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College Students' Reflection on the Uncritical Inference Test Activity in Organic Chemistry Course

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ABSTRACT. Effective teaching and learning is a continuous process of monitoring and re-organization of teaching method, so to benefit both students and educators. Reflective journal writing is an effective method for students to reflect on their learning experience about a new concept or subject taught and at the same time enables educators to improve on their academic skills. In the present paper, we have examined and evaluated the effectiveness of the Uncritical Inference Test (UIT) that was conducted in our basic organic chemistry course through a systematic network built based on students' reflective writing. From the data analysis, the UIT has benefited students in three dimensions, namely cognitive, affective and group learning domains. Moreover, the UIT activity instilled an active learning environment in organic chemistry classroom and deeper learning among chemistry students as shown in the collected data. In future, this activity could be adapted as a teaching method to enhance students' critical thinking skills and question-asking capability in other teaching courses.

Key words: Teaching and learning, Reflection, Reflective writing, Uncritical inference test, Systemic network

INTRODUCTION

Effective teaching and learning is pivotal to inspire students to develop keen interest in the subject taught, and at the same time students reciprocate by exhibiting learning experiences that are of a rich source of information to enable educators to improve further on the current teaching method.[1-5] It is like two sides of the same coin: to create a positive classroom environment, educators have to come up with many creative teaching activities, such as the incorporation of jokes in classroom session,[6] Think-Pair-Share,[7] haiku assignments,[8] Questioning Purposefully[9] and so on. When educators make the initiative to improvise on their teaching styles and in combination with a positive classroom environment, students display interest in learning and thus motivate them to excel further.[10]

Effective teaching and learning is not limited to curriculum content re-organization, but it relies on continuous review on the implemented teaching method and organizing the content so that to meet the students' needs. Students' learning is directly linked to the teaching method of their educators.[11] Lipton and Wellman remarked that "we do not learn to teach but we learn from our teaching" as an effective form of teaching and learning.[12] Consequently, teaching and learning from the understanding of student learning experience is imperative to uncover how students come to learn a new concept, while this meaningful information serves to further improve on the educators' academic skills.[13,14] Reflection is indispensable from the learning process. With a large scope of syllabus to cover in some of the subjects taught at universities, educators fail to inform students to reflect on the knowledge that is learnt in the classroom.[15] Students often complained that they tend to forget what they have learnt in classes after a few days. This is due to the fact that students' retention of knowledge decline to 3 % after three weeks without regular revision on lecture notes.[16,17] Therefore, reflection is particularly important in the learning process.

Reflection is a process where thinking and learning takes place simultaneously, where students learn by responding to new information, experience, situations or events.[18-20] Reflection enables learners to connect to their beliefs, thoughts and feelings when engaged in the learning activity.[21] According to Crowe and Youga (1986), reflective writing generates valuable knowledge to every new experiences. It enables learning by integrating new knowledge into learners, thus learners are able to bridge what is known and what is new.[22] Learners benefited by becoming more analytical and critical in learning upon the accomplishment of reflective writing.[23-25] In addition, reflective writing enables the retention

of new knowledge and without reflection, new learning experiences may diminished with time.[26] The benefits of the reflective writing are well demonstrated in the learning of chemistry subjects, especially in the practical sessions where students find inquiry-based instruction together with reflective writing in the Science Writing Heuristic (SWH) approach helped them to appreciate the art of experiments, and at the same time helped students to be more aware and critical in their experimental study.[27] On top of these benefits, reflective writing also functioned as an assessment tool to track student learning progress in a non-examination setting.[28,29]

