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# Employing Flipped classrooms: An instruction embedded with multiple-mode representations to teach elimination reaction mechanism

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***Abstract***

*Flipped classroom embedded with multiple mode of representation were employed to teach organic chemistry at the undergraduate level. As such the purpose of the study is measure the effect of flipped classroom embedded with various mode of representational in understanding elimination reaction mechanism in alcohol. A quasi experimental design was used in this study involving 70 students from two intact classes which have were randomly classified as experimental (N=70) and control (N=70) groups. The outcome of the result demonstrated that students post-test scores are significantly different F(1,137)= 71.57, p<0.05 partial eta squared =0.36 after controlling the pre-test scores. This study implies that chemistry educators should encourage students to use multiple-modes in addressing the difficulties in learning difficult concepts in organic chemistry.*

***Keywords:*** *Flipped classroom, multiple mode representation, organic chemistry*

## 1. Introduction

Organic chemistry has authentically being considered as a very difficult subject to master by all level of students as it is so content-laden and fast paced to address the learning outcomes. (Duis, 2011). In aid of teaching organic chemistry many instructional strategies that have been developed to aid in the teaching of organic chemistry at the undergraduate level (Ainsworth & VanLabeke, 2004). The challengers of effectively teaching this course comes from large amount of content that need to be served in short period (Anderson and Bodner , 2008). To overcome these problems, students tend to memorize the content of organic chemistry without understanding the concepts behind each reaction. Moreover, passive lecture has been critized by many as an ineffective way to help students acquire needed knowledge and skills (Hattic, 2008 and Schwerdt, 2010). Additionally research has demonstated that a student's attention declines after the 10 minutes of class, students remembers about 20% of material presented during the lecture (Karen, 2007). Although lecture has been criticized, it is well documented that this form of directed instruction is necessary to teach students in situations where they hold little or no prior knowledge. Thus knowledge must be constructed and reconstructed and is best done through the use of active learning strategies. One of the instructional approached is the flipped classroom where it strategic design includes Bloom's taxonomy educational objectives which consist of each level of learning.

Assessment and examination are an important aspect of science education to test student's understanding of certain concepts during examinations. Hand *et al*., (2010) claimed that students understanding of chemistry knowledge can be transformed or even created to some extent through nontraditional writing task which includes multiple modes of representation such as graph, equations, diagrams (Clayden, Greeves, Warren, & Wothers, 2001). According to Ainsworth 2006; Nakhleh and Postek 2008, multiple model representation play a vital role in shaping students in constructing deeper understanding of organic chemistry. In short, introducing the students to the material through interactive lecturing is one of the method shown to be much effective in helping students learn (Crouch and Mazur, 2001; Prince, 2004; Lasry et., 2008).

The flipped classroom that is primarily student centered provides an value added technology-enhanced active learning sessions with the flexible learning option added with multiple mode presentation which subsequently reinforce lessons through small learning group, tutor supported and problem-solving exercises (Gunyou, 2015). In the flipped classroom, what is traditionally done in class and as homework are switched or flipped. In other words, the removal of content from the classroom period allows the teacher to discuss actively with students by using variety of teaching tools instead of students listening to a lecture in class and then going home to read material and view videos which can enhance understanding of chemistry concepts (Chtouki, Harroud, Khalidi, & Bennani, 2012). In terms of pedagogy, the flipped classroom has very little published evidence exists about the effectiveness of the flipped classroom in higher education especially in organic chemistry but the has been a lot of indirect research promoting this approach within several allied health care disciplines (Pluta, 2013; Critz 2013; Mclaughlin, 2014, Ferreri, 2013;Pierce, 2012).

**Student understanding of organic chemistry concepts**

The organic chemistry topic of mechanistic problem solving is widely emphasized in the tertiary curriculum in organic chemistry (Cheung, Ma, & Yang 2009; Ozmen, 2008). Furthermore, basically topics in organic chemistry requires students to understand the elimination reaction mechanism reaction which will help to determine the major product involving rules like Sayzeff's Rule and Markoniov rule. For example electrophilic substitution like alkyl halides (Nucleophile substitution 1 and Nucleophile substitution 2), carbonyl compounds (Nucleophile Addition), alkane (free radical substitution reaction) and dehydration of alcohol (elimination) are considered difficult as the learner need to have prior knowledge on functional groups, types of reaction, polarity of the bond, electron deficiency groups, electrophile and nucleophiles. Furthermore the learner need to classify the alkyl halides and eventually determine the product. Teaching organic chemistry using passive lecture format works poorly in a course where students requires complex reasoning skills. Sundberg (2007) argued that to master and apply concepts in reaction mechanism, students must know how the basic kinds of reactions that the organic molecules undergoes. Furthermore the students must understand why theses reaction take place by analysing the reactant molecules to determine the site of high and low electrons density, deciding whether these sites will be basic /nucleophile or acidic/electrophile. According to Shapley (1999) the students must be able to visualise, possesses high level of complex reasoning beside imagination and fundamental knowledge of the facts.

