

## Assessment and evaluation in tertiary chemistry education: are we bothered?

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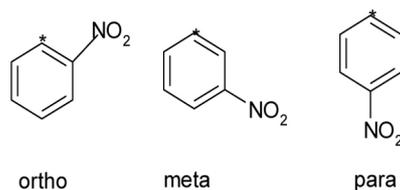
*Are the marks obtained by students in the qualifying UG & PG chemistry examinations really a measure of their academic potential? This question is open to debate, as there have been instances where a non-participative, weak student has ended up getting more marks than he/she deserves, whereas a student with good understanding has gone to a lower position. One of the reasons for this is the nature of the examination papers. This paper discusses some of the drawbacks of the current assessment and evaluation system, particularly regarding chemistry education and provides solutions to make it more meaningful.*

Undergraduate (UG) education is an important phase where students start engaging themselves seriously in the subject. At this stage, it is essential to present various facets of the subject in an engaging manner, so that students get an excellent exposure about the same. How much of the subject has been really understood by the student? Has the teaching-learning process really been effective? These are questions one needs to ask. It is here that assessment and evaluation can play a crucial role. Here we discuss the assessment and evaluation, particularly for the UG and postgraduate (PG) chemistry courses at University of Mumbai. The questions that we address include: What is really being assessed by regular university examinations? Do the marks obtained by students in such examinations truly reflect their understanding of the subject? In our opinion, assessment and evaluation is one of the most neglected area as far as UG and PG chemistry education is concerned.

Our observation is that university end-semester papers emphasize information-oriented (recall type) learning and thus students with poor conceptual understanding can easily score well in these examinations. Students write essays on short-note questions without even understanding the importance of the reaction and how it can be used to synthesize useful compounds. Such types of questions test the rote memorization capacity of the student. With untrue high scores, students do not feel the need to focus on enhancing their conceptual understanding. Very often students who are good with conceptual understanding end up scoring less in the descriptive pattern of examination, and hence they feel demotivated and at times start losing interest in the subject. The situation is alarming and needs serious attention.

### A case study in organic chemistry

Here we would like to present a case particularly with respect to organic chemistry, even though the arguments and issues that we are trying to address are true for various domains of chemistry. The current university papers for UG and PG chemistry examinations are descriptive in nature and abound in 'write short notes' and 'describe' type of questions. The entire paper presents questions where students have to recall information and there is no room for higher-order thinking, as never is an unknown situation presented to the students. If one sees the question papers of the past few years, the similarity in the pattern and even the questions is obvious. Hence, it is not difficult to score well in these examinations. In addition, with 100% option, certain core topics, particularly conceptually demanding ones like stereochemistry and/or spectroscopy are omitted from study by the students. If assessment and evaluation is only expecting students to perform at their minimal potential, then why would they exert themselves? By setting predictable papers, a sustained effort is made to curtail the students' thinking and understanding of the fundamental concepts. The end result is that most of these high achievers in terms of marks are poor with regard to conceptual understanding.



**Scheme 1.** Misconceptions in nomenclature of ortho, meta and para.

We would like to give some content examples that highlight the severity of the problem. For example, according to many students, the nitration of benzene gives three isomers, viz. *o*, *m* and *p*. The rationale for this answer is based on their misconception that the nomenclature of *o*, *m* and *p* is with respect to the carbon marked with an asterisk in Scheme 1.

Similarly, bromination of 2-butene yields two products, a Markownikoff and an anti-Markownikoff product and in the  $(4n + 2)$  Huckel's rule,  $n$  stands for the number of rings. Howlers like these answers really make us wonder what kind of graduates we are producing and would they be able to contribute to chemistry.

Students at UG level never use standard organic chemistry books. With predictable examinations, they prefer to study organic chemistry from lecture notes. It is intimidating to see that many students have lost their comprehension abilities, as they do not read standard undergraduate reference books. As a result, when students graduate to the PG level, they still expect notes to be provided by the instructors (which many teachers oblige). The argument presented by the teachers is that students do not have access to the reference books and hence there is need to spoon-feed them with the necessary study material. A consequence of this is that students never exert themselves and/or take the initiative to prepare lecture notes on their own.