In this paper, we would like to explore the qualitative data of students who have participated in the Uncritical Inference Test (UIT)[30] that was implemented in our organic chemistry course. The UIT activity comprises of a set of story and statements, and students were asked to decide whether the statements were true, false and not sure based on the story. In the previous UIT activity, students were directed to three sets of stories based on their knowledge in basic organic chemistry and students were asked to resolved the statements individually first and then proceeded to group discussion. Traditionally, organic chemistry is known as a challenging subject and students tend to fail to comprehend the fundamental concepts in the organic chemistry lectures.[31-33] In our previous paper focusing on quantitative data,[30] the result showed that students overall had benefited in their learning through group discussion, positive study environment and enhance problem solving skill designated for the UIT activity. However, the qualitative data to understand and monitor students learning process has yet to be collected such as how students analyze and react to questions and how they construct solutions through the integration of existing and new knowledge.[34] To get deeper insights on the understanding of concepts and learning process during the UIT activity, students' reflective journals were collected. Through reflective writing, we, as educators, can learn from students' impressions and experiences about the implemented activity during their organic chemistry course, as well as to assess the effectiveness of this activity as an effective form of teaching and learning.

METHODOLOGY

In the 2014/15 university session, the UIT activity was conducted for the second consecutive time on first-year chemistry students majoring in the environmental analytical chemistry program. The subjects of the study comprised of all 51 students who undertook the organic chemistry course (KIM 3200). Participated students have given their feedbacks in the form of reflective writing anonymously 30 minutes after the UIT activity was carried out in the lecture. In total, all 51 students handed their reflective writing, however only 30 feedbacks were taken into account after filtering, judging by the inability of some students to express or write a proper reflective journal. To analyze students' reflective journals qualitatively, the authors employed a systemic network approach which is appropriate for categorizing qualitative data.[35] All journals were carefully reviewed and categorized. After getting consent on the categorization and notation by all the authors, final network notation was confirmed.

RESULTS AND DISCUSSION

Overview of the Systemic Network

Based on the students' feedback on the UIT activity, a systemic network (*Figure* 1) was built in attempt to associate students' learning experience towards the activity, and simultaneously to disclose and understand their learning outcome as reflected in the students' written assignment.

From the data analysis, the UIT has benefited the students in terms of cognitive learning, affective learning, and group learning. The cognitive learning dimension, which was based on the cognitive domain of the Bloom's taxonomy,[36] can be known as a complex set of conceptual understanding formed as a result of students trying to recall and understand previous knowledge to solve particular problems. Analytical skills can also be used for problem solving and thinking skills were brought up as a result of solving problems. On the affective learning dimension, there were several apparent benefits, such as enhancing learning motivation, concentration, and participation. Fun was also a benefit of the UIT activity as joy-filled classroom environment is pivotal to learning.[30] Finally, in the group learning dimension, students commented that the UIT activity aided their learning through group participation, improving students' social skill and peers' motivation in group learning that led to the positive interdependence in the UIT activity.

Cognitive Learning Dimension

One of the main categories of students' feedback on the benefits of UIT activity was related to conceptual understanding. To solve the problem of a given task in the UIT, students have to first have a strong understanding of the organic chemistry concepts so that they can recall prior

