Check for updates

Received: 2 August 2020 | Accepted: 7 August 2020

DOI: 10.1002/bmb.21435

ARTICLE

Biochemistry and Molecular Biology Education WILEY

Undergraduate education in biochemistry and molecular biology: A parallel session at the IUBMB/PSBMB 2019 "Harnessing Interdisciplinary Education in Biochemistry and Molecular Biology" conference

Evangeline C. Amor[1] | **Anoja P. Attanayake**[2] | **Marilou G. Nicolas**[3] | **Gracia Fe B. Yu**[4] | **Janet O. Macaulay**[5]

[1]Institute of Chemistry, University of the Philippines-Diliman, Quezon City, Philippines

[2]Department of Biochemistry, Faculty of Medicine, University of Ruhuna, Galle, Sri Lanka

[3]Department of Physical Sciences and Mathematics, University of the Philippines-Manila, Manila, Philippines

[4]Department of Biochemistry and Molecular Biology, University of the Philippines-Manila, Manila, Philippines

[5]Biomedical Discovery Institute, Monash University, Melbourne, Australia

Correspondence
Janet O. Macaulay, Biomedical Discovery Institute, Monash University, Melbourne, Australia.
Email: janet.macaulay@monash.edu

Abstract

Although science education, including biochemistry and molecular biology education, starts before students commence university, for many students, undergraduate programs are their first real introduction to biochemistry and molecular biology. Students often report that biochemistry and molecular biology are relatively difficult topics hence the use of varied and well-thought-out approaches are critical to fully engage students. This session provided insights into undergraduate curriculum design.

KEYWORDS

biochemistry and molecular biology, conference report, education, undergraduate

Session Chair: Dr. Mafel C. Ysrael, University of Santo Tomas, Philippines.

Speakers: Professor Marilou G. Nicolas, Department of Physical Sciences and Mathematics, University of the Philippines Manila Manila, Philippines.

Professor Evangeline C. Amor, Institute of Chemistry, College of Science, University of the Philippines-Diliman, Quezon City, Philippines.

Dr. Anoja P. Attanayake, Department of Biochemistry, Faculty of Medicine, University of Ruhuna, Galle, Sri Lanka.

Biochemistry and molecular biology are taught at many levels. The depth and focus vary from high school to undergraduate and to postgraduate as do the approaches and techniques used in the classroom and beyond, but there are also many similarities. This session focused on undergraduate programs and the three speakers ignited the roundtable discussions with their presentations offering the audience insights into the different approaches being used in undergraduate biochemistry and molecular biology programs (Table 1). The roundtable discussions were varied ranging from a focus on factors to consider when revising the curriculum to the different approaches taken to the curriculum and delivery modes in different countries and the problems that arise with issues such as large student cohorts and the varied academic capabilities and interests of students.

Marilou G. Nicolas is a professor of biochemistry at the University of the Philippines Manila teaching biochemistry courses to undergraduate students and bioinformatics courses to graduate students. She has received various awards for education, including "Outstanding Teacher of the University of the Philippines Manila" in 1997 and 2007, and the Philippine

 © 2020 International Union of Biochemistry and Molecular Biology

TABLE 1 Topics presented in the session "Undergraduate Education in Biochemistry and Molecular Biology"

Speaker	Topic
Marilou Nicolas	Ensuring the quality of the University of the Philippines' Only Undergraduate Biochemistry Program
Evangeline Amor	Biochemistry course offering and its implementation in UP Diliman
Anoja Attanayake	Problem-based student-centered learning of Biochemistry in the curriculum of medical undergraduates: an experience in Sri Lanka

Society for Biochemistry and Molecular Biology Award for Education in Biochemistry and Molecular Biology in 2005. She is a staunch advocate of quality assurance in education and is currently lead assessor of the ASEAN Universities Network assessors' team conducting quality assurance assessment of programs and institutions in the ASEAN. Marilou discussed the development of the BS Biochemistry program offered by the University of the Philippines and the issues and solutions surrounding program design.

Evangeline C. Amor is a professor at the Institute of Chemistry, College of Science, University of the Philippines-Diliman. She has taught undergraduate biochemistry course for both chemistry majors and nonchemistry majors, graduate courses in advanced biochemistry, seminar topics in biochemistry, and general and organic chemistry undergraduate courses, both lecture and laboratory. Evangeline described the biochemistry courses available at the University of the Philippines and the issues faced when teaching students specializing in various scientific fields.

