IMPLEMENTING THE SEA APPLICATION FOR ORGANIC CHEMISTRY: ARROW-PUSHING VERSUS ELECTRON-MOVING TECHNIQUES

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ABSTRACT. The models used in organic chemistry are usually rigid; it is difficult for students to rapidly transfer between the macroscopic, submicroscopic, and symbolic levels of thought. As a result, students' perceptions of these models are sometimes incorrect. In organic synthesis students should comprehend information about reactions and, simultaneously, visualize the inverse of these reactions. Without deep understanding of the mechanistic aspects of organic reactions, students will face problems in an advanced chemistry course. Another problem in teaching organic chemistry effectively is the wide range of abilities and academic interests of students. The introductory organic chemistry class caters for students from various science and technology fields. Based on this context, a computer application was used as an alternative approach for teaching and learning organic chemistry with the assumption that animations could assist students to better understand concepts. In a study by Gilbert, Reiner and Nakhleh (2008), it was implied that animated presentations could exert an extra cognitive load on students. Consequently, a relevant question that educators need to answer is "How visuals should be animated in science instruction?" This study examined how an animation based computer application that applied an electron-moving technique was used as a supplementary material in a first year Organic Chemistry course and its effect on the performance of students. Using pre and post-test design, the study involved a comparison between an experimental group of first year students (n=28) who followed instructions that used moving-electron technique in a blended mode and a conventional group of first year students (n=27) who used arrow-pushing technique to learn the fundamental concept of organic reaction mechanism. The finding suggest the potential of using electron- moving technique as an instructional approach based on the improved post-test performance as compared to arrow-pushing techniques.

Keywords: organic chemistry; animation; arrow pushing technique; electron moving technique

I. **INTRODUCTION** Chemistry is a core subject in most educational systems offered to science-based students starting from secondary school. Organic synthesis is probably one of the most demanding aspects of organic chemistry. Students must comprehend information about reactions while simultaneously visualize the inverse of these reactions because synthesis typically starts by working backwards. The nature of chemistry which consist of an abstract, unobservable, particulate molecule will lead to misconceptions [1], [2] and difficulty in more advanced courses. Moreover, organic chemistry is always perceived by students as a difficult and complex subject to learn [2]. Students have found that the synthesis of new organic molecules through organic reaction mechanism the most difficult concept to understand. The addition reactions (such as electrophilic, nucleophilic and radical reactions), elimination reactions (E1 and E2 reactions) and substitution reactions (SN1 and SN2) are the three fundamental organic reaction mechanisms which students need to learn in any introduction of organic chemistry subject. In all organic reaction mechanisms, a single covalent bond consists of two electrons while other free electrons which are not involved in bonding are shown as dots on the atoms.

II. ARROW-PUSHING TECHNIQUE

A. Arrow-Pushing Technique All organic reaction mechanisms involve the movement of electrons during the process of formation and breaking of covalent bonds. The movement of electrons is represented by a curved arrow. Therefore, most educators using this approach will demonstrate the mechanistic process of the organic reaction mechanism. This technique, called the "arrow-pushing" technique, is popular among educators [3], [5]. The arrow is used to show the movement of a pair of electrons, from an electron rich location to an electron poor location. Arrow-pushing is a conventional way of teaching organic synthesis which demonstrates how the reactants are converted to products. Students are taught to write the mechanics of organic reaction mechanism using curved arrows. Arrow-pushing is actually a curved arrow drawn during the process of organic reaction to represent the flow of electron from an electron rich location to an electron poor location [3], [5], [6] which show the steps of reaction explicitly. This is the main process involved when organic reactants are converted to organic product. The arrow is used to show the movement of electrons during the formation and the breaking of chemical bonds to form a product. The movement of a single electron is represented by a single barb curved arrow while the movement of a pair of electrons is represented by double barb curved arrow.

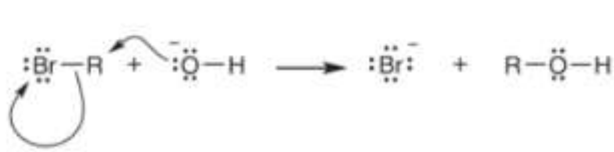

Figure 1 is an example of an organic reaction mechanism sequence taught to student in class [7].

