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UNIVERSITY STUDENTS' PERFORMANCE IN ORGANIC CHEMISTRY AT UNDERGRADUATE LEVEL: PERCEPTION OF INSTRUCTORS FROM UNIVERSITIES IN THE SADC REGION*

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Summary. Organic Chemistry is a challenging subject and students often fail to perform well in it. Both students and instructors have their own views about Organic Chemistry teaching and learning. The study describes the perception of Organic Chemistry instructors from different universities in the SADC (*Southern African Development Community*) region on the performance of students in this subject. They have perceived factors such as conducting tutorials, laboratory sessions and students' prior knowledge of the subject as contributing to students' success in Organic Chemistry whereas the presence of anxiety/phobia and time constraint contribute to their underperformance. The study reveals that the most popular method of instruction is lecture method using chalk and board followed by demonstration method using models. The suggestions of instructors on how to improve Organic Chemistry teaching and learning are also described.

*Presented at SAARMSTE Conference in January 2004 at Cape Town. South Africa.

Introduction

Organic Chemistry courses are considered difficult from students' point of view and their performance in this subject is relatively low. The students are expected to understand, master and apply the course material in problem solving. The abilities to manage information and to reason analytically, both deductively and inductively are essential requirements for success in Organic Chemistry. The instructors believe that if one learns fundamental principles and theories one will be able to make applications as needed. Dzama and Osborne [1] have reported about the poor performance of African students in Science. They found the absence of vocational incentives as the main cause of it. The research work in Organic Chemistry Education, conducted mainly in American and European universities, relates to problem solving, misconceptions about the subject and assessment methodologies. Maruto and Camusso [2] have assessed the knowledge acquired in an Organic Chemistry course using a multiple-choice exercise. The results were used to research areas that should be reinforced in order to improve the quality of the teaching-learning process. The application of metatasks for organizing previous knowledge in Organic Chemistry has been described by Fountain [3]. Bradley and co-workers [4] have described the importance of cooperative learning in the Organic Chemistry course in which the lecture component diminishes in the first semester and essentially vanishes in the second. Carpenter and McMillan [5] have also described the incorporation of a cooperative learning technique in Organic Chemistry. They used Learning teams that were overwhelmingly accepted by the students as it helped them in reinforcement of concepts through peer instruction. The knowledge space theory has been used for tracking the development of students' conceptual understanding of Organic Chemistry in second year [6]. This study has shown that the students' knowledge base increases but the cognitive organization of the knowledge is weak and misconceptions persist even after two years of college chemistry. Nash and co-workers [7] have measured conceptual change in Organic chemistry. Their results indicated that significant change in students' knowledge structure occurred during the semester.

Organic Chemistry is a component of the first year General Chemistry curriculum and a separate course from second year level onwards of the undergraduate program of most of the African universities. The difficulties in Organic Chemistry teaching and learning surface in various academic meetings in the *SADC* region that has given Organic Chemistry recognition as a difficult subject. Since there was no study in Africa to find out the cause of students' underperformance in the subject, it was considered pertinent to investigate the factors affecting students' performance by involving all the stakeholders. Firstly, we surveyed the students to find out their views on the performance in Organic Chemistry [8]. In this paper, we report the results of the survey carried out with

Organic Chemistry instructors in the *SADC* region to determine what factors they perceive influential to students' performance in Organic Chemistry, the preferred instructional methodology and their suggestions on how to improve the teaching and learning.

Purpose of the study

The purpose of this study was to find out reasons influencing the performance of undergraduate students in the *SADC* region in Organic Chemistry as perceived by their instructors in different universities. The objectives of the study were:

- To find the demographic data of the respondents.
- To find out the reasons perceived by instructors on Organic Chemistry teaching and learning.
- To find the methods of instruction used by Organic Chemistry instructors at undergraduate level in the *SADC* region.
- To enumerate reasons given by the instructors for underperformance of students in the subject.
- To outline suggestions made by the instructors on how to improve Organic Chemistry teaching and learning in the region.