Various literature supports that learning through passive promotes rote memorization among students (Peen & Arshad, 2014; Grove& Bretz2012; Treagust et.al.,2003). Moreover surface or rote learning is characterized by an intention to reproduce the material being studied by using routine procedures. Simple topics must be presented before complex topics which can hinder rote memorization so that the learning can be meaningful (Novak 1988, 2002). As noted by Grove and Bretz (2010) students struggle to develop a thought and coherent understanding of organic chemistry due to several reasons such as lack of meaningful learning which is a constructive process in which the learner strives to formulate links among existing concepts, information, and observations to accomplish understanding. It has been suggested that its difficulty originates from the recognition that organic molecular reactivity is a function of multiple and interacting variables, such as steric and electronic variables (Kraft *et al*., 2010). For instance, students are often confused about how to construct valid Lewis structures and are unable to recognize the implicit information that can be determined about a molecule. Similarly this problem arises due to lack of integration of knowledge between polarities or boiling point, to the explicit information that is shown with Lewis structures (Cooper *et al*., 2010, 2012).

According to Bhattacharyya and Bodner, (2005, 2008), organic reaction mechanisms and the arrow-pushing formalism employed to show electron movement hold no physical meaning for many students when they are performing exercises that require. Childs & Sheehan (2009) argued that concepts to this reactions are abstract and providing multiple modes of representation in the writing task would provide a context for the students to better express their understanding. There have been studies support that multiple role representation offers an alternative pathway to overcome the barrier in understanding organic chemistry learning. The purpose of using flipped classroom as a pedagogical model to address the difference between learners and to present teaching content through modalities that employs asynchronous video lectures, reading assignments, practice problems and other digital, technology based resources outside the classroom but and interactive, grouped based, problem solving activities in the classroom which includes writing, drawing graphs, discussion among peers inside the classroom (Hawks 2014). Using multimedia plays an important role in enhancing the visualization (Eysink & de Jong, 2011)(Mayer & Moreno, 2003).Additionally students can use various mode to explain the concept of elimination reaction mechanism with will indirectly improve students understanding as they write and create their own understanding (Schler, Scheiter, & van Genuchten, 2011) . As organic chemistry contains a rich and diverse collection of diagrammatic representational systems, it is important facet for the students to understand the symbolic meaning of the inscriptions (Chandasekaran *et al*., (1995); Kozma and Russell, 1997; Stieff, 2007).

**Flipped classroom embedded with Multiple Modes of Representation**

According to Sam *et al*., (2014) the use of a flipped, or inverted, classroom model, is a pedagogical approach characterized by reversing the traditional role or expectation of teachers giving lectures in classroom and students doing homework at home and allowing students to watch online video lectures before class and to participate in interactive activities such as problem solving, discussions, and debates during the in class sessions. This approached has indicated improved student-teacher interactions, opportunity for real time feedback and increased in student's engagement through the use of technology. Traditional classroom lectures often follow a one pace fits all philosophy. By reverting the traditional classroom into flipped classroom, student are given flexibility with collaborative learning trends and at the same time exposing the learner to being independent (Halili, Razak, & Zainuddin, 2014 ; Shibley & Zimmaro, 2002). Moreover teachers may adjust their lectures based on student feedback during the class hour based on the learning where some students will undoubtedly find the pace swift, while others find it slow. Video lectures provided through the flipped classroom model allow students to fast forward through examples they already understand, or pause and rewind to revisit topics which may require more processing time (Goodwin & Miller, 2013). Videos allow lectures to be broken into pieces, as opposed to traditional instruction which often contains a large volume of content delivered at one time (Brecht & Ogilby, 2008).

The flipped classroom provides students an opportunities to identify knowledge gaps needing clarification in an advanced time. During the in class time, teacher interact with students by clarifying points of confusion, giving more individual guidance, challenging students to thinking deeply about complex processes, and monitoring peer to peer, team based learning activities. Chemistry studies basically involve three types of chemical representations: macro, sub-micro and symbolic (Johnstone, 1993). Research consistently shows that the students encountered difficulties in understanding and interpreting these representations (especially sub-micro) and interpreting between the three types of representation so as to build their own representation (Johnstone, 1993; Treagust, *et al*. 2003; Chittleborough & Treagust, 2007; Gkitzia, *et al*. 2011). To help students understand chemistry at the three levels, researchers have suggested a variety of instructional approaches, such as adapting teaching strategies based on using technologies as learning tools (Barnea & Dori, 1996; Kozma, Russell, Jones, Marx, & Davis, 1996). For example, viewing dynamic and three-dimensional animations created by technological tools could help students learn to use microscopic and symbolic representations to describe and explain a chemical process (Williamson & Abraham, 1995). Therefore the teacher must design ''representational systems that mediate between something they cannot see and something they can'' (Kozma *et al*. 2000). As science of the 21st century becomes more complex and less available to direct perception and interaction, the challenge will be to help students move beyond their dependence on surface help to develop both their representational skills and their understanding of these increasingly complex scientific phenomena. In doing so, science educators must find new symbol systems and symbolic expressions that allow students to make connections between the things that they can see and manipulate and the underlying invisible science.

