

## Incorporation of Brainteaser Game in Basic Organic Chemistry Course to Enhance Students' Attitude and Academic Achievement

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(Received May 15, 2017; Accepted June 20, 2017)

**ABSTRACT.** Game shows are capable of grabbing students' attention in a lecture, and at the same time offers much delight to students to learn in a more interesting and entertaining way. A mind game was developed and incorporated into the teaching of basic organic chemistry course at the Universiti Malaysia Terengganu. The modified brainteaser game is comprised of a set of problems associated with vocabulary or concepts in basic organic chemistry, whereby students were required to solve within a stipulated time frame. Students' attitude changes were then evaluated with the administration of Attitude toward the Subject of Chemistry Inventory Version 2 (ASCIv2) questionnaire. The result of this study revealed that the intervention group experienced a significant change in attitude towards the course as compared to the control group. The intervention group also experienced a positive learning environment, resulting in an increased academic performance and interest.

**Key words:** Brainteaser, Basic organic chemistry, ASCIv2 and game

### INTRODUCTION

Many undergraduates perceived that basic organic chemistry is a difficult course to learn and apprehend, especially in the following topics: nomenclature, molecular visualization, reaction mechanism, and application of theory to problem-solving exercises.<sup>1</sup> For many years, "Chemophobia" or more popularly known as chemistry anxiety, was known to exist within students in many countries.<sup>2,3</sup> As a result, students have developed a negative perception in the chemistry subject as reported in previous literatures.<sup>4-7</sup> This has resulted in fewer students enrolment into chemistry courses and severely affecting chemistry-related careers.<sup>8</sup> As such, new teaching pedagogies or active learning methods in chemistry are urgently needed so as to create a positive learning experience for students.

Games and simulations have become an established educational method and popular tool in teaching.<sup>9</sup> When all went well, it allowed collaborative learning, address on affective issues, and thus enabled active learning among peers.<sup>10</sup> Many literatures have reported on game-based activities that were capable of creating students' interest and enabled students to review on past lectures in the chemistry classroom, such as the use of a card game for teaching organic synthetic course,<sup>11</sup> BINGO game for learning nomenclature,<sup>12</sup> molecular model game for revision on Lewis structure

and VSEPR theory,<sup>13</sup> Taboo game to create active learning in general chemistry classroom learning,<sup>14</sup> Jeopardy<sup>15</sup> and Who Want to be A Millionaire<sup>16</sup> to review on past lectures, and so forth. The implementation of games have offered much delight to students to learn in a more interesting and entertaining manner. In addition, students will be more attentive in the classroom if they actively participate by discussing listening, jotting notes and reflecting in parallel with an on-going lesson. In contrast to a traditional classroom, if no intervening pedagogies were introduced, students' concentration and learning was reported to decline after 10-30 minutes.<sup>17</sup>

In this paper, we would like to report the use of brainteaser activity to reinforce and review on previous knowledge learnt in the basic organic chemistry course, as well as to motivate students to be more attentive in the classroom. The brainteaser activity is a mind game that is capable of engaging students in learning and it could be employed to capture students' attention during a lecture. Students were required to solve a problem within a time frame. The instruction of the brainteaser activity presented here is easy to follow and prior preparation for this activity is also simple. A closer examination on the current literatures revealed that a mind game with similar objectives as the brainteaser-the concentration game, was employed to review on an environmental chemistry course.<sup>18</sup> A few other literatures have also described on the use of brainteaser as an instruction of

teaching, but without using the same kind of activity as presented in this paper.<sup>19,20</sup> In addition, very few studies have measured the affective dimension and intellectual accessibility of subjects by using a valid and reliable instrument in game-based learning activities. In this study, we sought to understand students' attitude changes with the administration of the Attitude toward the Subject of Chemistry Inventory Version 2 (ASCIv2) questionnaire.

## METHODOLOGY

### Subjects

This activity was carried out at the Universiti Malaysia Terengganu. The brainteaser activity was administered to 98 students in semester 1 2016/17, who enrolled into the environmental analytical chemistry program (intervention group). On the other hand, the control group comprised of 100 students who enrolled into the biology program, in which the basic organic chemistry course is a compulsory subject to both programs. The intervention group experienced the brainteaser activity, while the control group underwent a traditional lecture without the administration of the brainteaser activity.

