

# The Roles of Teacher and Students via Blended Problem-Based Learning: Improving Students' Mastery of Three Representation Levels of Chemistry

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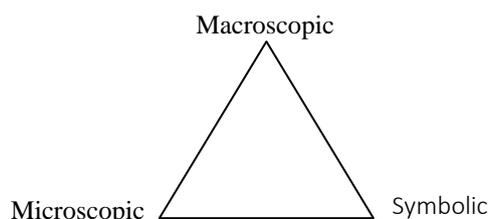
## Abstract

The current practice in teaching Chemistry subject is found to be teacher-centered where teachers engage actively in transmitting knowledge while students act as passive recipients of knowledge. This might affect students' mastery in learning three representation levels of Chemistry (macroscopic, microscopic and symbolic). As a result, students tend to form a non-scientific understanding and develop an alternative concept. The shift to Blended Problem-based Learning (BPBL) is therefore potential to help overcome this problem. Thus, this study is aimed at investigating the roles of teacher and students in overcoming the formation of alternative concepts for three representation levels of Chemistry in BPBL. This study applies a case study research design. Two teachers and 20 students from two different Fully Residential Schools are selected using purposive sampling technique. Data are collected through observations and students' documents, and analysed thematically. Overall, the findings of this study shows that teacher acts as mediator in giving immediate feedbacks and corrections on students' alternative concept while students act as evaluator in analyzing and evaluating other group's answers. As a conclusion, the implementation of BPBL is found beneficial to overcome the formation of alternative concept and thus helps to improve students' mastery of three representation levels of Chemistry.

**Keywords:** Three representation levels of Chemistry, Alternative concept, Blended Problem-based Learning

## INTRODUCTION

Poor mastery of three representation levels of Chemistry has resulted in poor achievement in this subject. Macroscopic, microscopic and symbolic are related to one another (refer Figure 1) and failure to understand this complex relationship will lead to confusion and misunderstanding [1,2]. The macroscopic representation level refers to the phenomenon that can be touched, viewed and smelt, such as seeing the colour changes as the result of chemical reaction [3,4]. The microscopic representation level is related to atomic matter theory, which is in relation to atoms, molecules and ions [5,6]. The symbolic representation level includes chemical equations and formulas representing microscopic representations [7,5].



**Figure 1:** Three Representation Level of Chemistry

Studies on this issue have discovered that the lack of understanding of this concept is rooted from poor ability of students in connecting these three representation levels [8, 9, 10]. As a result, students tend to form an alternative concept [6], which is misleading. Students tend to rely on this concept that is part of their existing knowledge, and thus limiting their ability to master the correct concepts [11, 12]. As viewed by [13] in his Cognitivist Theory, a new knowledge can only be constructed from the existing knowledge. Therefore, it is pivotal to ensure students acquire a correct understanding as the foundation to develop their new knowledge.

In addition, providing students with opportunities to share their existing knowledge with each other in discussing a particular problem [14], such as in Problem-Based Learning (PBL) is very beneficial [15, 16, 17]. This is because, collaborative learning in PBL allows students to solve problems efficiently [18], and is proven to be beneficial in correcting students' alternative concept [19, 20].

Unfortunately, these scenarios do not occur in the current teaching and learning in schools where students are mostly acting in a passive manner; depending on the teacher's instruction and guidance [21, 20] including high achiever students in fully residential schools (*Sekolah Berasrama Penuh*) [21, 20]. Hence, there is a need to transform a teacher-centered teaching approach to PBL. This is because, PBL is highly potential to help address the issue of alternative concept formation among students in learning three representation level of Chemistry [19, 22].

Besides, in line with the 21st century learning, technology integration through a combination of face-to-face and online learning modes known as the Blended PBL (BPBL) approach, is potential to enhance the existing PBL learning process [23, 24]. This is because the combination of face-to-face and online learning mode helps to strengthen the benefits of existing PBL and at the same time overcome the weaknesses in both learning modes [23, 25, 26].

Realizing its potential in overcoming the above issue, it is worth to further investigate roles of teacher and students in a students-centred learning of BPBL. The findings are pivotal to further highlight BPBL strengths in developing mastery of the three representation levels of Chemistry concept.

