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Undergraduate Students' Performance in Basic Organic Chemistry by Using Organic Chemistry Mapping Model

Mohd Tajudin Mohd Ali*

Faculty of Applied Sciences, Universiti Teknologi MARA, Shah Alam, 40450, Selangor, Malaysia

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Abstract:

This case study involved students in CHM 457 (ORGANIC CHEMISTRY I) course, in which students from one group used the Organic Chemistry Mapping Model (OCM) model in their study, whereas another group was treated with the conventional class method. The objective of this study was to compare the performance of students in their examination using or without using the OCM model. A total of 121 students were chosen and grouped into two groups in this study. Research instruments used in this study were the OCM materials for organic reactions, evaluation tests, examinations, an assignment, and experiment evaluations. In addition, an assessment was done by comparing their examination results for the whole semester. The results suggest that the performance of students using the OCM model increased significantly.

Keywords: undergraduate basic organic chemistry, organic chemistry, curriculum, student-centered learning, innovation in chemistry education.

应用有机化学作图模型分析本科生在基础有机化学中的表现

摘要:

本案例研究涉及中医药457（有机化学I）课程的学生，其中一组的学生在他们的研究中使用有机化学映射模型(OCM)模型，而另一组则使用传统的课堂方法。本研究的目的是比较使用或不使用OCM模型的学生在考试中的表现。在这项研究中，总共选择了121名学生并将其分为两组。本研究使用的研究工具是用于有机反应、评估测试、考试、作业和实验评估的OCM材料。此外，通过比较他们整个学期的考试成绩来进行评估。结果表明，使用OCM模型的学生成绩显着提高。

关键词: 本科有机化学基础、有机化学、课程设置、以学生为中心的学习、化学教育的创新。

Corresponding Author: Mohd Tajudin Mohd Ali, Faculty of Applied Sciences, Universiti Teknologi MARA, Shah Alam, Malaysia; email: tajudinali@uitm.edu.my

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1. Introduction

Creativity has now become a necessary and fundamental characteristic towards a person's achievement, especially in the learning process. It is not only subject to innovation or invention, but it covers all acts and thoughts. In line with developments in technology like smartphones and globalization, Malaysians need to be highly innovative and progressive contributors to the scientific advancement of the future (Mohd et al., 2012). Innovation in teaching and learning activities is very interesting, as it is believed that the implementation of innovative teaching methodologies could increase student's achievement in science courses such as chemistry (Situmorang & Situmorang, 2014); thus, the development of learning materials is vital towards a better understanding of students in chemistry subjects. Development in teaching and learning has been conducted through many approaches such as thorough inquiry-based learning (Maab & Artique, 2013), project based-learning (Toolin, 2014), and interactive multimedia (Qian & Xuefeng, 2013). Concerning smartphone technology and the IoT environment worldwide, it will be advantageous to include the use of these devices for educational purposes to make learning activities more exciting, interesting, and accessible. Successful cases by incorporating technology in undergraduate chemistry students were reported by Pursell (2009). They applied for the flashcard program as a supplementary teaching kit for organic chemistry students learning nomenclature, structure, or organic molecules and their reaction mechanisms. They reported that students appreciated the convenience of having apps on their smartphones (Pursell, 2009).

Incorporating multimedia presentation in the classroom could enhance chemistry learning activities since it can be used as modeling, learning, assessment, and instructional tools (Chiu & Wu, 2009).

Teaching an organic chemistry subject, especially basic organic chemistry, is challenging since many students have difficulties understanding and memorizing many reactions involved in the subject. They must understand electrophile or nucleophile of the chemical synthons, the role of the reagents or solvents in an organic reaction, reaction mechanism, the reactive functional groups in one molecule, predict the reaction products. For catering to these teaching problems, the Organic Chemistry Mapping model (OCM) was introduced to solve or minimize the problems faced by the students. To the best of our knowledge, no such models were found in the literature regarding animation reactions in basic organic chemistry models.

