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NON-TRADITIONAL EXAMINATION: A STUDY TO IMPROVE ACADEMIC AND RESEARCH PERFORMANCE OF UNDERGRADUATE ORGANIC CHEMISTRY STUDENTS#

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#Dedicated to the Memory of Late Professor R. R. Gupta for his brilliant academic activity and education

Abstract:

An investigation of conducting a presentation examination instead of a classical written examination method on academic and research performance of undergraduate chemistry students was performed at the University of Texas-Pan American. The results suggest that chemistry students do much better in the presentation examination compared to the written examination at the advanced organic chemistry course. But, the performances of the students in the lower level courses are mixed. However, students do much better in research work when presentation examination was conducted.

Introduction:

Undergraduate chemistry students appear to be weak when compared to students of other subjects. Despite the high quality instructors in organic chemistry in university and college settings, the performances of undergraduates in organic chemistry courses are not satisfactory. Since organic chemistry plays a central role in our daily lives, a study was conducted at the University of Texas-Pan American (UTPA) to improve students' performance in terms of grades as well as learning experience. Organic chemistry instructors, in general, conduct written examinations either through multiple or descriptive types of questions. This is a very traditional procedure regardless of the subjects. We have conducted experiments and identified methods that are most effectives in terms of learning and performances in organic chemistry class courses with undergraduates. At least one seminar examination was conducted along with traditional examinations for all students in the second part of organic chemistry and advanced organic chemistry courses over the past few years. This study indicates that students perform better in a seminar type of examination compared to traditional examination methods in some instances. In continuation of our endeavor in undergraduate science education, we have adopted a novel strategy and obtained important

results. This paper describes a versatile method of introducing presentation examinations for students which can be used in the classroom to improve grades as well as quality for the students.

Improving the quality and knowledge of undergraduate chemistry students is an important goal. Numerous books and research articles have described improvements for students' performances (Brown, 1967; Entwistle, 1960; Schwartz, 2007; Neely, 2007; Furlan, 2007). The performance of the undergraduate students has also been examined by providing advance notes (Garcia, 2008). Clearly, this study confirms that advance class notes help the students significantly in performing better regardless of the quality of the students.

The University of Texas-Pan American is a located in the Rio Grande Valley in Edinburg, Texas. This university has approximately 19,000 students, of whom 90% are of Hispanic origin. Like many other universities, implementing higher education programs in different areas is one of the major goals. The number of students in different subjects is increasing and the competition level amongst students has gone up tremendously. An increasing graduation rate with better grade point averages is definitely a major target for any higher educational system. In particular, this is relatively more valid for UTPA, minority serving institutions and minority institutions since most of the students come from economically poor families to these types of institutions. In many instances, the majority of students are first generation college students and therefore it is difficult for many of these students and their families to organize time, effort, and resources that are necessary for successful completion of a college degree with high credit.

Organic chemistry is a required course for biology, chemistry, pre-medical, pre-dental, and pre-pharmacy students. The instructors at UTPA have chosen to teach a number of topics in organic chemistry II. For example, organic chemistry part II includes benzene and other aromatic compounds, electrophilic aromatic substitution reactions with activation and deactivation, various reactions and synthesis of alkenes, alkynes, alcohols, phenols, ethers, epoxides, and amines. Students who are interested in higher level chemistry enroll in advanced organic chemistry. This course includes chemistry of carbohydrates, reaction of active methylene, several named reactions, metal-mediated processes, and application of reagents in organic synthesis. It is expected that organic chemistry students learn the basic concepts, mechanisms of reactions, and application of these reactions in real-life.

The enrollment of organic chemistry II in each section is approximately 60 students and advanced organic chemistry has an average enrollment of 35 students. Most of them are in age groups of 19-24. In general, 4 examinations are taken for both courses. All examinations are equally important. At the end, an average is taken and the grades of the students are calculated based upon standard practice. Student grades depend on the average point they make after the four written examinations. To obtain "A," "B," "C," or "D" grades, students need to earn 90 or higher, 80 or higher, 70 or higher, and 60 or higher respectively. Students who are less than 60 are considered "F" (fail). To evaluate the success of students in organic chemistry courses, we have adopted a seminar examination (presentation examination) as one of the examinations taken without having any prior results or information. Interestingly, this method has shown to improve student grades and has significantly improved their learning abilities. Our method has been tested for 3 years both in the organic chemistry II and advanced organic chemistry courses.