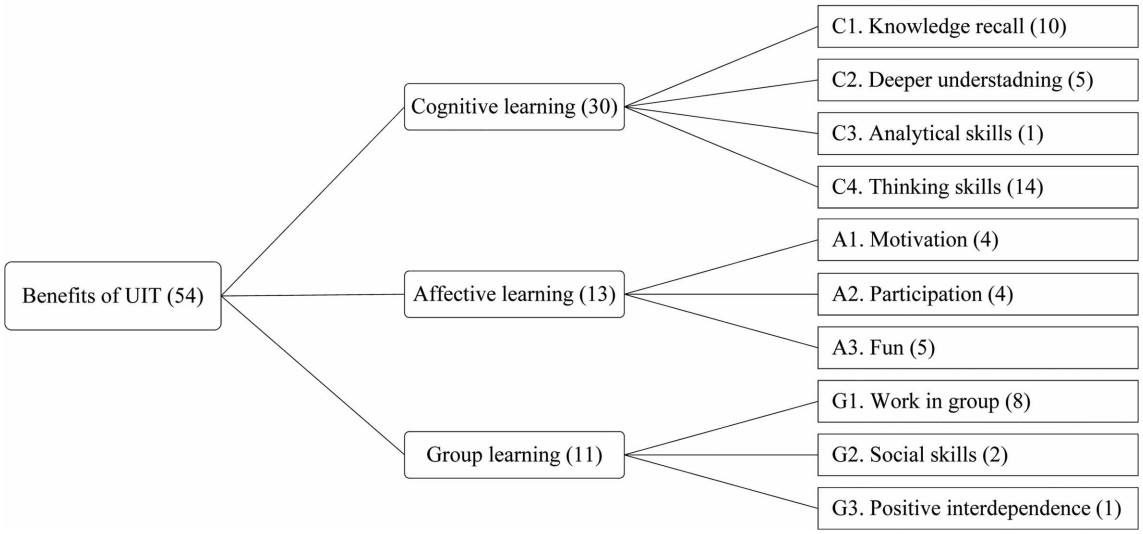

***Figure* 1.** The network diagram of students' feedback on the UIT activity. The bracket represents number of commentaries.

knowledge and select the theories learnt in organic chemistry for problem solving. Ten students indicated that they have benefited by recalling on previous knowledge and some of these theories were the Markonikov' rule, specific definition, isomerism, elimination reaction, Zaitsev rule, physical properties of isomers and degree of unsaturation and so on, as written in their reflective journals.

On top of that, five students successfully achieved beyond knowledge regurgitation, and led to deeper understanding and the application of knowledge in problem solving. For example, Student 15 elucidated the Kolbe-Schmitt reaction by applying the concept of nucleophiles and electrophiles in mechanism elucidation, though only information on the starting materials in the Kolbe Schmitt reaction was provided on the white board.

The Kolbe reaction is a carbonylation reaction which converts a phenol to hydroxy benzoic acid. The nucleophile is the phenol and the electrophile is the carbon dioxide. [Student 15]

Similarly student 14 recalled how to direct a position in benzene and thus managed to apply and worked out the Kolbe-Schmitt reaction that yielded two products, namely the *ortho-* and *para-* hydroxy benzoic acids.

I have learnt that the phenol group is ortho- and para-directing group. The carbon dioxide will add on to the ortho- and para- position of the phenol. [Student 14]

Another interesting observation was one of the respondents reflected the quality of analytical skill, in which the respondent managed to identify and analyzed all the given information, and produce new comprehensive idea or solution. For example, Student 13 identified energy difference between *E-* isomer and *Z-* isomer, and also considered steric hindrance of each case. Finally, he/she applied all the information to this situation and obtained the final answer.

In theory, the E isomer is lower in energy compared to Z-isomer. The larger bulky groups prefer to be located "trans" to each other while the smaller groups prefer to be located "cis" to each other in the Z-isomer. However, in this case only Z-isomer is obtained as E-isomer would require a syn-perilanar elimination. [Student 13]

In the reflective journal assignment, students were more affirmed of their study and able to give justification on the reasoning of their chosen answer. This could be observed in a student's feedback who responded that the underlying condition to obtain a newly double bond alkene was through the elimination of alkyl halides.

The condition required for elimination reaction is a base and alkyl halides. This is because the base will deprotonate the proton next to the leaving group in order to form a carbon-carbon double bond in the newly alkenes. [Student 11]

Another reflective journal demonstrated that student was able to justify and give reasoning to compare the acidity

of salicylic acid and acetylsalicylic acid by distinguishing between mono- and polyprotic acid.

Acetylsalicylic acid is a weaker acid compared to salicylic acid. This is because acetylsalicyclic acid is a monoprotic organic acid with only one proton whereas salicyclic acid has two protons which is a diprotic acid. [Student 16]

About half of the feedbacks addressed on the improved thinking skills, which were reported by fourteen students. Some students described that the UIT helped them to develop thinking skills such as critical thinking and self-regulation on their learning. For example, Students 7 commented that the UIT deepened reasoning during group problem solving, and also correlated the benefit of the UIT with job preparation.

I have significantly developed my skills in deeper thinking, my independent problem solving skill and enhanced my ability in making decision. These skills are important to me as a learner because they can help me to become a good student and employee in the future. [Student 7]

Student 29 pointed out that the UIT activities helped them to realize new or previously known concepts and knowledge, which is generally called self-regulation, one of the meta-cognitive skills essential in the strategy of learning.

