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Discussion Forum

What Should the Student-Centered Teacher of Biochemistry and Molecular Biology Be Aware Of?

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In BAMBED's 2008 closing issue, Harold White highlights the importance of putting "ourselves in the students' place" [1]. In fact, the importance of centering university-level teaching around students is the theme of entire books [2, 3], guidelines, and recommendations from scientific societies [4]. As teaching becomes more "student-centered"—i.e. considers the learning needs and interests of students—it is likely that students will be more committed and, thus, better able to process the materials and, ultimately, learn more Biochemistry and Molecular Biology (BMB) [5–7]. Unfortunately, BMB teaching proceeds largely unaware—or in disregard—of pleas to pursue in that direction. A recent report on the state of BMB education in liberal arts colleges in USA concludes that introductory, intermediate, and advanced courses, all are by and large content-driven and lecture-delivered [8]. Essentially, the report reveals the little concern teachers have for how and for what students learn in BMB.

Students can learn substantially from one another when assigned more active roles in the learning process. Fresh evidence presented in two recent articles in Science contributes to this idea. In an enticing narrative, Eric Mazur (a Harvard Physics professor top rated by students) portrays the benefits of moving from delivering brilliant lectures to igniting student discussions in class by "peer instruction"—a method in which students discuss and get instant feed-back on ideas, answers to conceptual questions in the classroom [9]. Of great interest is the research article by Smith and co-authors on how "peer-to-peer" discussion within the same method helps students learn conceptual issues with no contribution of the teacher [10]. BMB faculty must decide to leave the lectern. When the power balance in class is shaken the odds that our students will learn BMB will increase [11].

In this article, we present an individual account that illustrates how unexpected outcomes can come out of listening to students in class. Furthermore, drawing both on personal experience and on the existing literature, we contextualize the importance of listening to students in BMB courses and list student-related factors that impact learning across subject areas.

THE IMPORTANCE OF LISTENING TO STUDENTS

In 2003, one of the co-authors (MJC) designed and taught a bimestrial introductory biochemistry course of a degree in agricultural sciences of a University in Asia. The daily 90 min classes were taught in the teacher's language of origin which was also the country's official language. The 11 students, unfortunately, were only moderately proficient in that language since they communicated through two local languages, which were both unknown to the teacher. Yet their mastery had allowed most students to succeed the degree's previous 14 courses—which included organic chemistry or introductory and cellular biology—taught in the official language in an identical format.

In the first class, after introductions, the teacher performed a demonstration and asked for interpretations. The demonstration consisted on pushing a bottle with holes in the bottom into a container with water and observing the effect on water level of screwing and then unscrewing the bottle's cap [12]. The exercise was meant to summon up the chemistry of air as a starting point to build on photosynthesis. Even though it was evident that some students were very bright, the class struggled with the observations during long minutes and, at the end, was unable to advance with an explanation for the rise in water level when the cap was screwed. The reason was simple and easy to pick up from the discussion: every student was convinced that air was nothing but empty space. Listening to students in the first few minutes of the course had exposed severe frailties in their understanding of the world.

As classes progressed, paying attention to and, in fact, eliciting student comments, led to the discovery of gaps in

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the molecular understanding of nature unimaginable in students who had taken full college courses on chemistry and on introductory biology. For example, students could not make sense of the concepts "matter" and "permeable" (even though the "semi-permeable" character of biological membranes was beyond any doubt to all of them). Interestingly, neither of the two latter concepts existed in their native or second languages, as it became evident from listening to students. The learning objectives set for the students were reconsidered and class design was revamped: an unplanned extensive use was made of pre-class reading assignments complimented with student discussions on words with meanings they could not grasp at start of every class. This simple change improved the communication in class, had an apparent positive effect on student commitment and made the teacher aware of other dimensions of student difficulties. For example, of the toll of tropical diseases on class attendance.

What these students told the teacher and not what the teacher told the students, was one of the most important aspects of the course. The observed benefits of listening to students were beyond the most optimistic expectations.

NON-COGNITIVE ISSUES AND STUDENT-CENTERED LEARNING IN HIGHER EDUCATION

Perhaps the hardest challenge for student-centered teaching is that classes are not taught to stereotypes of "the student." There are no students or classes exactly alike in subsequent or distant years. Nevertheless, being aware of some characteristics found in students may help teachers to manage the classroom environment. Some are contextual factors and others relate to non-cognitive student variables, as shown by research on student learning of mathematics, physics, medicine, and other sciences [13]. Few studies have been undertaken in the context of BMB [14, 15] but there is much to learn from research in other fields.