In fact, today, good textbooks/reference books are more readily accessible to any student either in print medium and/or through internet as e-books. The current books have several novel features, such as good visualizations, real world applications, case studies, conceptual questions, exercises and problems. Some publishers also give access to

on-line test banks without incurring any additional expense. Referring and reading to such textbooks is an essential skill that needs to be developed by students. In our opinion, this is one of the most essential changes needed at UG level. Reading and studying from good/reference books will help students comprehend the concepts better. Solving end-of-chapter problems from these books will further enhance their problem-solving skills, build their confidence and develop a liking for the subject.

The three years of UG chemistry education needs to be harnessed as much as possible to generate ample opportunities for meaningful learning and understanding of chemistry. In fact, various proactive efforts, e.g. lectures by eminent chemists, open discussions with practising chemistry researchers/Ph D students, visits to advanced chemistry laboratories in leading scientific institutions/chemical industries, problem-solving, peer tutoring are needed so that students start perceiving chemistry as an exciting and happening science rather than a boring and monotonous one. Assessment and evaluation need to be equally vibrant and must challenge the students in some way or another. It is an integral part of the whole process and should take centre stage. Unless the desired changes are made in assessment and evaluation, any suggestions with respect to classroom teaching and learning will be futile and often will not be paid attention to.

Let us now look at laboratory courses and their assessment. The cook-book recipes for conducting laboratory tasks fail to generate opportunities for learning. Thus, often students do not understand the purpose of a given laboratory task and what is the learning outcome after doing the given task. The evaluation often presents standardized experiments/situations to students and perhaps what is being assessed is competency in the skills needed to perform wet laboratory experiments. As an end result, students are lost when it comes to doing simple tests independently. For example, detection of chemical type or functional group of a given organic compound or type of a binary organic mixture is a challenge for many students without reference to a handbook. Similarly, in estimation of organic (and inorganic) compounds, writing and balancing equations (particularly redox-type), calculations of normality and preparation of

standard solutions appear difficult. Is it impossible to present such situations as part of regular laboratory course and allocate marks for the planning and execution of experiments? In our opinion, such changes are feasible and will not need more money or time.

The sanction for introducing PG courses in colleges has resulted in the programme being run on an unaided basis in many colleges. As a consequence, there is an increase in the number of PG seats. There is no entrance examination for admission to the PG programme in the University of Mumbai; it is purely on the basis of marks obtained in their UG examinations. Thus, anyone who applies is likely to secure admission in some college or the other. The end result is there is an annual churn out of many Master's graduates who lack the necessary knowledge and skills.

With the introduction of the credit-based system at the PG level in the University of Mumbai, internal assessment has become important with 40% weightage given to the same. The method of evaluating the students is by seminar presentation on a topic of their choice, related to the relevant paper. So in each semester a student has to make four presentations, and thus 16 presentations over a period of two years. The idea of introducing the seminars was to encourage students to do some additional reading and gain knowledge. On the contrary we observe that most of the times the presentations are directly lifted from the internet or copy-pasted from internet resources. Basic questions being asked on the seminar topic are often met with silent responses or fumbling answers. In fact, in our opinion, doing the same in a workshop mode and as group activity (cooperative learning and peer interactions) will help and benefit students in various ways. Critical reflection and discussion on advance topics, asking and answering questions, and thus internalizing the topic is essential for the students. The peer interaction and cooperative learning can be used effectively for the same.

Most of the colleges have an average of 10 students in each branch of chemical (physical/organic/inorganic and analytical). The number of colleges offering specialization in organic and analytical chemistry is more compared to the other two branches. Giving projects to all students so that they get a flavour of

research is often not feasible due to lack of instrumental/infrastructure facilities at the local colleges. In our opinion, projects need to be seen as an opportunity to develop a feel about processes in experimental work such as reading, formulating a hypothesis, planning experiments, understanding variables in given experiments, etc. Such projects can be planned and are also doable at colleges that lack infrastructure<sup>1</sup>.