Anoja P. Attanayake is head of the Department of Biochemistry in the Faculty of Medicine, University of Ruhuna, Sri Lanka. She lectures biochemistry, supervises biochemistry undergraduate research programs, and has designed a modulator in Curriculum Development Committee in the faculty related to "Biochemistry." Anoja discussed the success they have had in Sri Lanka with problem-based student-centered learning and case-based learning.

The three speakers have prepared the following summaries of their presentations.

1 | PRESENTATION 1: ENHANCING THE QUALITY OF THE UNIVERSITY OF THE PHILIPPINES' ONLY UNDERGRADUATE BIOCHEMISTRY PROGRAM

Speaker: Marilou G. Nicolas, email: mgnicolas@up.edu.ph

1.1 | The study

This is a retrospective analysis of the performance of our graduates (graduating from 2000 to 2017) and the continuous quality enhancement the department did in the past 20 years since the program was launched in 1996 and continues to do so.

The study looks at 406 students who were admitted to and graduated with a Bachelor of Science in biochemistry. These are 15–17 years old mostly from private high schools in Metro Manila (41%) and special science high schools (31%) as well. They comprise 68% female and 32% male. The program was launched in 1996 and our first class of graduates in 2000. From the time the program was instituted, it has undergone multiple revisions in response to stakeholders' inputs and the needs of the workplace. The latest revision in 2018 was in response to the basic education reform of the country that instituted senior high school or an additional 2 years of basic education. These latest cohorts are not included in the analysis.

1.2 | Cognitive and psychomotor skills

All students of the University of the Philippines are accepted through the UP College Admissions Test. The result of the examinations and the grades of first 3 years of high school are computed using a formula with the final score given as UP College Admission Test Grade (UPG) gauge the potential of the students in their chosen course when they entered the university (Figure 1). From the figure, the overall class UPG is generally good.

Employers' opinion of the graduates is that biochemistry graduates are "excellent, a standout, efficient, analytical, has integrity, knowledgeable, skillful and professional." The number of graduates with honors and chemistry licensure exam topnotchers and passers supported such observations as well. Our undergraduate students together with their advisers have published in the scientifically indexed literature. The program has also produced medical doctors and research/academic doctors. Those who went to join industry as chemists in government and private institutions are now occupying key positions.

Despite these successes, the program has a graduation rate of around 62% on the average. To help students, we reviewed our teaching learning strategies. Focus group discussions and surveys show that there are threshold concepts that were not clear to students hence courses discussing these concepts became bottleneck courses contributing to delays in graduation. The alumni say that there are concepts that are difficulty to grasp particularly,

15393429, 2020, 6, Downloaded from https://iubmb.onlinelibrary.wiley.com/doi/10.1002/bmb.21435 by Sri Lanka National Access, Wiley Online Library on [04/07/2023]. See the Terms and Conditions (https://onlinelibrary.wiley.com/terms-and-conditions) on Wiley Online Library for rules of use; OA articles are governed by the applicable Creative Commons License

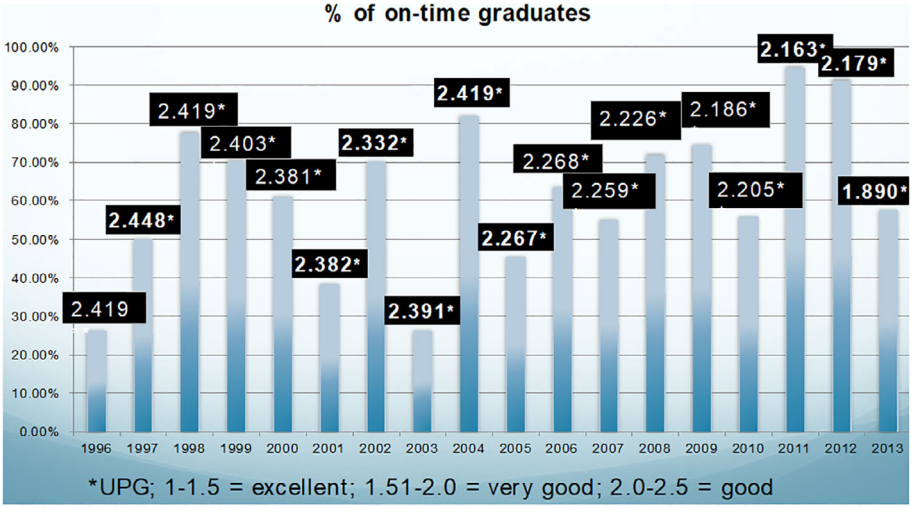

FIGURE 1 Bar graph showing the % on-time graduation of several batches of students. The year shown is the admission year of the students. The numbers above each bar is the average UP College Admission Test Grade (UPG) of the students in the batch [Color figure can be viewed at wileyonlinelibrary.com]