STUDENT APPROACHES TO LEARNING

In a student-centered class, learners are required to take responsibility for developing their own understanding of course materials. The fact is that not all students approach a course or an assignment identically. Individual approaches to learning will depend on perceptions on what "needs" to be learned to successfully complete a course, on the general conceptions on the nature of knowledge, on prior knowledge and experiences with course content and on the importance perceived of the course to student's future [13]. There are students who believe that learning in a given course is just reproducing a syllabus and perhaps using it to pass a test, and there are those who consider that learning implies developing conceptual understanding. Translating into a BMB context, there will be students who consider learning metabolism as equivalent to memorizing metabolic pathways and others who will strive to see how metabolism can contribute to their understanding of biological or medical phenomena. These two approaches are well described (i.e. surface and deep, respectively) and research has uncovered that the quality of learning and the achievements of students depend on which of two they adopt with deeper learners generally having preferable learning outcomes [16, 17].

Minasian-Batmanian and colleagues [14], have shown that the intentions of 87% of a class of Physiotherapy and exercise and sports entering a Biochemistry course were merely content reproduction. By asking the same entering class what students thought biochemistry was about, 83% of the answers were of the type "chemistry within the body" and were designated by the authors as "fragmented" conceptions of Biochemistry. Most students conceived biochemistry as a collection of separate facts rather than as a "cohesive" body of knowledge. Interestingly, 91% of the students with this "fragmented" entering conceptions intended to adopt a surface approach to learning [14]. In a subsequent study, these findings were corroborated with students at the conclusion of the same course [15]. In other subjects such as physics [18] and mathematics [19] or chemistry [20], it has also been shown that student preconceptions on a certain course play a major role in the way they will approach and try to learn the subject matter. It would perhaps be of great interest to understand how applicable such conclusions are to BMB classes in multiple institutions. The implications for a student-centered teacher are that teaching should lead students to learn both the biochemical content and to how to approach it.

PERSONALITY TRAITS

A separate set of findings reported in the literature relate to the associations between student personality traits and academic motivation and achievement. Psychological theories agree that five factors underlie personality—the "Big 5": "neuroticism," "extraversion," "openness to experience," "agreeableness," and "conscientiousness" [21]. Table I describes the most important characteristics of each factor.

"Conscientiousness" has proved a strong predictor of academic performance, for example of medical students [22, 23]. It relates to the extent that students are able to structure their learning process. Traits that increase the likelihood of higher academic accomplishments like persistence, organization, and motivation characterize

TABLE I
Characteristics of the big five personality factors

Five factors	Characteristics
Neuroticism	Anxiety, Hostility, Depression, Impulsiveness, or Vulnerability
Extraversion	Warmth, Assertiveness, Humor, Activity, Excitement seeking, or Positive emotions
Openness to experience	Fantasy, Curiosity, Imagination, or Original ideas
Agreeableness	Altruism, Trust, Modesty, or Compliance
Conscientiousness	Competence, Order, Dutifulness, Achievement striving, and Self-discipline

students with higher "conscientiousness." Moreover, students who score high in "extraversion" have been found to have higher risks of failing (specially, students who also score high in excitement seeking) [22], and those who score high in "neuroticism" tended to express lower academic motivation [23].

Research on the impact of personality on the learning of BMB would be valuable to uncover which personality traits would be associated with student under-performances and perhaps devise suitable remediation strategies. A student-centered teacher may wish to consider the ensemble of profiles in a class to adjust how directive he/she should be in terms of task orientation or on deciding how frequently the delivery of assignments should be.

THE CONTEXT OF THE CLASS AND THE INSTITUTIONAL ENVIRONMENT

Contextual factors are also known to impact student learning. Academic environments influence student's motivation, persistence, and student involvement in the academic community [24]. For example, curricular flexibility, promotion of appealing extra-curricular activities, and of initiatives that stimulate student critical thinking, are associated with better academic adjustment of students in higher education [24]. The student integration model by Tinto, one of the most extensive and thoroughly validated empirically, suggests that persistence results of the interaction between student's characteristics and school environment, and that integration is a process of changes and adaptation [25]. In addition, students will sense the school's environment differently according to their personal characteristics and to their perceptions of institutional support [24].

Further important contextual factors to consider are student background and socio-demographic characteristics, previous individual record track in Higher Education (HE) [26] and experience in the first year of college [27]. In particular, the "first year" in higher education is the most critical year, since it is when the percentages of withdrawals are highest and it is the year which mostly influences student motivation and will to persist in Higher Education [28]. Therefore, being aware of contextual factors is critical, in particular, for teachers of BMB first year courses. Being more available and attentive to academic or social integration of students in difficulty may be crucial to promote the well being necessary for academic achievement.

FINAL REMARKS

In summary, contextual factors and non-cognitive student variables are important dimensions in student learning in Higher Education, and hence, in BMB courses. More studies are needed so that we learn more on their influence on the academic success and on the well being of our students. Along with the use of appropriate course design and teaching approaches, such knowledge would pave the way for better student-centered BMB teaching. BAMBED could, perhaps, welcome such studies.

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