### Brainteaser Activity

The basic organic chemistry course is comprised of two one-hour lessons per week for a total of 14 weeks. The brainteaser activity was directed twice to students, at week 12 (Brainteaser #1 to 7) and at week 13 (Brainteaser #8 to 14) during the last 15 minutes of the lecture. All the problems directed to students were obtained from concepts or vocabulary learnt from the previous lessons in the basic organic chemistry course.

In this activity, students were required to analyze the jumbled up questions and determine the correct word(s) or answer(s) from the brainteaser activity as illustrated in brainteaser #1 and #2 (Fig. 1). To increase the complexity of the brainteaser activity, students were challenged to pick out the correct answer(s) from a set of choices (brainteaser #6, Fig. 1).

Throughout the activity, students were allocated one minute for each problem and the course instructor will then proceed to the next problem. During this activity, students were allowed to discuss their answer among their peers. At the end of each activity, the course instructor discussed the answers along with explanation of the basic chemical concepts with students.

### Instrument

The administered ASCIv2 questionnaire<sup>21</sup> was a short

Brainteaser #1

oncjugation

Brainteaser #2

byhdriization

Brainteaser #6

hciwh fo eth olfloiwnng si/era roaicmat?

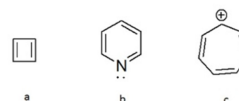


Figure 1. Selected problems in the brainteaser activity.

version of the original ASCI,<sup>22</sup> which has an eight-term questionnaire and two polar adjectives with seven-point scale. The items 1, 2, 3 and 6 were designated for Intellectual Accessibility (IA) subscale, while the items 4, 5, 7, and 8 were designated for the Emotional Satisfaction (ES) subscale. The ASCIv2 questionnaire was previously employed to study the effectiveness of flipped course and evaluated how a particular pedagogy intervention affected students' attitude toward the organic chemistry course.<sup>23</sup> As such, the result of the ASCIv2 in this research will enable the course coordinator to understand the effectiveness of the intervention at firsthand, so that immediate transformation and modification of existing intervention in the chemistry curriculum can be made.

The pre- and post-ACSIv2 questionnaires were administered to both intervention and control groups in the basic organic course, in semester I 2016/2017. The pre-administration of ASCIv2 questionnaire was carried out at week 7 after the mid-term exam, and the post-administration of ASCIv2 questionnaire was carried out at week 14, a week before the final exam. In total, 98 students in the brainteaser-administered basic organic chemistry course and 100 stu-

**Table 1.** Means and standard deviations of pre- and post-test of ASCIv2 in the control and intervention groups

Subscale and item	Pre-test				Post-test			
	Control group (n=100)		Intervention group (n=98)		Control group (n=100)		Intervention group (n=98)	
	M	SD	M	SD	M	SD	M	SD
<i>Intellectual Accessibility (IA)</i>								
1. Easy-hard <sup>a</sup>	3.27	0.81	3.29	1.17	3.33	0.82	4.15	1.47
2. Complicated-simple	3.59	1.26	3.49	1.24	3.31	1.30	3.93	1.41
3. Confusing-clear	3.66	1.46	3.77	1.30	3.56	1.44	3.84	1.42
6. Challenging-not challenging	3.19	1.51	2.58	1.36	3.40	1.48	3.20	1.52
Total	13.71	5.05	13.12	5.06	15.12	5.82	13.60	5.04
<i>Emotional Satisfaction (ES)</i>								
4. Uncomfortable-comfortable <sup>a</sup>	4.15	1.15	3.63	1.04	4.23	1.10	4.50	1.44
5. Satisfying-frustrating <sup>a</sup>	3.45	1.24	3.38	1.09	3.49	1.23	4.82	1.41
7. Pleasant-unpleasant <sup>a</sup>	3.98	1.06	3.70	0.99	4.26	1.01	4.69	1.36
8. Chaotic-organized	4.14	0.98	3.86	0.76	4.28	1.04	4.63	1.48
Total	15.72	4.44	14.57	3.87	16.26	4.37	18.64	5.69

