students to a thorough description of enzymes, including history, properties, purification, industrial applications, and much more. The article provides information on what is being done in the author's department, while the evaluation on the instructor provides the basis for modification of the course and future work. It is apparent that the students did not like the portion of the course dealing with history, which the author feels is important. A challenge then is that in the future, new ways should be found to handle the history

of enzymes so that students find it interesting and learn important lessons. For example, the history could be presented throughout the course, or the students could be tasked to independently read actual historical papers to connect the lecture and text material with actual experiments.

5. CONCLUSION

This study, the first of its kind in the author's Department, has thrown light on the course content of a final year core course and its presentation. The mode of delivery of the instructor has been shown to be a blend of several pedagogies. Students had reckoned the course to be relevant and had ranked the mode of presentation to be very good. However, areas where students have shown aversion should be addressed, for better learning outcomes in the future.

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