Group activities are good because we then know our limitation and what we know and don't know in this subject. [Student 29]

In one of the reflective journals, the student has expressed that the UIT activity has indeed stimulated one's mind and deeper understanding for the questions asked.

I like this kind of learning because it opens up my mind to think clearly and understand for each questions. [Student 30].

In regards to self-empowerment in learning, students realized their weaknesses and lack of fundamental knowledge in organic chemistry after participating in the UIT activity. As a result, students are determined to study deeper for this course and becoming more independent in their study.

This is a fun activity. Now I realized I have many weakness in organic chemistry. I should try harder on this subject. [Student 24]

On the individual level, the UIT activity has also promoted higher order learning amongst students. Five students' reflective journals stated that responses and problem solving skill picked up from peers have reformulated their understanding towards study and led them to higher order of learning. For example, Student 2 commented that group discussion with the UIT required high level of thinking skill.

This test unlike other tests and is one of the most efficient method because it included all the aspect of thinking that suits a chemistry student. The choices of answer given which are true, false and not sure are actually simple and short answer but required high level of thinking skill and some discussion in solving the problem. [Student 2]

In addition, one will be trained more creative in thinking as commented by Student 6 "…I now realized that this activity gave me inspiration and made me think creatively." Three students including Student 7 above have also acknowledged that the UIT activity served as a trail to train them in decision making and develop independent thinking skills which are pre-requisite soft-skills prior to joining the workforce or dealing with problems in daily life. The incorporation of reasoning in science and mathematics education has been one of the long line interests researched by educators.[37,38]

Based on the students' reflective writing, it was clear that cooperative approach in the UIT activity had led to deeper learning and understanding in the subject taught. According to Rhem, the cooperative approach of learning reinforces deeper learning.[39] Theories in science and mathematics are not merely superficial knowledge, it is with the hope that by having more cooperative learning, students are able to connect and relate knowledge with problems. By presenting new problems to students, they felt being challenged with their current knowledge to solve the problems and thus striving for higher order of cognitive thinking.

Affective Learning Dimension

On affective learning dimension, students benefited from the UIT activity in several learning outcomes, including feeling motivated and improved concentration on the course. They also felt the sense of involvement in the classroom activities and hence experienced fun in the organic chemistry course.

Based on the students' comments, it was noteworthy that students' learning process is directly linked to an educator's initiative and effort in course preparation prior to class. For example, it was observed that the change of traditional pedagogy to the UIT activity has enhanced leaners'

motivation in organic chemistry course learning. Student 1 responded that s/he paid more attention in lesson and actively participated in class when this activity was implemented during the lecture. Stimulating students' motivation by the UIT activity was also found from the feedback of Student 3.

At first, I thought that active learning activity is a waste of time but now I realized that this activity grabbed my attention and concentration in my studies. It prevents us from feeling bored in class. [Student 1]

I think this kind of learning style will make me want to learn more about organic chemistry. [Student 3]

There were also students who experienced joy-filled learning during the problem solving session in the UIT activity like Student 5 below.

Since my lecturer started to do the UIT, my interest and focus is more towards the lecture time. The reason is when my lecturer does this activity, most of the students can have chances to take part in the learning process. As an example when my lecturer does the quick activity, students will listen carefully for each instruction given by lecturer and we need to think critically to get the right answer. [Student 5]

All these learning outcomes contributed by the UIT activity towards the affective dimension of learning in organic chemistry had promoted students' active learning, where they transform from being a passive learner to actively participate in the learning process and at the same time have the opportunity to explore their own values and attitudes.[40] Just as shown in the comment by Student 28, the UIT activity and its cooperative learning environment made students participate actively in group work and also enjoy these processes.