The Organic Chemistry Mapping model (OCM) is a type of organic chemistry teaching material that has been developed using the classification strategy of functional groups. In the OCM method, each organic reaction in a certain functional group is arranged systematically depending on reagents, organic reaction

rules, and the ease of reactions. The basic organic topic covered in this OCM model are reactions in alkene, alkyne, alcohol, alkyl halide, and aromatic groups. OCM is suitable for students at the level of undergraduate chemistry, matriculation students, foundation, or A-Level students. Its emphasis is on the strategic learning method supported by an effective student-centered learning process and online material published on youtube.

2. Research Methodology

2.1. Research Overview

In the case study presented here, the Organic Chemistry Mapping model (Figures 1, 2, 3, 4) was developed to provide an innovative basic organic chemistry (CHM457) learning material for the Faculty of Applied Sciences (FSG) students majoring in forensic chemistry (AS253) and applied chemistry (AS245), in Semester 1. This model was introduced to students, together with the conventional teaching and learning approaches (lecture, tutorial, experiments, assignment, tests, and final examination). Finally, the effectiveness of OCM on a student's achievement was then evaluated in their tests, assignment, and examinations. The data was then collected and compared with the control groups.

2.2. Research Population and Sampling

The populations are from the Faculty of Applied Sciences, Universiti Teknologi MARA, Shah Alam students majoring in Forensic Chemistry and Applied Chemistry, involving 121 students. Group A was chosen as the control group. Teaching and learning basic organic chemistry activities were conducted using conventional methods, and all students were equally treated in the activities. For the second group (group B), other than the above approaches, all students have been introduced to the OCM model, and they used it in their classroom via e-flashcards. They can also find this model in the online version.

Table 1. The description of population and samples

Group	Student number	Semester	Overall Performance Grade (Number of student and percentage)				Total
			A	B	C	D	
A	43	1	2 5	18 42	18 42	5 12	43 %
B	78	1	11 14	41 53	22 28	4 5	78 %

2.3. Research Instruments

The instruments used in this study were: (1) Organic Chemistry Mapping model consisting of alkene

reactions as depicted in Figure 1, alkyne reactions as depicted in Figure 2, alcohol reactions as depicted in Figure 3, and aromatic reactions as in Figure 4. (2) Evaluation tests and examination questions. (3) Assignment task and (4) Experiment evaluations. A set of evaluation tests (test 1, test 2, and test 3) and final examination contains various questions from simple to difficult questions. The questions are designed to cover eight basic organic chemistry topics and measure students' achievement in chemistry.