## **RESEARCH OBJECTIVE AND QUESTION**

The current study aims to investigate the roles of teacher and students in overcoming alternative concept formation in three representation levels of Chemistry via BPBL. Hence, the research question is: What and how are the roles of teachers and students in overcoming the formation of alternative concept of three representation level of Chemistry concept via Blended Problem-Based Learning?

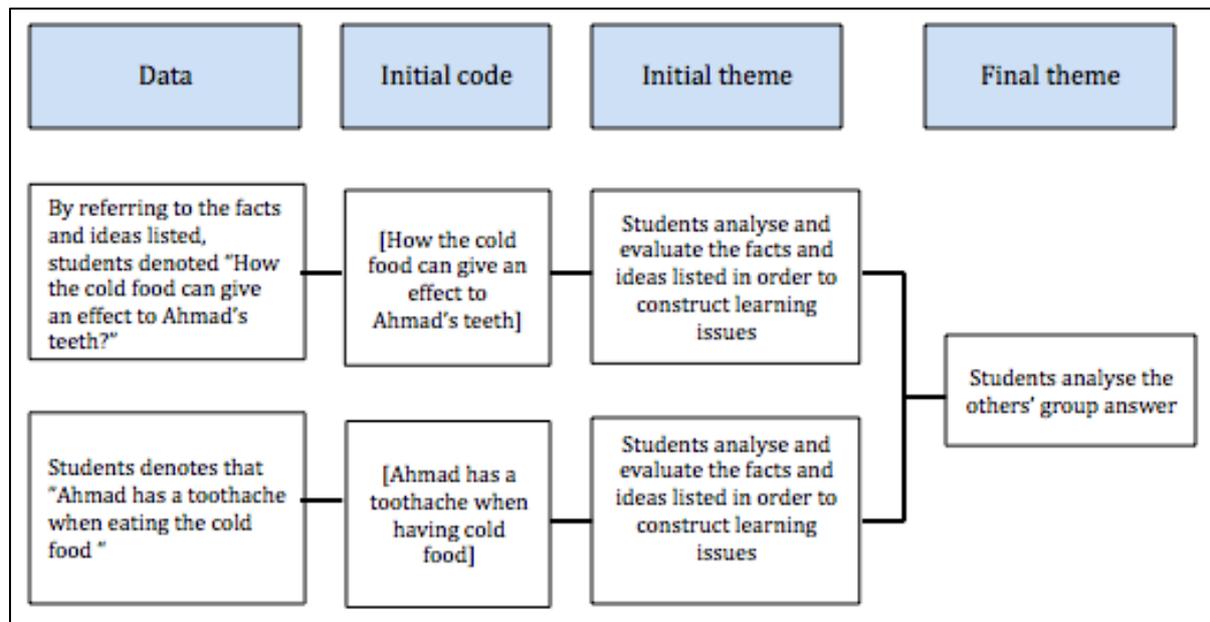
## **METHODOLOGY**

This study applied a case study research design as proposed by [27]. He further elaborated that this design is relevant to further explore and understand a unique case related to an issue. Relevant to the aim of the current study, the selected schools are unique as it implements BPBL compared to other fully residential schools that practice teacher-centred classroom. The selection of these schools is aligned with the aim of the Ministry of Education of Malaysia to upgrade fully residential schools as the bench mark and example to all schools in Malaysia [28].

For this study, two teachers and 20 students from two fully residential schools were selected using purposive random sampling technique. This sampling technique is selected as the initial selected schools have met the criteria for this study, which: i) are relevant to be a model school for

excellence, and ii) have Form Four students who study Chemistry subject. Next, a random draw technique as suggested by Chua (2010) has been utilized to pick two schools from 69 possible schools that have met the criteria.