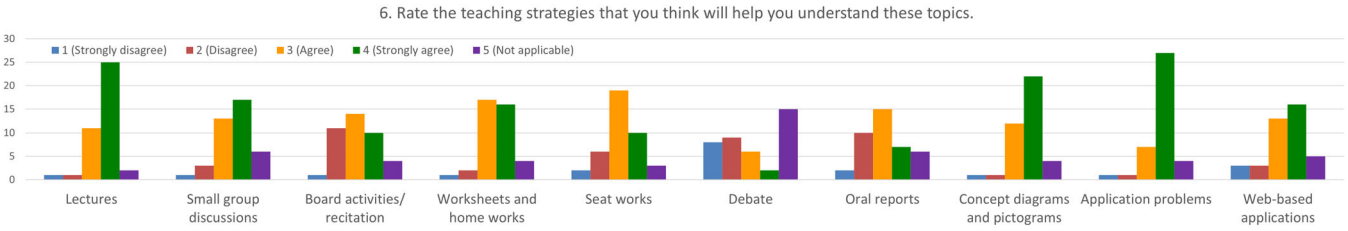

FIGURE 2 Graph of the teaching strategies that students believe will help them understand difficult threshold concepts [Color figure can be viewed at wileyonlinelibrary.com]

kinetic mechanisms and arrow pushing, thermodynamics, and bioenergetics including adenosine triphosphate (ATP) synthesis. On the other hand, aside from these concepts, the faculty and students also find that topics about intermolecular forces of attraction, acidity and basicity, and stereochemistry are also difficult concepts to grasp. It appears that if the approach is too theoretical, students find it difficult to conceptualize (Figure 2). They find the use of practical applications, concept diagrams, and lectures more helpful in understanding various biochemistry topics.

1.3 | Attitude

Although employers were impressed with the graduates' technical and theoretical skills, they also noted that the BS Biochemistry graduates must improve on their communication and soft skills. Graduates need to develop teamwork and leadership skills. A class-by-class comparison of the performance of the entire class (Figure 1) does not seem to correlate with the UPG. Teamwork, leadership skills and maturity appear to be the better gauge of performance. I cite two batches, one with a UPG of 2.163 and the other batch with overall UPG of 1.890. In the university, the highest grade is 1.0 while the lowest or failing grade is 5.0. The graduation rate of the former was more than 90% while the latter could barely make 60% graduation rate.

Another observation of employers is the lack of a business sense among the graduates particularly with regard to using time and resources; they also have to understand jurisprudence and regulatory practices in chemistry as well.

Attitude also seems to be the major reason for some students shifting out of the program on their second year. When high school students were asked about what their basis for choosing a higher degree program, the top three answers were (1) peers or friends, (2) parents, and (3) interest as only a third choice. It is therefore no wonder that most of our students who graduate on time or with honors were actually students who transferred to the BS Biochemistry program from another program where they were initially admitted. Interest was thus a major factor in ensuring on-time graduation and a determinant of the student's capacity to cope with major challenges in the courses of the program.

15393429, 2020, 6, Downloaded from https://iubmb.onlinelibrary.wiley.com/doi/10.1002/bmb.21435 by Sri Lanka National Access, Wiley Online Library on [04/07/2023]. See the Terms and Conditions (https://onlinelibrary.wiley.com/terms-and-conditions) on Wiley Online Library for rules of use; OA articles are governed by the applicable Creative Commons License

2 | SUMMARY AND CONCLUSIONS

In 2012, when the Philippine education ministry undertook a major reform in the basic education, it created a ripple effect on all tertiary education programs. All college degrees had to revise their curriculum; nonetheless it allowed us to assess program implementation and how best the program can be improved. This study is an assessment of the 20-year implementation of the program (1996–2017). Results of Focus Group Discussions (FGDs) and surveys with stakeholders and data analysis as well were used in the revision of the existing program and its courses. Following comments from students and alumni, concept maps were created to identify courses or topics that have to be emphasized while laboratories and lectures were integrated so that there is better coordination between theory and application. It has been 2 years since our first cohorts of the K-12 basic education program were admitted to the university in 2018 and we continue to monitor such revisions, ensuring continuous quality enhancement and updating of the only undergraduate biochemistry program in the University of the Philippines.