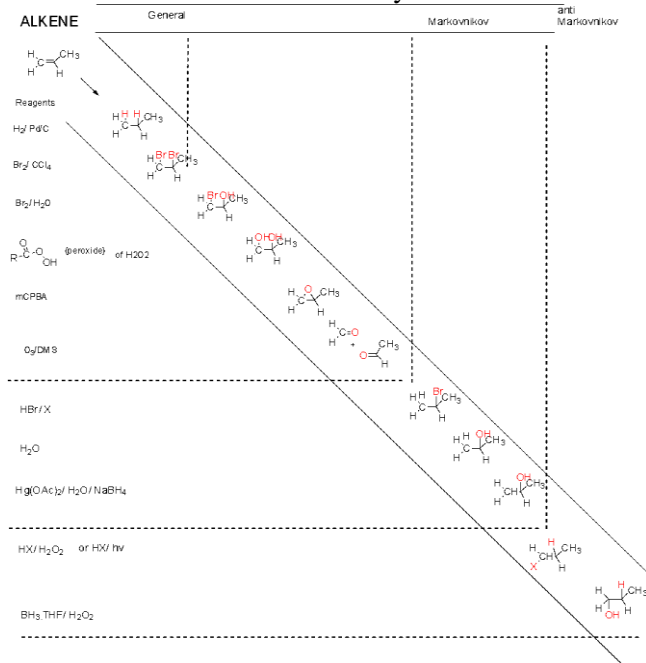


Figure 1. Organic chemistry mapping for alkene

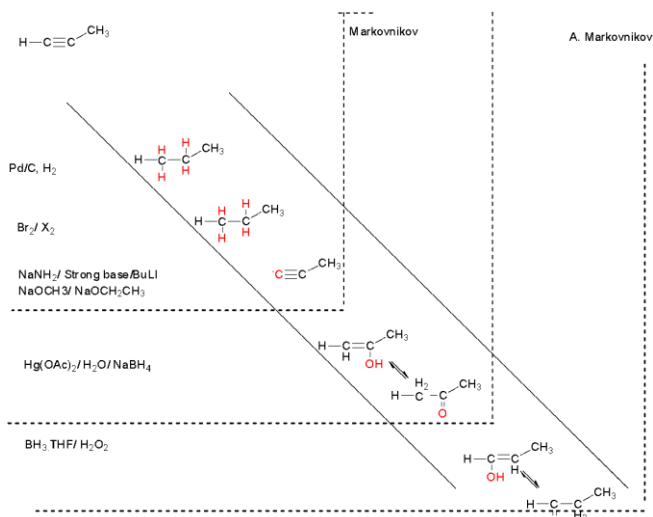


Figure 2. Organic chemistry mapping for alkyne

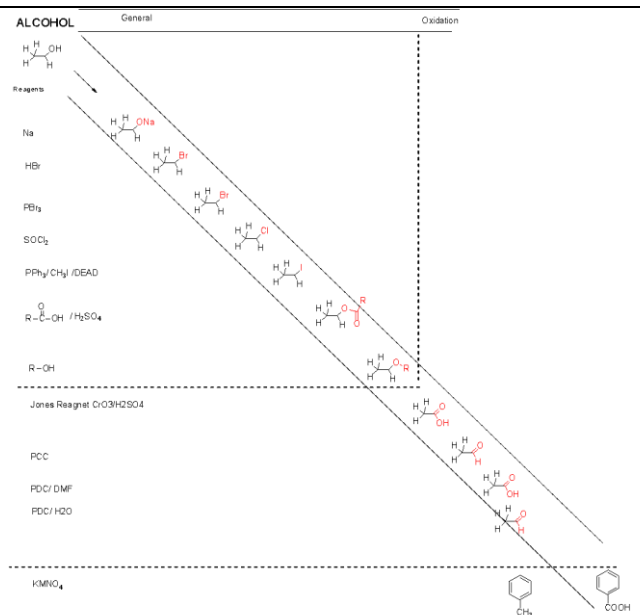


Figure 3. Organic chemistry mapping for alcohol

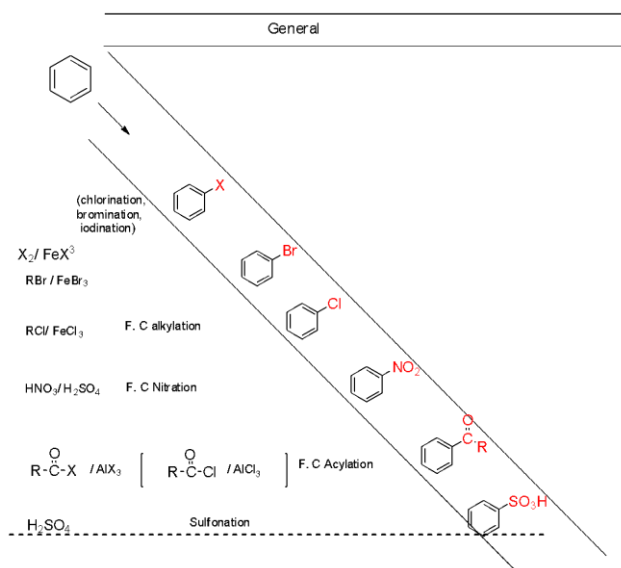


Figure 4. Organic chemistry mapping for aromatic compounds

2.4. Research Procedures

Before the introduction and implementation of the OCM model for group C students, all of them must follow and experience the lecture conducted by their lecturer as similar as group A and B. Then the OCM model could be used by the students in group B, in their classroom or outside through the use of e-flashcards or youtube channel. For example, during the explanation of chemical reactions involving an alkene such as hydrogenation or hydroboration, after a normal discussion or lecture, the lecturer will introduce the method to use the OCM model at the end of the alkene topic. The achievement of students could be accessed through test 1 (with weightage 10%), test 2 (with weightage 10%), test 3 (with weightage 10%), and the final examination (with weightage 40%). For each test and final examination, all questions follow the difficulty level.

These evaluations, together with their assignment and laboratory performance (weightage 20%), are reflected in their basic organic chemistry subject.

3. Results and Discussions

Table 1 represents student's examination results for basic organic chemistry subjects (CHM457). The result obtained was a combination of all three tests, one assignment, experiment performance, and final examination result.

Much educational research has been conducted by employing graphics, pictures, multimedia, and animations to encourage and promote e-learning (Clark & Mayer, 2011). It has been shown that animations as educational tools have increased students' attitudes and achievements (Betrancourt & Tversky, 2000). In addition, the visual expression is more attractive when the colors, movements, and texts are used in the teaching and learning processes (Rosen, 2009).

The effectiveness of using the OCM approach towards student's achievements (group B) in basic organic chemistry and the control class groups (groups A) using conventional learning has been investigated. It was observed that during class sessions conducted in the experiment group (Group B), students were more interested in using the OCM model in which they can view the animation presented through their mobile phone, together with their movements of reactions following the changing of the reagents used. Through this model, all reactions involved in a particular topic, such as alkene, alkyne, alkyl halide, alcohol, and aromatic compounds, were arranged systematically starting from the ease of reaction to the more complex reactions depending on the reagents used. This arrangement system, together with its animation and movements of the chemical formulas, will allow students to concentrate on the active and vigorous functional groups (Falvo, 2008).