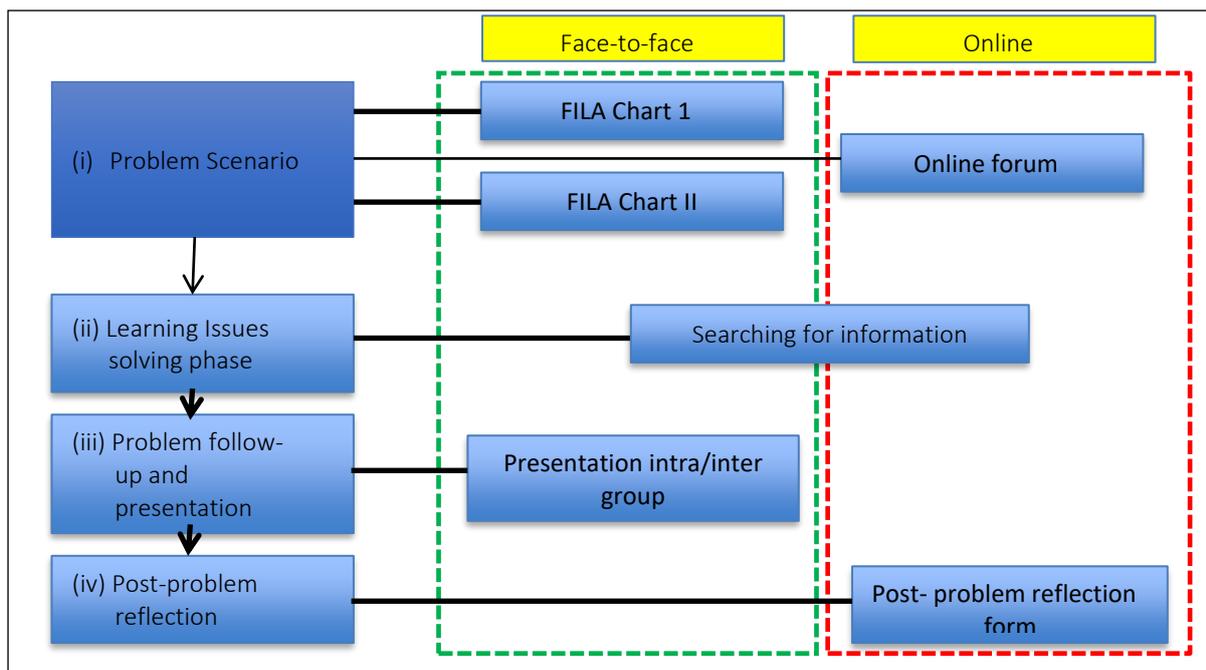
Data was collected from two instruments: (i) Data from observation (direct and online forums discussion), and (ii) student documents (FILA Chart). Data was analysed thematically as suggested by [29], as shown in Figure 2.



**Figure 2:** Example of thematic data analysis

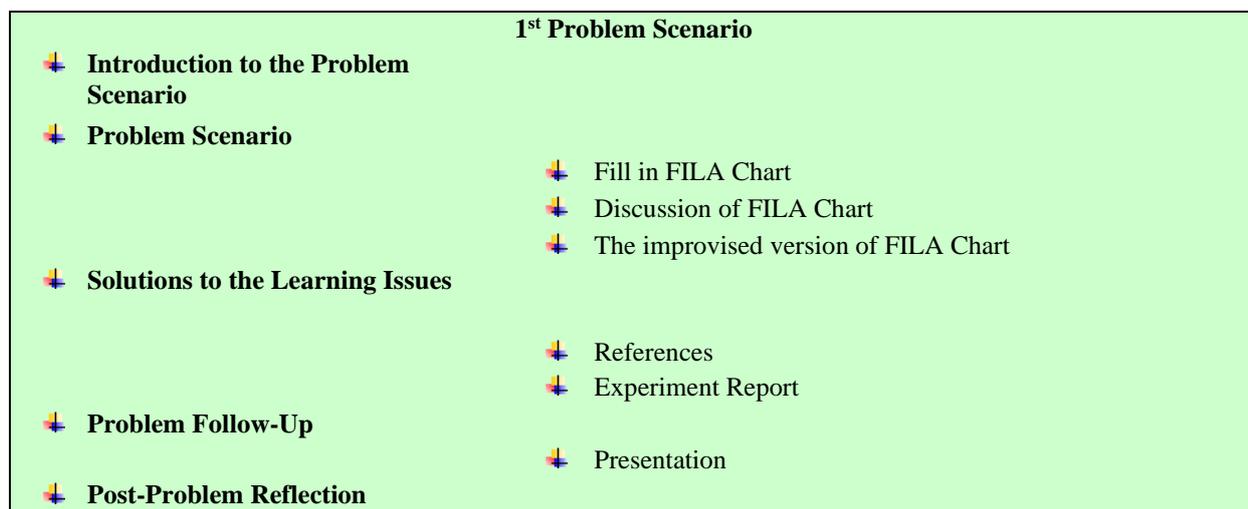
Figure 2 shows an example of thematic data analysis implemented in this research. There are four stages of data analysis which are: (i) data, (ii) initial code, (iii) initial theme, and (iv) final theme. In step i, the data from all instruments was transcript. Then, in step ii, the transcript data was read few times in order to classify them into groups known as 'initial code'. Next, in step iii, all the initial codes, which have the same pattern, will be grouped in the same 'initial theme'. Lastly, in step iv, all the initial codes were checked again. Those, which have the same pattern, will be combined together as the new theme known as the 'final theme'.