**Theoretical Framework**

Constructivism is a learning theory describing learning as an active process, where learners are involved by constructing knowledge based on their prior knowledge. This theory indicates that knowledge cannot be transmitted from one another (Pape, 2012). Thus, knowledge must be constructed or reconstructed by individuals by trying to make sense of new information based on the known information. This study conducted based on constructivism and cognitive theory model in which student engage is best done through the use of problem based learning such as flipped classroom. Constructivism is considered the source for the theories problem-based learning (Grabinger and Dunlap, 1995). Constructivism which will describe the usage of multiple modes of representation in writing task, where students construct their own understanding and knowledge to the world through their prior experience. When multiple modes of representation is used students tend to create their own mental models they have to create, generate the idea of elimination process and link all the different modes correctly. Flipped classroom embedded with multiple mode representation where one tool consists of three component of flipped class; before class, during class and after class. Each component encourages demonstration of all levels of Bloom's Taxonomy for example, the work students engage in before the face to face class focused more on the lower levels of Bloom's taxonomy(remember, understand) whereas the face to face portion of the flipped class allowed for higher level learning such as application, analysis and synthesis. The final component, the after class continued to build on these higher levels of learning through formative or summative assessment.

For the flipped design, online modules included mini-lectures (between 10 and 15 minutes), video obtained from sources such as Khan Academy, writing task worksheet. The Khan Academy videos are used as audiovisual and online mode, gives students a pathway or encourages students to use multiple modes of representation using cognitive theory model (Moreno & Mayesr,2002). Meaningful learning will take place where initially learners will select what is relevant from presented material. The purpose of multimedia is to provide multiple communication channel to address the difference between learners and to present teaching content through optimum modalities which includes text, narration, graphics, illustration, charts. Flipped classroom embedded with multiple model representation help learners to construct their own understanding and knowledge based on the previous experiences linked problem solving and cooperative learning (Bergmann & Sams, 2014).

**Research question**

What is the effect of flipped classroom embedded with multiple mode of representation in changing students understanding about elimination reaction mechanism of alcohol?

**Hypothesis**

$H_o$ : There is no significant difference between the control group and experimental groups in terms of understanding of elimination reaction mechanism of alcohol in post test means after controlling the pre test scores.

## Method

In this study, quasi-experimental design involving two groups namely an experimental group and a control group were employed. The sample of this study consisted of 140 matriculation students from two intact classes who were enrolled in a chemistry course. For the purpose of this study the sample was divided into two groups. The control group and the treatment group each consisted of 70 students. The duration of the matriculation programme is 11 months. The chemistry course is inclusive of chemistry I and II; chemistry I is offered in semester one and covers physical chemistry, while chemistry II is offered during the second semester and the course content focuses on organic chemistry.

In this study the intervention was flipped classroom embedded with multiple mode of representation with experimental group (N=70) whereas the control group undergo traditional lecturing method. The control group, the lecture was delivered using power point lectures and the students were assigned the same assignments to work on outside of the class. During the traditional class, students received the instruction during the class, and most written task will be at home. For the experimental group, each class session students will be provided with learning outcome at least 7 days in advance of class time. The next step involved preparation for the power point lectures and the corresponding notes. Each section began with a statement of the learning outcome, followed by presentation of concepts. The students were provided with guided notes that outline the video lectures together with assessment task. The lecturer upload the material for the assigned group. Students need to log in into the portal of Penang Matriculation College, watched the video, take notes from the video and complete the assignment before attending the face to face lesson with the lecturer. The video uploaded into the learning system (portal) which was adapted from Khan Academy technology on dehydration of alcohol on elimination reaction mechanism using Sayzeff's rule. In class the first 5 minutes were used to revising to reviewing the content of the homework video and discussion of questions. Video shows students the step by step the process of dehydration (protonation of hydronium ion, formation of carbocation , deprotonating of hydronium ion). This helps students to visualise the whole mechanism vividly and gasp the knowledge as the students are doing it again. The reminding time , 40-45 minutes will be spend engaging in problems or variety of activates given during the class using multiple mode representation such as writing, chemical equation, graphic , equation to represent their answer.