<sup>a</sup>Reversed item

dents in the traditional basic organic chemistry course have filled out the ASCIv2 questionnaires. In order to test for internal reliability of the subscales on ASCIv2, the Cronbach's Alpha values were determined. All the values were above the acceptable value of 0.7 and in agreement with previous literature.<sup>24</sup>

### Analyses

Before proceeding to statistical analysis using SPSS 20.0, items 1, 4, 5 and 7 were recorded in the way that higher scores represented the positive dimensions of students' attitude (Table 1). The gain scores (post-pre) for the IA and ES were calculated before proceeding to statistical analysis as dependent variables. In addition, we also examined whether the pre-scores could affect the gain scores. In the descriptive data, there was no statistical difference between IA pre scores ( $F = 1.209, p = 0.273$ ) and ES pre scores ( $F = 6.031, p = 0.15$ ) for both courses.

## RESULTS

The intention of this activity is to enable students to review on the basic organic chemistry course in a positive learning environment and also to make students attentive during the typical 45-60 minutes lecture. After the implementation of the brainteaser activity, we sought to learn how students feel about chemistry learning experience and to compare the attitude of students in the intervention group to that of the control group.

The mean and standard deviations for each item in IA and ES subscales for the intervention and control groups were shown in Table 1. The results ( $F(2, 195) = 12.850, p$

**Table 2.** Results from MANOVA

Model variables	Wilk's Lamda	Significance	$\eta^2$ value
Overall model	$F_{(2,195)} = 12.850$	0.000	
IA gain	$F_{(1,196)} = 7.743$	0.006	0.038
ES gain	$F_{(1,196)} = 21.392$	0.000	0.098

= 0.000) of one-way MANOVA calculated using SPSS (Table 2) indicated that there was an attitudinal difference existed between the intervention and the control groups. More specifically, the one-way MANOVA indicated that significant differences were observed between both groups, with IA gain ( $F(1, 196) = 7.743, p = 0.006$ ) and ES gain ( $F(1, 196) = 21.392, p = 0.000$ ) in the intervention group. In particular, if the  $p$ -values are less than 0.05, it indicated that the results were statistically significant having a 95% confidence interval. In this study, we also took into account the effect size (eta-squared). The suggested effect size for eta squared can be classified by small (eta-squared = 0.01) to medium (eta-squared = 0.03) and large (eta-squared = 0.14).<sup>25</sup> In the one-way MANOVA, there was a small to medium effect size (based on eta squared) existed for IA (0.038) and ES (0.098). As a result, we can conclude that students in the brainteaser-administered course felt more intellectual accessible and emotionally satisfied compared to the traditional course.

## DISCUSSION

In this study, students' attitudinal changes in both intervention and control group were surveyed with the ASCIv2 questionnaire. Based on our evaluation, the intervention group showed moderate but significant impact on students'

attitude toward the basic organic chemistry course learning. Previous studies showed that the post-test scores strongly correlated with the final exam score.<sup>24</sup> In addition, they also observed a small but statistically significant difference in students' intellectual accessibility and emotional satisfaction. Our result analysis had indicated that a small to medium effect size, suggesting that the result of our study have some practical significance. In our case, the brainteaser-administered class has resulted in an improvement of students' performance in the final examination (average of 68%) when compared to the traditional class (average of 60%). However, these increases may be linked to the intervention of curriculum introduced by educators.<sup>26</sup> As a result, students will be motivated to learn and continue to excel with the introduction of new pedagogies, such as the active learning method.<sup>27</sup>

As hinted in the results, we also sought to understand students' perception on the implemented activity in the basic organic chemistry course by inviting students to write a short comment at the end of this activity. Table 3 summarizes the positive and negative comments provided by the students. Of the positive comments, about 72% of the participants feedback that this activity has provided an entertaining learning environment, while 14% of the participants agreed that this activity was indeed an interesting pedagogy. About 2% of the participants responded that this activity promotes peer learning and 8% of the participants pointed out that this activity has enhanced their intellectual accessibility, leading to the development of fun learning environment and