In this study, the BPBL learning process was implemented based on BPBL Model proposed by [22] as presented in Figure 3.



**Figure 3:** Blended PBL Model adopted from Mohd Mokhzani *et al.*, (2016)

According to [22], there are four steps in BPBL model: (i) problem scenario, (ii) learning issues solving phase, (iii) problem follow-up and presentation, and (iv) post-problem reflection. Step iii was done via face-to-face mode while step i, ii and iv were done both in face-to-face and online mode. But in this paper, only step i (problem scenario) will be discussed into details. This is because alternative concept formation typically occurred in this phase, and failure to address this issue will affect the overall learning process [19]. Step i, iii and iv were implemented during class session while step ii was implemented both during class and after class. For the purpose of implementation, the BPBL environment has developed in the online platform as presented in Figure 4.



**Figure 4:** The Blended Problem-Based Learning Environment

Figure 4 shows an example of the BPBL learning environment which has been developed in the *Modular Object-Oriented Dynamic Learning Environment*, also known as *MOODLE* [30]. Online forum discussion and hyperlink are some features of *MOODLE* which potentially enhance students' social interactions [31, 32], and thus, have been applied in this research. Students were divided into groups of five. Each group needed to appoint a leader, a secretary, observers and scribes. Each position has its own task as illustrated in Table 1. Then, the learning process began with a problem scenario given by the teacher. The problem scenario is about a conversation between a school boy who was having a toothache and a dentist at a clinic (refer Appendix 1). The problem covers the acid and base chapter, which is included in the form four chemistry syllabus designed by Curriculum Development Centre Malaysia (2012).

**Table 1:** The Task to Each Position

Position	Task
Leader	Lead the discussion session
Secretary	Post (upload) the FILA Chart to the online forum
Observer	Actively engage in the discussion session
Scribe	Write down all the main points during discussion session.

In helping students to analyse the problem, a FILA chart (Facts, Ideas, Learning Issues and Actions) which adapted from [33] as in Figure 5, was given. Here, the three representation levels of Chemistry (macroscopic, microscopic and symbolic) were emphasized in the 'Idea' column. The explanation for the FILA chart is given in Table 2.

Facts	Ideas			Learning Issues	Actions
	Macroscopic	Microscopic	Symbolic		

**Figure 5:** FILA Chart adapted from Tan Yin Peen and Mohammad Yusof (2013)

**Table 2:** Explanation of the FILA Chart

Column	Explanation
Facts	Information extracted from the problem scenario.
Macroscopic Ideas	Any ideas about the problem based on facts identified.
Microscopic Ideas	Theory at particulate level
Symbolic Ideas	Related to any symbols, for example chemical equation.
Learning Issues	Things that need to be found to solve the problem.
Action	Ways/Methods/ Activities to be taken in order to get the answer for learning issues which has discovered earlier.