Experimental Section:

This study was conducted for 3 years starting from 2010 to 2012 with organic chemistry II students. Excellent notes were given to all students in advance. However in 2010-2012, the

3rd examination was selected as the seminar examination for students enrolled in organic chemistry II. A similar study with advanced organic chemistry students were also conducted, but not in consecutive years (in between 2007 to 2012). Class notes were also given to each student in advance to this group of students. The final examination was comprehensive for both of these courses. All examinations except the final contained a mixture of multiple choices in addition to descriptive questions. In some years, final examination was based on multiple choice examinations only.

Results and Discussion:

As mentioned, based upon the consent taken from the students, the 3rd examination was selected as the seminar examination for both organic chemistry II and advanced organic chemistry courses. Approximately 4% students dropped the course before completion of the semester. There were numerous reasons to select the 3rd examination as the seminar examination. In general, the 3rd examination was taken after 3 months of the semester. Students were exposed to most of the subject matter prior to the seminar presentations and thus allowed them to acquire a broader range of knowledge. It did not mean that all students have leant the topics well even at the end of the semester. However, serious attempts were made to make the subject enjoyable, informative, descriptive and creative. In many instances additional classes were taken for an extended period of time to help the students who may have difficulty and also to discuss the subject more critically. Various topics were selected based upon student level for the presentation examinations. In organic chemistry II, topics were selected from the following reactions or methods: Aromaticity and Non-Aromaticity; Differences between Aromatic Compounds and Alkenes; Electrophilic Aromatic Nitration Reaction; Electrophilic Aromatic Sulfonation Reaction; Friedel-Crafts Alkylation Reaction; Friedel-Crafts Acylation Reaction; Electrophilic Halogenation Reaction; Electrophilic Thallation Reaction; Activation of Aromatic Rings; Deactivation of Aromatic Rings; The cause of Activation and Deactivation; Nucleophilic Aromatic Substitution Reaction; Addition-Elimination Reaction of Aromatic Compounds; Conversion of Aromatic Compounds to Another; Oxymercuration of Alkenes; Ozonolysis of Alkenes; Several Oxidation methods for Alkenes; Reduction of Alkenes; Synthesis of Alkenes; Addition of Hydrogen Halides to Alkenes; Various Addition Reactions of Alkenes; Allylic Halogenation; Hydroboration of Alkenes; Preparation of Alkynes; Hydroboration of Alkynes; Reduction of Alkynes; Preparation of Alcohol; Oxidation of Alcohol; Preparation of Ether; Claisen Rearrangement of Allylic Aromatic Ether; Preparation of Phenol; and Preparation of Epoxide. The topics were discussed with extensive mechanism of the processes.

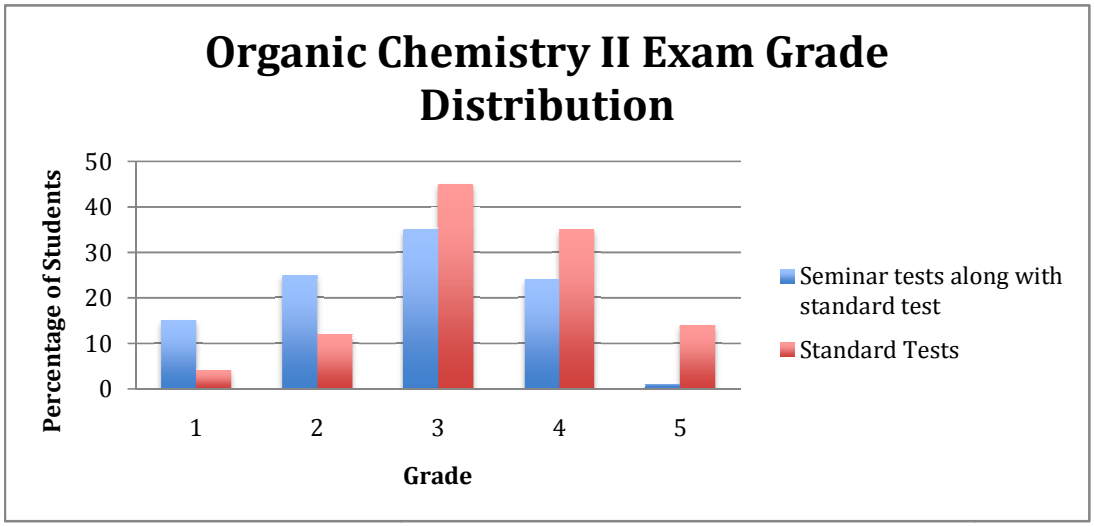
For advanced organic chemistry seminar presentations, the following topics were selected: Homologation and Degradation of Carbohydrates; Mutarotation in Carbohydrates; Pyranose and Furanose Structure of Carbohydrates; Periodic Oxidation of Sugar Derivatives; Ferrier Rearrangement Reaction of Glycal; Asymmetric Synthesis using Carbohydrates; Preparation of Acid Derivatives from Diethyl Malonate; Preparation of Ketone Derivatives from Ethylacetoacetate; Alkylation of Ketone through Enamine; Birch Reduction; Indium Metal-Induced Reactions in Water and Organic Solvents; Reactions in Water; Samarium Metal-Induced Selected Reactions; Samariun Diiodie-Catalyzed Selected Reactions; Indium Salts-Catalyzed Selected Reaction; Fries Rearrangement; Beckmann Rearrangement; Hoffman Degradation; Paal-Knorr Reaction; Michael Reaction; Reformatsky Reaction; and Tributyltin Hydride-Induced Reactions for the construction of Polycyclic Ring Structures.