Methodology

The survey research methodology was used for this study. The questionnaire was sent by email to Organic Chemistry instructors in the universities of the *SADC* region (*Angola, Botswana, Democratic Republic of Congo, Lesotho, Mauritius, Malawi, Mozambique, Namibia, Seychelles, South Africa, Swaziland, Tanzania, Zimbabwe and Zambia*). The instructors from Botswana, Lesotho, Mauritius, South Africa, Swaziland, Zimbabwe and Zambia responded. The instructors were asked to rate the importance of fourteen statements in Section A of the questionnaire on a 5-point Likert scale on which 5 indicated that they strongly agreed with the statement and 1 indicated that they strongly disagreed with the statement. The fourteen statements were selected from the literature [2, 9] and our experience of Organic Chemistry teaching in the region. In Section B, respondents had to indicate the methods of instruction used during their lectures. In Section C, the respondents were asked to indicate their demographic information such as gender, highest educational level and teaching experience. The two open-ended questions were asked to seek information from instructors on reasons for under-performance in Organic Chemistry and suggestions on how to improve Organic Chemistry teaching and learning in the region. The content validity of the instrument was established in consultation

with two educationists from the Department of Agricultural Economics, Education and Extension, Botswana College of Agriculture. The data collected was analyzed using SPSS (Statistical Packages for Social Sciences) for Windows. To interpret the data, an overall mean of 3.5 or above was taken to denote agreement with all the statements and mean below 3.5 was considered to denote disagreement.

Findings and Discussion

Demographic Information

The majority of instructors from the universities in *SADC* region who responded to the questionnaire have teaching experience of more than 5 years (Table 1). All the instructors had PhD in Organic Chemistry. The respondents comprised of 33 % female and 67 % male.

Table 1: Factors influencing students' performance in Organic Chemistry as perceived by the instructors

| | STATEMENTS | Mean Std Error | Ranking | Decision |
|----|--|-------------------|---------|----------|
| 1. | Students' prior knowledge in Organic Chemistry improves their understanding and learning ability in the subject. | 4.45 ± 0.21 | 2 | Agree |
| 2. | Providing a detailed Organic Chemistry course outline at the beginning of the semester improves their performance. | 3.75 ± 0.25 | 10 | Agree |
| 3. | Providing modes of assessment of Organic Chemistry course at the beginning of the semester improves their performance. | 3.08 ± 0.25 | 11 | Disagree |
| 4. | The students feel any time constraint in completion of the Organic Chemistry course in the allocated time. | 3.82 ± 0.35 | 9 | Agree |
| 5. | Conducting tutorial sessions in the subject for practice of concepts improves their performance. | 4.67 ± 0.14 | 1 | Agree |
| 6. | Conducting laboratory sessions in Organic Chemistry improves their understanding. | 4.42 ± 0.26 | 3 | Agree |
| 7. | Presence of any anxiety or phobia for Organic Chemistry affects their performance. | 4.33 ± 0.19 | 4 | Agree |

| | | | | |
|-----|--|------------|---|-------|
| 8. | Students' understanding that Organic Chemistry is a complicated and challenging course, affects their performance. | 3.91 ±0.29 | 8 | Agree |
| 9. | Provision of any extra handouts/notes in Organic Chemistry improves their performance. | 3.92 ±0.23 | 7 | Agree |
| 10. | Demonstrations using models improves their understanding and performance. | 4.08 ±0.19 | 6 | Agree |
| 11. | Use of active learning methods like short exercises during lectures improves their understanding. | 4.17 ±0.27 | 5 | Agree |
| 12. | Use of examples from day to day life during lectures helps in generating interest and understanding Organic Chemistry. | 4.42 ±0.19 | 3 | Agree |
| 13. | Use of lecture outlines, concept maps, diagrams help in Organic Chemistry learning. | 4.33 ±0.14 | 4 | Agree |
| 14. | Group discussions improve their understanding and performance. | 3.92 ±0.34 | 7 | Agree |

Perceived factors influencing Students' Performance in Organic Chemistry

The reasons influencing students' performance in Organic Chemistry as perceived by the instructors have been analyzed and presented in Table 2. These factors are discussed in the succeeding paragraphs.