However, most students face difficulty to visualize the actual movement of electrons in the organic reaction mechanism as understood by their teachers [8]. Organic chemistry requires that students adopt a process-oriented view of the reaction, in which they must envision a continuous flow along the mechanistic pathway that transforms the reactants into the products of the reaction. As an alternative, students would use "memorization" since they believe this technique is an effective way to understand the basic principles of organic reaction mechanism [2],[6], [9]; however this technique ignores the fact that they will encounter more complex organic mechanism reactions in the future. Furthermore, it is difficult for students to visualize between the movement of electrons and the formation of chemical bond while drawing the arrow because this process involve the macroscopic, submicroscopic, and symbolic level of thoughts [10], [11], [12]

B. ELECTRON-MOVING TECHNIQUE :

Computers in science education can generally be categorized as information resource tools, and knowledge construction tools. As information resource tools, computers are used to retrieve information from an educational application or through the Internet. In the second category, computers act as knowledge construction tool often emphasizing practice and drilling of information in students [13]. Hence, the increasing availability of advanced authoring software has enabled the use of computers as an alternative constructivist medium for teaching and learning science. Computer technology in education is generally effective in enabling better understanding of teaching materials, facilitating interaction between students and learning materials, providing effective use of examples and illustrations to capture students' attention, and assisting students to retain information through emphasizing important and relevant information. For this to be achieved, a computer application should be designed to facilitate the construction of knowledge. The present study has designed this kind of computer application, namely the Simple Explicit Animation (SEA) to teach the fundamental concept of organic reaction mechanism using animations particularly to systematically portray explicitly the movement of electrons through the "moving-electron technique". Figure 2 shows the content and learning objectives of the SEA application.

Figure 2: Content and learning objectives of SEA

Through an animated courseware, students of diverse backgrounds and levels of understanding can study organic reaction mechanism according to a flexible time frame before they proceed to advanced topics. Besides, utilization of the animated computer application as a supplementary material is practical and economical for mass lectures. Figure 3 shows both the example of arrow-pushing and eletron- moving tecniques.

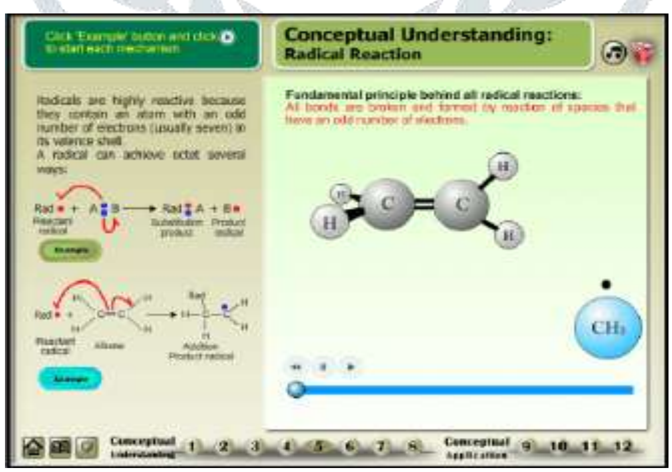

Figure 3 - Screenshot shows the example of arrow-pushing and animation of the electron-moving techniques

Organic reaction mechanism consists of abstract concepts; therefore educators should consider how these concepts could be visualized in effective forms. Computer animation can be exploited to enhance the understanding of organic reaction. For example, through the demonstration of an animated movement of an electron instead of using a curved arrow, assist students will be assisted to understand the movement of electrons during organic reaction mechanism explicitly. The objective of the SEA courseware is to demonstrate the organic mechanism reaction explicitly in simple movements. For example, the animation in Figure 4a and 4b clearly demonstrates that both electrons in the homolytic cleavage mechanism are transferred to only one atom followed by the break up of a covalent bond