I like to participate in this type of activity because we can communicate with other group members and try to solve the problems together. Besides, it is fun to students while doing this activity. [Student 28]

Undoubtedly, all the positive impacts discussed above were in agreement to a previous study, which states that active learning creates students' interest in learning, affects one's cognitive, sensorimotor and affective domain of learning.[41]

Group Learning Dimension

The contribution of the UIT activity in terms of group learning dimension towards the learning of organic chemistry was also examined. It was interesting to note that, in group problem solving session, students showed keen interest to learn more in the subject taught if they were allowed to perform problem solving in a cooperative way of learning as captured from eight students' reflective journals.

Eight students mentioned the UIT activity helped them work in groups. In groups, students could voice out one's opinion freely (Student 4), have chances to take part in the learning process (Student 5), discuss ideas together in the groups (Student 9), and learn together with friends to choose the correct answer (Student 25).

It can help students to reflect back and discuss the reasonings together in the groups. It is much easier and fun as we can discuss together and find the answers together. [Student 9]

In order to be a successful group, positive interdependence among members which is one of five components of cooperative learning is essential. One of the reflective journals captured has added that peers' motivation in the group study has aided other students to build up their confidence and continuously progress towards their goal of learning; where an active learner supported a passive group member which exemplifies the quality of positive interdependence in group dimensional learning. Feedback by Student 8 shows positive interdependence within groups.

I learnt that a passive student can learn from an active student that has good communication skill. The passive students will be brave to give their opinions towards their inference. Active students will help out if there were any students who do not understand the questions of the short story in the case studies. They will use all their knowledge that they learnt to help me. [Student 8]

Two reflective journals obtained from students commented that the group learning promoted social skills. It helped practice to talk in front of their friends (Student 4), and enhanced students' communication skills (Student 7). The journal of Student 4 showed that the UIT activity helped students' free discussion and enhancing social skills and critical thinking.

From this activity, students voiced out their opinions freely about the topic, and practice to talk in front of their

friends. Students will also develop critical thinking and problem-solving skills. [Student 4]

On the whole, the learning outcomes on the perspective of group learning dimension showed that the UIT activity is inextricably bound to the fundamental of cooperative learning, which is to listen, to talk, to link the knowledge content and applied what they had learnt in problem solving.[42]

Limitation of the UIT activity

There were no specific guidelines or sample of reflective journals provided to students, as a result, not all the students were capable of reflecting deeply on the UIT activity. About 40% students merely regurgitate the advantages of the UIT activity, provided a brief summary on the activity done and finally gave their suggestions to improve further on the UIT instead of focusing on the outcome of the learning process gained from the UIT. Some of their comments were shown as follows:

In my opinion, this method is better compared to traditional method of teaching.

This activity should be combined with traditional way of learning.

Students should be given more related exercises such as the one in the case study three to make sure they really understand the mechanism involved in a particular synthesis.

CONCLUSION

The UIT activity, as reflected in the students' reflective journals, had shed lights to benefit these three cognitive learning, namely conceptual understanding, affective learning and group learning dimensions. Based on the students' reflection after participating in the UIT activity, a higher level of cognitive thinking was achieved, such as the students were able to provide justifications and analyze the problems with application of knowledge. It also facilitated in the recall of previous knowledge, self-empowerment in learning and higher order learning, which are the qualities of active learning in higher educational study. On affective learning dimension, the UIT activities enhanced leaners' motivation, concentration, participation and impart fun in the subject taught. On group learning dimension, the UIT has created positive interdependence of learning and enhanced social dimensional learning during group processing of problems. Lastly, the cooperative learning triggered deeper learning as reflected by students' reflective writing.

One of the key elements to enhance students' learning is through the introduction of an active learning environment. In the present paper, we noticed that the change of pedagogy in classroom teaching has motivated the leaners' conceptual understanding that would lead to the enhancement of critical thinking and problem solving skill. The main purpose of this study is to introduce this activity as a complementary tool for teaching, and also to understand deeper on the learning outcomes gained by learners and its effectiveness after the implementation of this activity. In the future, the authors would like to expand the scope of the UIT activity to other subjects so that the benefits of the UIT activity are not limited to the subject of chemistry and also to check on its effectiveness and further improve on the UIT activity.

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