3 | PRESENTATION 2: UNDERGRADUATE BIOCHEMISTRY COURSE OFFERINGS IN THE UNIVERSITY OF THE PHILIPPINES-DILIMAN: IMPLEMENTATION AND CHALLENGES

Speaker: Evangeline C. Amor, email: ecamor@up.edu.ph

Two types of undergraduate biochemistry courses are offered by the Institute of Chemistry, University of the Philippines-Diliman (UPD). One for nonchemistry majors, also referred to as service courses, and the other for chemistry majors. The biochemistry service courses were first offered in 1940 while those for chemistry majors were offered as early as 1935. Offering a biochemistry course for chemistry majors at that time was notable because it was only fairly recent that biochemistry was made a core course in the curriculum of the BS Chemistry degree program in the Philippines. All courses are implemented in the course of a 16–17-week semester. The lecture courses are taken twice a week with a meeting time of 1.5 h each while the laboratory courses are also taken twice a week but with a meeting time of 3 h each.

The often-required undergraduate biochemistry courses for nonchemistry majors were taken by students in the BS Molecular Biology and Biotechnology, BS Biology, BS Community Nutrition, BS Food Technology, Bachelor in Secondary Education major in chemistry. A complementary undergraduate laboratory course is also required. For chemistry majors, there were also two required courses, a lecture and a laboratory course. The biochemistry courses covered the properties and functions of the biomolecules as well as major metabolic pathways.

The handling of the two types of courses differed in that there is more in-depth discussion in those taken by chemistry majors. One of the challenges in implementing the courses was to cover all the topics in a 16-week semester. Having discussion groups in the laboratory courses and making sure that the scheduling of the laboratory experiments was aligned with the topics being taken up in the lecture somehow managed this challenge.

In the early 2000, an additional biochemistry course for chemistry majors was instituted. This was in recognition of the need for more time to cover the topics in biochemistry in an in-depth manner. The first biochemistry course essentially focused on the structure and function of the biomolecules while the second biochemistry course concentrated on the metabolic pathways of the biomolecules.

At about the same time, the Institute of Chemistry converted applicable experiments from macroscale to microscale. This is to address and manage the cost of implementing the laboratory courses given the limited resources of the university. The other important consideration in going microscale was to have a more efficient and sustainable waste disposal system in the institute.

In my experience, I have observed that students—both majors and nonmajors—experienced difficulty when the topic was already in metabolic pathways. I surmise that this is because of information overload. To handle this, I experimented with allowing students to have a one-page "cheat sheet" during exams for them to have a reference. This somehow improved the learning of the students, as they were able to focus on analyzing and integrating knowledge of the metabolic pathways with the structure and function of the biomolecules involved in the pathways.

In 2008, the Institute of Chemistry moved toward an integrated approach in its laboratory course offerings for chemistry majors. This resulted in integrating necessary biochemistry-related laboratory techniques in experiments that also had analytical, inorganic, and physical chemistry-related techniques incorporated in two advanced laboratory courses. There were implementation issues and challenges that resulted in review and evaluation of all integrated laboratory course offerings for chemistry majors after 8 years of implementation. After

15393429, 2020, 6, Downloaded from https://iubmb.onlinelibrary.wiley.com/doi/10.1002/bmb.21435 by Sri Lanka National Access, Wiley Online Library on [04/07/2023]. See the Terms and Conditions (https://onlinelibrary.wiley.com/terms-and-conditions) on Wiley Online Library for rules of use; OA articles are governed by the applicable Creative Commons License

review and evaluation, it was deemed better to offer a separate biochemistry laboratory course that will provide focus on essential biochemistry laboratory techniques and skills as well as exposure to specialty biochemistry equipment such as the gel electrophoresis set-up. A new undergraduate biochemistry laboratory was therefore instituted in 2016.

At this time, there are still two undergraduate biochemistry courses for nonmajors—a lecture and a laboratory course. And, there are three undergraduate biochemistry courses for chemistry majors—two lecture courses and one laboratory course. The three biochemistry courses for chemistry majors are complemented by two integrated laboratory courses, with biochemistry-related techniques incorporated in the experiments. Periodic review and assessment are done to ensure that learning outcomes of the courses are met.