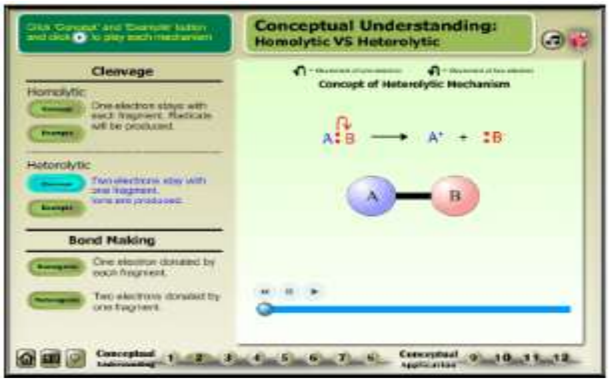

Figure 4a - Screenshot shows the molecule

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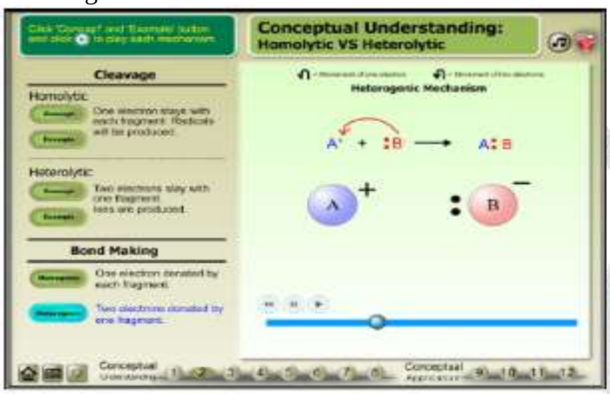

Figure 4b - Screenshot shows the moving of electrons

To actively involve students, it is necessary to provide a means for them to interact with the animation in a meaningful way. The interactivity principle states that information is better comprehended if students has control over the pace and flow of animation. Commonly a multimedia presentation has a few control buttons such as Play, Back and Forward. A control bar as shown in Figure 5a dan Figure 5b, is used to control the moving visuals, at any point of the presentation; students could speed up or slow down the movement of electrons. This control bar allows the process of organic reactions to be repeated by students, especially during segments that require several repetitions for more understanding.

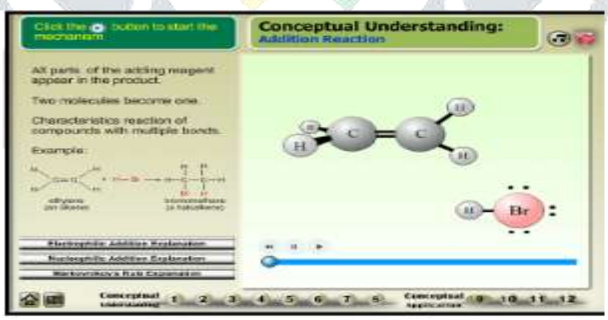

Figure 5a: The control bar allows the process of organic reacti to be repeated

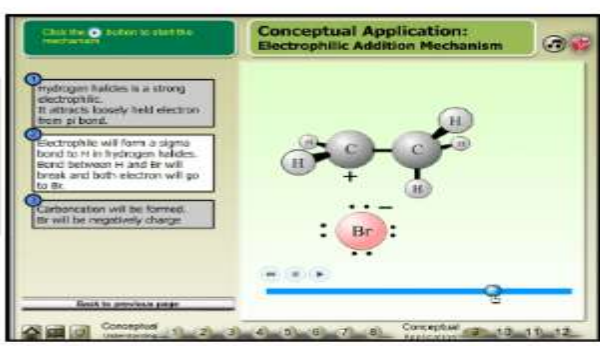

Figure 5b: Screenshot shows the process of the reaction

III. PROCEDURE AND ANALYSIS This study compares the effects of using the SEA computer application which demonstrates the electron moving technique with the conventionalbased instruction that uses the arrow-pushing technique to teach students' the concept of organic reaction mechanism. Using pre and post-test design, the study involved a comparison between the SEA group (n=28) whose lecturer had used a blended learning mode and the conventional learning group (n=27) whose lecturer had delivered instruction based essentially on the arrow-pushing techniques. The hypothesis for this research is as follows: Ho: There is no significant difference between the post-test score of the SEA group and the post-test score of the conventional learning group after the pretest was analysed as a covariate. Table 1 below shows the descriptive analysis of the pre-test and post-test for both groups.