**Table 3.** Students' comments on the basic organic chemistry course administered with brainteaser activity\*

Category	Example of quotes
Positive aspect	
· Entertaining learning (71)	· <i>This activity is fun. I like it.</i>
· Interesting alternative pedagogy (14)	· <i>Another type of teaching method, quite interesting.</i>
· Peers learning (2)	· <i>Thank you Dr. for this activity. It is such a challenging activity. We can learn a lot from peers around.</i>
· Enhance intellectual accessibility (8)	· <i>This activity is fun and also improve our learning.</i>
Negative aspect	
· Mental dizziness (1)	· <i>At first, I was excited with this activity. Somehow, later I felt a bit dizzy with the sentences presented in front of me.</i>
· Mental agility (2)	· <i>It is very hard for students, especially people like me who need to take some time to guess the tricky sentences posed in the brainteaser.</i>

\*The bracket represents the number of commentaries

**Table 4.** Students' perception on the course instructors in the basic organic chemistry course

Statement <sup>a</sup>	Mean (SD)	
	Intervention (n = 98)	Control (n = 100)
Motivate students to learn in the class	3.6 (0.5)	3.6 (0.5)
Teaching made in the class is clear, easy to understand and confident	3.7 (0.5)	3.7 (0.5)
Lectures plan according to schedule	3.5 (0.6)	3.6 (0.5)
Lectures that encourage students to think	3.6 (0.5)	3.6 (0.6)

<sup>a</sup>Excellent = 4, Good = 3, Moderate = 2, Poor = 1

rich discussion amongst students. Moreover, this activity also enhanced their interest in this subject as evident in their comments. On the contrary, the implementation of this activity has created some negative issues, one of such comments was mental dizziness caused by the jumbled up brainteaser questions. In addition, this activity was challenging to some students, as it requires brain imagery to solve the designated questions.

The 'teacher effect' was also taken into consideration since the traditional course or the so called control group was taught by a different course instructor. Based on the students' mid-term scores, the mean score for intervention group was found to be 2.83 out of 4.00, while the control group is 2.90 out of 4.00. The students' mid-term scores for both classes were also examined using an independent *t*-test. There was no significant statistical difference between the mid-term scores ( $F = 0.695, p = 0.405$ ) for both classes. In addition, students' evaluation on both instructors who were involved in the teaching of this course was also taken into account, whereby 4 items were found to be similar, with no statistical difference (Table 4).

Finally, the average final exam scores recorded by the intervention group was 68.1 (SD = 15.9), while the average final exam score for control group was 60.0 (SD = 11.3). Statistically, there was a significant difference between the final exam scores ( $F = 16.772, p = 0.000$ ) for both groups. As hinted in the above study, the organic chemistry classroom administered with the brainteaser activity made the students felt more emotional and cognitive satisfied. It is evident that by implementing in-class game show activity, students became more motivated to learn as compared to those in the conventional classroom. The positive learning classroom has impacted students' engagement in the subject and thus led to a better performance in the final examination.

## CONCLUSION

The purpose of this activity is to provide a meaningful

learning and teaching method for both lecturers and students, and at the same time to instill students' interest in the subject of organic chemistry. The current activity has resulted in an increased academic performance (average of 68.1) in the intervention group as compared to that of control group (average of 60.0) in the final examination. According to the ASCIv2 survey, students in the intervention group experienced attitudinal enhancement, both emotionally and intellectually, in comparison to the control group. In addition, students also experienced positive learning environment as indicated in the students' comment, thus the activity can serve as a supplemental resource in classroom teaching. However, some limitations were also identified, such as the activity may cause mental dizziness and require mental agility, which may be perceived negatively by students, but if one views the activity positively, it might be an exercise to train students' brain imagery.

In the future, the brainteaser activity can be modified to cater for different courses and subjects. The instruction of this activity is easy to understand and the prior activity preparation is simple. In addition, cost of preparing this activity was low, as the problems were prepared based on chemistry vocabulary or concepts learnt previously in the class by using Microsoft® PowerPoint. In the basic organic chemistry course, students are expected to learn as many chemistry vocabularies and concepts as possible. In this case, the brainteaser is a desirable activity to novice students, so that they can learn in a more entertaining and interactive way with their peers during the basic organic chemistry lecture.

**Acknowledgments.** The authors would like to extend their acknowledgement to students who took part in this activity and also to the Universiti Malaysia Terengganu. The authors would like to thank Dr. Chew Seng Chee for his advice on statistical methods. This work was supported by the Ministry of Education of the Republic of Korea and the National Research Foundation of Korea (NRF-2016S1A5B8913807).

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