Each topic was written on post card paper and kept at the instructor's classroom bench upside down. A few topics were chosen multiple times by changing the description of the questions

and examples. Students were asked to select a post card and were required to lecture for 10 minutes on their selected topics at the classroom in the presence of all other students and the instructor. After presenting, other students and the instructor were given an opportunity to ask two questions to the presenting student. In addition to the presentations, students were required to submit an approximately 10-pages report with references to the instructor.

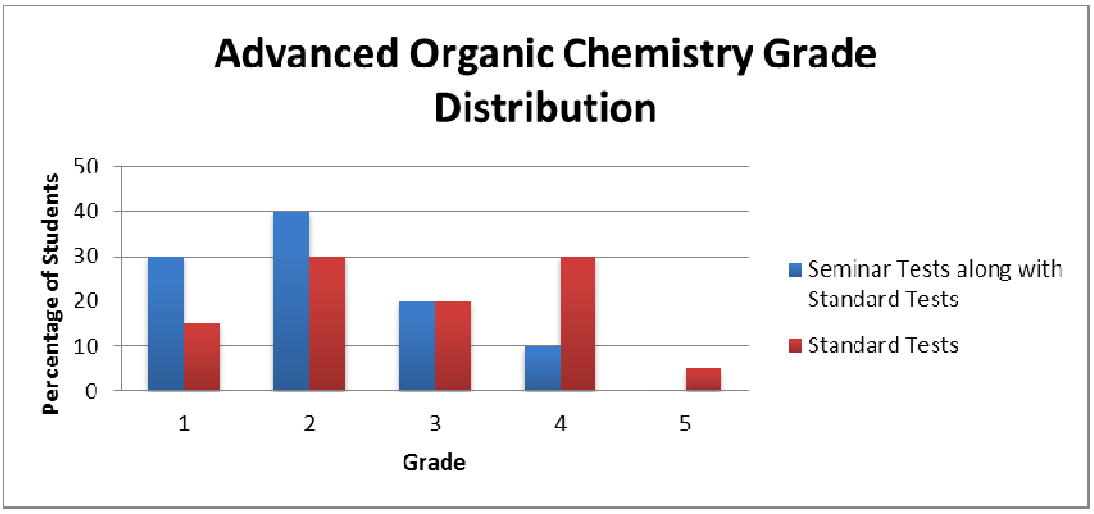
The table 1 showed the observed data: 1 (excellent, A: 15/2); 2 (good, B: 26/10); 3 (average, C: 35/43); 4 (weak, D: 23/33) and 5 (poor, F: 1/12). The data obtained showed an increase of A and B grade students when the presentation examinations were included in making the ultimate grade decision. This trend was observed in organic chemistry II lecture course. It is important to note that the number of failing grades (F) decreased when presentation examinations were conducted. This trend is believed to occur due to the confidence gained by many students in delivering lectures and studying a particular topic repeatedly. Since all students were required to stay in the classroom regardless of whether they completed their presentations or not, support the fact that students performed much better overall and learned various topics from their peers. This procedure surely contributed to the success of the students and their retention in the class. Some students depended only on the classroom teaching materials and therefore did not perform well in the presentation examination (C- and D-grade students). These students were probably much more confident on written examinations or they were nervous in presenting the subject in the presence of whole class (**Table 1**).

Table 1



In an identical method as described herein, the superior grade distribution for the advanced organic chemistry classes could be attributed to better quality of students in the course. This was due to the fact that only students who were interested in chemistry were enrolled in the advanced organic chemistry courses. Naturally, the standard scores of the students in the advanced organic chemistry classes were better than that of organic chemistry II classes (**Table 2**). The table 2 showed the observed data: 1 (excellent, A: 30/15); 2 (good, B: 40/30); 3 (average, C: 20/20); 4 (weak, D: 10/30) and 5 (poor, F: 0/5). Only the percentages of the weak students were decreased when presentation examination was conducted. However, major improvements were observed among all other students (excellent, good, average and poor) in advanced organic chemistry class.