Moreover, students will be able to forecast first the product formed at the stereospecific active site, and their understanding and memorizing capacity on organic chemistry reaction will be improved significantly. Through this model, the student's understanding of nucleophiles and electrophiles was increased. Also, they could understand better the Markovnikov and anti-Markovnikov rule. Furthermore, they used the OCM model in problem-solving activities (tutorials) conducted in their classes. They also used the OCM as a reference reaction for their learning activities.

The results showed that student achievements in experimental classes (group B) were higher than those in the control class (group A). The percentage of students with grade A increased to 14% in group B compared to the 5% in group A. The percentage of students with grade B also increased significantly from 42% in the control group (A) to 53% in group B.

In addition, the percentage of students with grade C reduced significantly to 28% when they applied OCM in their class, compared to 42% of students in group A. For students with grade D, the percentage of students in

group B was 5% compared to students in group A, with 12%.

This finding is consistent with the reported results from Baglama et al. (2018). They discovered that students who adapted the animation tools in their learning process tended to have a deeper understanding than with text and static figures.

The contents of organic chemistry in innovative learning material, alkene, alkyne, alkyl halide, alcohol, and aromatic group, are used as sources of knowledge as stated in the syllabus, making the students improve their competence in organic chemistry. In addition, the facilities such as internet penetrations in the learning material can help the students learn chemistry by themselves.

Hence, this innovation could improve the performance of undergraduate students in basic organic chemistry courses, increasing the number of students with grades A or B and reducing the number of students with grades C and D. Results of this study suggest that students and teachers should apply this OCM model to facilitate their learning and teaching processes.

4. Conclusion

The novelty of this Organic Chemistry Mapping model, which strategically combines the reactions of each functional group with different reagents ranging from simple to complex processes, has proven to be a valuable tool for students to easily verify reaction sites and products for the certain functional group. This model has been developed to enrich the organic chemistry knowledge in students through a functional group classification system. The developed model helps students learn organic chemistry subjects more interactively and systematically and was found to improve student achievements in organic chemistry.

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