Table 2: Methods of Instruction

| Teaching Method | Percentage response | Ranking |
|---|---------------------|---------|
| Lecture method using chalk and board | 80 % | 1 |
| Lecture method using transparencies and OHP | 53 % | 3 |
| Oral explanation of notes on handouts | 33 % | 4 |
| Dictation of notes | 7 % | 6 |
| Lecture method using Power Point slides and CDs | 0 % | 7 |
| Demonstration method using models | 67 % | 2 |
| Any other method | 27 % | 5 |

Prior knowledge and Sequential Learning

In the SADC region, the secondary school Chemistry curriculum has a sizable portion of Organic Chemistry. The Organic Chemistry course in the first year of undergraduate program is built on this foundation. With regard to statement 1, a mean value of 4.45 (Table 2) was obtained that indicates the instructors agreed with the statement. This finding is in agreement with Ausubel's [10] study that indicated a positive relationship between learning and prior knowledge. The requirement of sequential study has been advocated by Felder and Silverman [11].

Providing detailed Organic Chemistry course outline, modes of assessment and extra handouts/notes in Organic Chemistry

Majority of instructors distribute the course outline and assessment methods at the beginning of the course. The instructors also provide extra handouts during the semester. However there might be a difference in opinion among them about how much these affect the students' performance. This led us to investigate the opinion of instructors on the impact of distribution of these course related materials on students' performance. The instructors agreed with the statement 2 (Mean = 3.75, Table 2) relating to the distribution of course outline at the beginning of the semester and students' performance. The course outline helps students to familiarize themselves with the topics prior to the lectures and even plan their time. The instructors disagreed with statement 3 (Mean = 3.08, Table 2) that disclosing of assessment methods at the beginning of the course would improve the students' performance. The provision of supplemental material such as handouts and notes helps in improving their performance as statement 9 has a mean of 3.92 (Table 2).

Time constraint in completion of the course in the allocated time

A mean value of 3.81 (Statement 4, Table 2) suggests that the instructors agree with students feeling of time constraint in completion of the Organic Chemistry course in the allocated time. The paucity of time thus affects their performance during assessment tests and examinations. However, the reason for time constraint was not clear from this study because curriculum designing takes time factor into consideration [12] and instructors do consider it so as to give the best delivery of course material in the allotted time.

Conducting laboratory sessions/tutorials in Organic Chemistry

High mean values of 4.67 and 4.42 for statements 5 and 6 (Table 2) indicate that tutorial and laboratory sessions are the most important and greatly improve the performance in Organic Chemistry. Rosenthal [13] has also emphasized on usefulness of lab sessions in understanding of the subject. The writing

assignments have been proved successful in learning Organic Chemistry [14].

Presence of anxiety/phobia for Organic Chemistry

From Table 2, a mean value of 4.33 (Statement 7) indicates that the instructors believe that the presence of anxiety/phobia affects students' understanding in the subject. A lower success rate in Chemistry has been reported for the students with anxiety for the subject in comparison to those with no anxiety [15]. The Russians have reported the presence of chemophobia [9] among students. Eddy [16] also reported about chemophobia in a college classroom. Probably due to this anxiety the students consider Organic Chemistry as a problematic science. From our observations [17] the anxiety/phobia for this subject among students has been a major factor affecting their performance.

Organic Chemistry as a complicated and a challenging course

A mean value of 3.91 (Statement 8, Table 2) indicates that instructors believe that students' understanding of Organic Chemistry as a complicated and challenging course, affects their performance. It has been well established that students find Organic Chemistry complicated and challenging [18].

Demonstrations using models

It is evident from a mean value of 4.08 (Table 2) for statement 10 that demonstration using models improves students' performance. Molecular models are used for explaining the three dimensional structures of organic molecules [19]. These are helpful for students in visualizing and thus improve their understanding of Organic molecules.

Use of active learning methods like short exercises during lectures

The mean value for the statement 11 is 4.12 (Table 2). Writing promotes critical thinking and provides a method for student discovery and growth [20]. Active learning methods [21] during lectures such as concept tests and problem sheets have been proved to be successful in improving the grades. The instructors in the SADC region also agreed to this statement and found them useful.

Use of examples from day to day life during lectures

This statement has a mean of 4.42 (Table 2) that shows the instructors agree that students find the course interesting if examples from day to day life are cited. There are more than 7 million organic compounds such as foodstuffs (proteins, carbohydrates, vitamins, fats), fuels, fabrics, wood, paper, plastics, soaps, detergents, cosmetics, medicines and explosives.