4 | PRESENTATION 3: PROBLEM-BASED STUDENT-CENTERED LEARNING OF BIOCHEMISTRY IN THE CURRICULUM OF MEDICAL UNDERGRADUATES: AN EXPERIENCE IN SRI LANKA

Speaker: Anoja P. Attanayake, email: anoja715@yahoo.com

Biochemistry is one of the rapidly developing subjects in medicine. There is no wonder that the major share of Nobel prizes has gone to research workers engaged in biochemistry. Biochemical principles, concepts, and technology have become increasingly important for the understanding of a disease, management of the disease and for medical research. Advances in biochemical sciences have led to progress in medicine by the medical profession. Medical biochemistry could be taught in various ways that integrate basic and clinical sciences that have been or are being adapted by medical schools worldwide. Indeed, biochemistry subject needs to be taught with comprehension of concepts and mechanisms together with orientation of clinical aspects of diseases especially for medical undergraduates. However, in the past, there was a general dissatisfaction with the teaching of biochemistry in medical faculties in Sri Lanka and is considered as a hurdle by many. However, this has been a turning point of implementation of new biochemistry curriculum in most of the medical schools in Sri Lanka with an emphasis on problem-based student-centered learning, conductance of small group discussions, use of advance computer tools and smart screens for understanding of cellular mechanisms and illustrations, conductance of integrated modules for certain sections, and so forth.

The curriculum of teaching biochemistry in Faculty of Medicine, University of Ruhuna, Sri Lanka is thus based on conventional lectures, small group discussions/tutorials attained by interactive case-based tutorials, guided learning sessions, laboratory sessions, and so forth. Lectures are the main array of teaching of biochemistry as in the traditional way in most of the medical schools in the world. This has been similarly practiced here in Sri Lanka. Small group discussions are basically to discuss clinically oriented problems and generally conducted with an aim of relating biochemistry to illustrate real-life problems and practicing them for final examinations. Attempts are taken with case scenarios to generate enthusiasm, motivate learning, and to integrate the knowledge to make a real-time picture of a particular disease or of a condition. There can be no single best way of learning and teaching biochemistry alone, therefore the use of multiple teaching tools is beneficial. However, the incorporation of problem-based student-centered learning of biochemistry to the curriculum of medical undergraduates as much as possible is worth for the clinical years that lie ahead. Guided learning sessions with problem-based learning in a form of case scenarios are introduced in parallel with practical demonstrations with an emphasis on interpretation of biochemistry test reports rather than practically performing the experiments. The problem-based learning is important to develop the student's skills to interpret clinical problems. The case scenarios are formulated accordingly to match the level of prior knowledge, stimulate thinking, analysis of reasoning in a way of enhancing interest in the subject matter with a proper relevance to the future profession with a realistic approach. Patient history, photographs, basic laboratory investigatory results, chemical pathology results are aided in structuring the case scenarios. This is an important tool for understanding the pathological aspects, which in turn form a bridge between health and disease. The students are able to comprehend the content and its difficult concepts in association with structural and functional relationships by clinical cases presented during discussions.

In teaching biochemistry, the teacher has the responsibility to teach and take the responsibility for what is to be learned by the students. However, student-based self-directed teaching is more important with corroborating problem-based exercises during practical sessions and tutorials which have been recognized as an effective integrated approach to learn biochemistry in medical schools in Sri Lanka. The students' satisfaction was highly significant in problem-based student-centered learning and, however,

15393429, 2020, 6, Downloaded from https://iubmb.onlinelibrary.wiley.com/doi/10.1002/bmb.21435 by Sri Lanka National Access, Wiley Online Library on [04/07/2023]. See the Terms and Conditions (https://onlinelibrary.wiley.com/terms-and-conditions) on Wiley Online Library for rules of use; OA articles are governed by the applicable Creative Commons License

there are many practical difficulties identified as increased intake of students to medical schools, lack of infrastructure facilities, language difficulties etc. However, to date all efforts have been taken to foster medical students to become physicians who will be lifelong-independent learners and critical thinkers with healthy skepticism and provide high-quality patient care guided by the best evidence-based learning methods.

ACKNOWLEDGMENT

The author would like to acknowledge the Office of Admissions, UP and the Office of the College Secretary, CAS, UP Manila, and all students, academic staff and alumni of the BS Biochemistry program for the data used in this presentation.

ORCID

Janet O. Macaulay https://orcid.org/0000-0002-9212-9578

How to cite this article: Amor EC, Attanayake AP, G. Nicolas M, Yu GFB, Macaulay JO. Undergraduate education in biochemistry and molecular biology: A parallel session at the IUBMB/PSBMB 2019 "Harnessing Interdisciplinary Education in Biochemistry and Molecular Biology" conference. *Biochem Mol Biol Educ*. 2020;48:602–607. https://doi.org/10.1002/bmb.21435

15393429, 2020, 6, Downloaded from https://iubmb.onlinelibrary.wiley.com/doi/10.1002/bmb.21435 by Sri Lanka National Access, Wiley Online Library on [04/07/2023]. See the Terms and Conditions (https://onlinelibrary.wiley.com/terms-and-conditions) on Wiley Online Library for rules of use; OA articles are governed by the applicable Creative Commons License