Table 1: Descriptive Statistics for experimental group

	N	Minimum	Maximum	Mean	Std. Deviation
pre	28	5.00	19.00	13.3889	3.91286
post	28	18.00	33.00	22.6111	4.11795
pre	27	13.00	20.00	17.4118	2.00184
post	27	22.00	31.00	27.8824	2.64297

The results of ANCOVA in Table 2 shows that the SEA group pretest[$F(1, 52) = 4.49$, $p < .05$)] and conventional learning group pretest [$F(1, 52) = 28.2$, $p < .05$)] had significant effect on each of their posttests. This demonstrates that after the pretest was controlled, the instructional techniques used by both groups did affect the post-test scores of the subject. However, the post-test score for the SEA group is better than the conventional learning group.

Table 2: Tests of Between-Subject Effects

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	430.308a	2	215.154	32.375	.000
Intercept	241.398	1	241.398	36.324	.000
pretest	187.379	1	187.379	28.195	.000
group	29.835	1	29.835	4.489	.042
Error	212.664	52	6.646		

IV. CONCLUSION This research has documented an increase understanding in the fundamentals of organic reaction mechanism for the group who had use the electron-moving technique as compared to the group who were taught the arrow-pushing technique. It can be hypothesized that a dynamic and abstract organic reaction mechanism process has more cognitive demands so the use of the electron-moving technique had a positive effect on the students' understanding. Therefore, students who used the electron-moving technique are more likely to succeed in solving tasks entailed in understanding the fundamentals of organic reaction mechanism.

REFERENCES:

[1] J. B. Friesen, "Saying What You Mean : Teaching Mechanisms in Organic Chemistry," J. Chem. Educ., vol. 85, no. 11, pp. 1515–1518, 2008.
[2] D. L. Lafarge and L. M. Morge, "A New Higher Education Curriculum in Organic Chemistry: What Questions Should Be Asked?," 2014.
[3] G. Bhattacharyyat, "Research and Practice Trials and tribulations : student approaches and the electron-pushing formalism," Chem. Educ. Res. Pract., 2014.
[4] A. Ghosh, "Six Impossible Mechanisms Before Breakfast: Arrow Pushing as an Instructional Device in Inorganic Chemistry," 2013.
[5] M. A. Kayala, J. H. Chen, and P. Baldi, "Learning to Predict Chemical Reactions," pp. 2209–2222, 2011. [6] R. Ferguson and G. M. Bodner, "Making sense of the arrowpushing formalism among chemistry majors enrolled in organic chemistry," pp. 102–113, 2008.
[7] N. P. Grove, M. M. Cooper, and E. L. Cox, "Does Mechanistic Thinking Improve Student Success in Organic," 2012.
[8] G. Bhattacharyya, "From Source to Sink: Mechanistic Reasoning Using the Electron-Pushing Formalism," 2013.
[9] J. H. Chen and P. Baldi, "Synthesis Explorer : A Chemical Reaction Tutorial System for Organic Synthesis Design and Mechanism Prediction," J. Chem. Educ., vol. 85, no. 12, pp. 1699–1703, 2008.
[10] Y. Dori and M. Barak, "Virtual and physical molecular modeling: Fostering model perception and spatial understanding," Educ. Technol. Soc., vol. 4, pp. 61–74, 2001.
[11] S. Wei, X. Liu, Z. Wang, and X. Wang, "Using rasch measurement to develop a computer modeling-based instrument to assess students' conceptual understanding of matter," J. Chem. Educ., vol. 89, pp. 335–345, 2012.
[12] K. S. Taber, "Revisiting the chemistry triplet: drawing upon the nature of chemical knowledge and the psychology of learning to inform chemistry education," Chem. Educ. Res. Pract., vol. 14, p. 156, 2013.
[13] J. Ainley, D. Banks, and M. Fleming, "The influence of IT: Perspective from five Australian schools," J. Comput. Assist. Learn., vol. 18, pp. 395–404, 2002.

BIBLIOGRAPHY:

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