Table 2



The group and peer cooperation learning method through the presentation examination was found to be a more effective means to the overall grades and learning experience for the advanced organic chemistry students. But, the results for the organic chemistry II were mixed. There were many observations that were taken into account. For example, this method helped students research and identify materials for their presentation with references, prepared them to produce power point presentation materials, helped them learn to draw chemical structures, gain ideas for oral delivery, stimulated them to interact with other students and the instructor, and developed writing skills. Importantly, they were also exposed to a variety of current and challenging topics in organic chemistry along with the mechanistic interpretation. However, this method did not help a few students to have higher grade, although it had raised the status of many students not only in terms of higher grade and performance, but also in improving their inter-personal skills (Dhar, 2013; Rowan, 2007; Stainbarn, 2011).

Outlook and Scope:

These types of examination as described above were conducted in a US university. Many US universities are involved in research work with undergraduate students. It has been found undergraduate students who have performed excellent by this method of teaching mostly joined research groups of several professors and researchers. For example, they conducted research for their theses, course works and future career development plan/higher education. Many of them ended up with publications in research journals or presented their finding in important conferences. For example, one of the authors (BKB) has published and presented more than 350 papers/presentations in which one of the authors was an undergraduate or high school students. Their research topic include heterocycles, carbocyles, synthesis, mechanism, beta lactams, polyaromatic hydrocarbons, catalysis, enzymes in chemistry, natural products, alkaloids, terpenes, vitamins, hormones, carbohydrates, microwave, and ultrasound. Many other scientists have demonstrated that undergraduate students can perform meaningful research if suitable opportunity and training can be provided to them. As a result, these groups of students enjoyed better facilities and opportunities in their career. In contrast, examination system in India and probably other Asian Countries is different. As far as we know research with undergraduates in Asian Countries is also very limited. Based upon the current trend of high profile research activities and high demand for the future in world

science, it may be necessary to change the examination systems in India and other countries. We are expressing our opinion for better results although we know lots of hurdles are there. This is definitely a very challenging task to realize this objective since numerous authorities need to be involved in the whole process. Certainly, there will be a lot of debate. However, the method described here may help the Indian as well as other Countries (where research by undergraduates is limited) undergraduates to learn the subject more effectively if they receive similar type of opportunities as exemplified by this perspective. The undergraduates may conduct chemistry research at the college level for better understanding of the subjects as a whole and a particular topic in more detail. Indian college level systems have numerous facilities to undertake this type of program through joint discussions with the administration of higher authority. This procedure will certainly enhance students' involvement in research starting from their careers. This may sound a difficult topic to pursue. However, it is necessary to initiate and implement this type of program in India to remain highly competitive in the world level. This method if becomes available to majority of science and engineering students, good outcome is expected.

Conclusion:

This study clearly confirms that presentation examinations in the form of a seminar provided to organic chemistry II and advanced organic chemistry students reduced the failing rate of the courses as well as increased the good to excellent grades. Thus, providing students with this kind of challenging method during their studies facilitates their learning process. It was clear that a few students appeared more anxious and nervous (C- and D-grade students of organic chemistry II). In contrast, most of the students demonstrated confidence during their seminar presentations. This observation was also confirmed when the report on the presentation topic by the students were evaluated. Students who had scored high in the presentation examinations had written better reports. It was found that these students followed the subject matter and understood the concepts. However, a large number of organic chemistry II students presented the topic randomly with no correlation and flow in the selected materials. These students did not make any eye contact with the instructor or any other student during the presentation. With these examples, it is clear that some students were unable to capture the topic adequately. Indeed, it appeared that these students wanted to finish their presentation as quickly as possible ignoring the time frame. On the basis of this study, presentation examinations should be included as one of the examinations for undergraduates, particularly for the senior level students. Because of the experience in class presentation on a particular topic along with their ability to search corresponding scientific literature would make these students even stronger if they choose a career path for advanced degrees. A different long-term study should also be undertaken to focus working with the students (average and weak) to identify their difficulties and non-satisfactory performances. The current procedure is extremely new to the undergraduates of UTPA. It may be considered a new examination technique for the undergraduates in many other universities as well. Therefore, it may require a few years to popularize this exciting procedure among the students. Faculty members and researchers cannot deny the future academic and economic benefits that can be obtained from this type of novel approach in the future. Many students who have performed well through this procedure have conducted good laboratory-based research during their undergraduate degree and remained highly competitive in their future career. It is expected that Indian colleges and universities would be able to revise their curriculum towards different academic and research benefits for the B. Sc. students. This change may help the students in their career development pathways. Our study indicates that

undergraduates can conduct reliable research if they understand subject more effectively through presentation examinations.

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