Use of lecture outlines, concept maps, diagrams

A high mean value of 4.33 (Table 2) proves that lecture outlines, concept

maps, diagrams are helpful in Organic Chemistry learning. The use of lecture outlines, summary sheets, line diagrams, concept maps [22] during lectures have resulted in improvement in chemical education.

Group discussions

This statement 14 has a mean value of 3.92 (Table 2). Instructors agree that group discussions are helpful in understanding of the subject and improve the students' performance. Although in chemistry classrooms, the lecture is the dominant teaching mode but multiple teaching methods are being used [23]. Group discussions, cooperative learning methods are becoming popular as active involvement of students improves their understanding.

Instructional methodology

The results related with methods of instruction are presented in Table 3. The lecture method using chalk and board is the most popular method of instruction followed by the demonstration method using molecular models. Our survey results with students [24] also showed that the lecture and demonstration methods were the preferred methods of instruction.

From this finding, it can be inferred that the present teaching methodology is suitable for students. Other methods used by instructors were exploration/discovery method, short assignment during lectures, individual demonstration and demonstration through experimentation.

Table 3: Teaching experience in years

| Experience in years | Percentage of respondents |
|----------------------------|----------------------------------|
| Below 5 | 7 % |
| 5 – 10 | 33 % |
| 11 – 15 | 27 % |
| 16 – 20 | 0 % |
| Above 20 | 33 % |

Analysis of open-ended questions

Reasons given by instructors for under-performance in Organic Chemistry

The instructors have given the following reasons for students' underperformance in Organic Chemistry at the undergraduate level.

- Poor background of Organic Chemistry from pre-university level
- The students find Organic Chemistry concepts very complicated.
- The students do not want to put effort themselves rather believe in spoon-

feeding by their instructors.

- Time constraint as the students have a heavy load of work.
- Lack of active study. Students do not practice by writing to learn and understand.
- Large intake of students that results in crowded lecture halls.
- The students tend to memorize rather than understand the concepts and therefore fail to apply it in new situations.

Instructors' suggestions for improvement

The instructors made the following suggestions in order to improve Organic Chemistry teaching and learning in the *SADC* region.

- The students should be encouraged to write and practice exercises.
- The course should be completed well in time or the time allocated for the course should be increased.
- The frequency of small group tutorial sessions and discussions must be increased.
- The exploratory approach through experimentation must be used more frequently.
- The students should be provided with more learning aids.
- The lecturers must draw a relationship with prior knowledge and current topic as it helps student's to understand.
- The students should be advised on good study methods. For example, they should be encouraged to make notes themselves.
- The students should be introduced to the idea of problem based learning rather than rote learning.
- The students should be asked short questions during lectures.

Conclusion

The findings indicate that tutorial and laboratory sessions are the most important factors that greatly improve the performance in Organic Chemistry. Other factors that improve their understanding in the subject are active learning methods, use of demonstration models, lecture outlines, concept maps and diagrams. Provision of detailed course outline and extra handouts may improve their performance. The most preferred method of instruction is lecture method using chalk and board followed by demonstration method using models. The instructors have felt lack of time, prior knowledge and insufficient writing and practice responsible for the poor performance in the subject. The instructors suggested on increasing tutorial sessions, advising good studying patterns in Organic Chemistry and insisted on writing assignments regularly.

Acknowledgements

Authors are grateful to Professor B. M. Dlamini and Professor S. K. Subair of Department of Agricultural Economics, Education and Extension and Dr I. Riddoch of Basic Sciences Department, Botswana College of Agriculture, for helpful suggestions. We thank the Heads, Department of Basic Sciences, BCA, and Department of Chemistry, UB, for providing the facilities.

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ТРУДНОСТИ В ПРЕПОДАВАНЕТО НА ОРГАНИЧНА ХИМИЯ В ЮЖНАТА ЧАСТ НА АФРИКА

Резюме. Най-популярният метод на преподаване на органична химия във висшите училища на района на Южна Африка, включващ 14 държави, е лекционният с тебешир и черна дъска. Понякога се използват подходящи модели на някои молекули на органични вещества. Този метод не дава добри резултати и предизвиква фобия у обучаваните към предмета. Работата съдържа редица препоръки как да се повиши ефективността на обучението по органична химия. Повечето от тези препоръки имат място и в българската образователна практика.

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