### Looking at some tangible solutions

Concerted efforts from every stakeholder of the university system are essential to raise standards so that our students are in demand in the industry and academia. It is obvious that the evaluation system needs revolutionary reforms. While the credit system may have been genuinely reformist, its hurried implementation has left the teachers angry and baffled. A huge systemic change of this magnitude requires discussion, invitation of suggestions and training; a process that requires at least a year or two. Unfortunately such effort has not been undertaken by the universities/Boards of Study in the different subjects. In its present form the credit system can only cater to small groups of students. Let us modify the system with inputs from all sections so that it fulfils the intended purpose.

We strongly feel the refresher courses should be used as a constructive forum for discussions of changes that universities want to implement. During such courses, along with content sessions, pedagogical sessions involving serious discussions and reflections on the changes that are being introduced need to be included. Such a forum can be used effectively to study different aspects of assessment (and other equivalent issues) and feasible changes that need to be introduced. Teachers can participate in workshops which involve a critical analysis of (i) different assessment and evaluation tools/modes, (ii) various types of question papers from other universities in India and abroad, and (iii) laboratory courses in different universities and their assessment. Such efforts will not only educate teachers (at least the motivated ones), but also force them to reflect upon the questions to be set for assessment and evaluation in a meaningful manner. Coopting teachers in such discussions and considering their feedback

will make the entire process more open and transparent.

Under the present Academic Performance Indicator (API) system, teachers must publish research papers to qualify for promotions. If exposed appropriately, teachers can venture into serious scholarly studies related to evaluating the students' understanding and their misconceptions, use of different innovative techniques for classroom teaching-learning, innovation with respect to chemistry laboratories, designing and developing meaningful instructional material, effective use of different assessment modes, etc. Such research that falls in the realm of chemistry education can provide empirical data to bring appropriate changes with respect to assessment, classroom teaching, laboratory courses and revision of syllabi. This research is definitely doable at local colleges; it does not demand too much finance or infrastructure and should be recognized on equal footing to research in the areas of pure chemistry. Teachers engaging themselves in chemistry education research are beneficial to teachers as well as to students. In fact, in our opinion, a lot is doable, particularly at the UG level if we sensitize teachers through serious chemical education sessions.

Here we (L.R. and G.S.) would like to mention our involvement with various activities that are conducted by the Chemistry Cell of Homi Bhabha Centre for Science Education (HBCSE)<sup>2</sup>. Par-

ticipation in the Chemistry Olympiad-related teacher workshops helped us develop a feel for conceptual questions. We internalized the fact that presenting context or designing questions (theoretical or experimental) using context has its own pedagogical value. Designing questions without ambiguity and with objective-type answers is the unique feature of Chemistry Olympiad questions. Such exposure helped us frame conceptual and challenging questions on conventional topics which are part of the UG/PG curriculum. Participation in the Process Oriented Guided Enquiry Learning workshops and International Conference on Education in Chemistry (2010 and 2014)<sup>3</sup> at the Centre introduced us to curriculum material and instructional practices based on inquiry. The National Initiative on Undergraduate Science<sup>4</sup> chemistry programme of HBCSE helped us develop projects that are doable by UG students.

We now develop conceptual and challenging questions on conventional topics which are part of the UG/PG curriculum. In fact, participation in all the above activities further provided us insight on how the assessment and evaluation can be modified to make it more meaningful.

We are aware that implementation of such suggestions will not be easy. However, an open mind on the part of the authorities and teachers can initiate a new beginning. If we do not accept the

existence and severity of the problem and work harmoniously towards tackling it, we will keep producing students who will have the degree but lack the necessary skills and knowledge required. Such generations of students with no understanding and analytical and reflective abilities, do not have any future. We and many among us have begun to feel that without radical changes, we and our students will become irrelevant and unwanted.

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1. Ladage Savita and Ravishankar, Lakshmy, *Curr. Sci.*, 2013, **104**(10), 1269–1270.
  2. <http://www.hbcse.tifr.res.in/>
  3. <http://www.associationofchemistryteachers.org/iccc.htm>
  4. <http://nius.hbcse.tifr.res.in/subjects/chemistry>
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