Twelve hours of lesson was conducted and the study carried out for two weeks. Each lesson conducted for an hour. Both group answers pre test before intervention and post test questions after intervention. Then, subjective questions are given to the students to analyse their understanding of elimination of alcohol and determine the major and minor product using Sayzeff rule. Students need to identify the alcohols given whether primary, secondary or tertiary and further determine the correct mechanism to yield the maximum product according to Sayzeff's rule and stability of carbocation. The student's answers will be marked based on the rubric generated by the researcher.

**Table 1** The quasi-experimental design

| Group | Pre-test | Treatment | Post test |
|---|---|---|---|
| Experimental | $O_1$ | $X_1$ | $O_2$ |
| Control | $O_3$ | $X_2$ | $O_4$ |

$X_1$ intervention with flipped classroom with multiply modes or representation
$X_2$ intervention with tradition teaching with multiple modes of representation

## Results and discussion

Data collected in this study will be analysed using SPSS with the level of significant 0.05 (p>0.05). The descriptive statistics for writing task the mechanism of elimination is evaluated and marks are given accordingly using a rubric validated by two senior lecturers. Table 2 includes the outcome of the descriptive analysis. The result indicate that both the groups have shown some improvement after the treatment. The experimental group exhibited increases in the mean value in the post test ( $M_{exp}$ = 49.984; $SD_{exp}$ = 0.322) compared to the pre-test mean value ($M_{exp}$ = 47.884; $SD_{exp}$ = 0.521). Similarly an increase in mean value also noticed in the mean value of the post test ($M_{con}$ 48.321; $SD_{con}$ = 0.385) compared to the pre test ($M_{con}$ 48.321; $SD_{con}$ = 0.385) among the control group students. Increase in the mean values shows that after treatment students exhibited higher understanding of mechanism elimination of alcohol using flipped classroom embedded with multiple mode representation.

**Table 2** Descriptive statistic

| Group | | Mean | Std Deviation | N |
|---|---|---|---|---|
| Control Group | Pre-test | 47.520 | 0.496 | 70 |
| | Post- test | 48.321 | 0.385 | |
| Experimental Group | Pre-test | 47.884 | 0.521 | 70 |
| | Post-test | 49.894 | 0.322 | |

One way analysis of covariance (ANCOVA) was conducted to find out the effect of flipped classroom embedded with multiple mode representation in understanding mechanism in elimination of alcohol. As shown in the table 3, there is significant main effect for the group (F(1,137)= 71.57, p<0.05 partial eta squared =0.36). These result shows that the changes in the post test probably could be due to the intervention received by the students. A partial eta squared =0.33 indicate that 36.0%

of the total variance in the post test scores were due to treatment with flipped classroom embedded with multiple mode representation. According to Cohen (1988) the eta squared vale of 36% indicate a relatively large effect of the treatment on the post results. Therefore statistically significant difference in performance existed between the each group that signifies the advantage of flipped classroom embedded with multiple mode representative in improving students understanding of mechanism in elimination of alcohol.

**Table 3** Analysis of Co-Variance for Mean Understanding Mechanism

| Source | Df | MS | F | p | Partial Etha Square |
|---|---|---|---|---|---|
| Pre-Test | 1 | 0.079 | 0.304 | 0.00 | 0.02 |
| Group | 1 | 18.63 | 71.57 | 0.00 | 0.343 |
| Error | 137 | 0.26 | | | |
| Total | 140 | | | | |

## Conclusion

In total 140 students participated in this study were assigned into control group and experimental group. For the students in the control group, elimination of alcohol was taught using conventional method and for the experimental group flipped classroom embedded with multiple mode of representation was employed to teach in this study. ANCOVA was performed to weight the effect of the instruction on the student's understanding of the elimination reaction of alcohol. Results and findings indicated students were more engaged, more involved in the flipped model of instruction when compared to the traditional delivery approach. Students in the flipped classroom experienced quality instruction that was student-centred and student-focused. The flipped classroom allowed for the improvement of class time, where multiple mode of representation strategies, including hands-on activities, writing task can be fully utilised. During the traditional classroom experience, students received direct instruction during class and application occurs at home. Bergmann and Sams *et al*., (2014) believed that the ability for students to review these recorded lectures allowed for greater information retention in comparison to lecture which heavily rely on memory and personal notes.

The positive outcome not only portray that the students become more independent learners, but also studies has also shown that students were more enthusiastic and highly motivated when video visual were used (Clark, 2004). For future purposes, research on the flipped classroom should employ controlled studies that objectively examine student performance throughout a semester. Even though the flipped model embedded with multiple mode of representation is a relatively new instructional approach, it certainly has the potential to be deemed effective in terms of improving student engagement and performance in the matriculation chemistry classroom.

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