In groups, students discussed with each other to complete the FILA chart. Next, the secretary of each group needed to upload the FILA chart in the online platform. During the online forum session, each group must give feedback on others' FILA chart. Students reviewed with their group members on their FILA charts if any amendment needed, after the online discussion session ended. Next, the secretary of each group uploaded the revised FILA chart on the online platform again. Overall, BPBL took six weeks to be implemented as presented in Table 3.

**Table 3:** The Duration of the Implementation of BPBL

Learning Phase	Learning activity	Duration
Problem scenario	• Assigning the task between group member	Week 1 and week 2
	• FILA chart (1)	
	• Discussion forum	
	• FILA chart (2)	
Learning issues solving phase	• Discussion in group in order to solve the learning issues	Week 3 and week 4
Problem follow-up and presentation	• Intra and inter group presentation	Week 5
Post problem reflection	• Student complete the post problem reflection form.	Week 6
	• Interview	

## RESULTS AND DISCUSSIONS

In this study, after the implementation of BPBL, it is found that the teachers were able to help students overcome the formation of alternative concept during learning sessions. Students, on the other hand, were able to work collaboratively and independently in developing an accurate mastery of three representation levels of Chemistry during the lessons. As aforementioned, the students will first discuss among their group members to complete the given FILA Chart (1) and post it into the online forum as shown in Figure 6.

Facts	Ideas			Learning Issues	Actions
	Macroscopic	Microscopic	Symbolic		
<ul style="list-style-type: none"> <li>• Ahmad has toothache when eating cold food</li> <li>• Ahmad love to eat pickle</li> <li>• Ahmad always drink pepsi</li> <li>• Ahmad always use different tootpaste brand.</li> </ul>	<ul style="list-style-type: none"> <li>• Pepsi contains an high maount of sugar</li> <li>• Pepsi is an isotonik drinks</li> <li>• Teeth also known as calcium carbonate</li> </ul>	<ul style="list-style-type: none"> <li>• Sugar acid corrodes Ahmad's teeth and causes him to have sensitive teeth.</li> </ul>	<ul style="list-style-type: none"> <li>• Calcium, Ca</li> <li>• Carbonate, CO<sub>3</sub></li> <li>• Carbon, C</li> </ul>	<ul style="list-style-type: none"> <li>• How cold food can give an effect to Ahmad's teeth?</li> </ul>	<ul style="list-style-type: none"> <li>• Discussion with the groups' members</li> </ul>

Alternative concept

**Figure 6:** Students' alternative concept on microscopic level in FILA Chart (1)

Figure 6 shows an example of the alternative concept on microscopic level done by student in FILA Chart 1. In the third column at microscopic idea, students have given an answer as 'Sugar acid corrodes Ahmad's teeth and causes him to have sensitive teeth'. It is found that, the teacher stimulated students to justify microscopic ideas that led them to identify alternative concept (the use of incorrect term, sugar acid) as the example in Figure 7.

Student A: Sugar Acid? Can you explain about it?
Teacher: I am also interested to know more about sugar acid. Can anyone from your group explain about it in detail?
Student B2: Sugar acid, what we meant is actually acetic acid, CH <sub>3</sub> COOH
Student A: Can acetic acid be called as sugar acid?
Student B2: For me, both of them are the same.

**Figure 7:** Example of students' alternative concept for 'sugar acid' on microscopic level.

Based on the above example, the discussion started when Student A asked explanation on 'sugar acid' term. Instead of providing answer, the teacher prompted a question: "Can anyone from your group explain about it in detail?". Clearly, the prompted question functions as thought-provoking question that encourages students to justify their statement through discussion. This is in line with what has been highlighted by [34], as an advantage to use this approach in encouraging students' active participation and reasoning in learning.

Students are also responsible for analyzing and evaluating other group's answer on Fact, Idea, Learning Issue and Action (FILA) charts in order to gain justification regarding ideas on microscopic level. This discussion begun when Student A asked for further explanation on the term 'sugar acid' used by his group ("Can acetic acid be called as sugar acid?"). However, Student B2 simply concluded that both terms were correct ("For me, both of them are the same"). This is an example of formation of alternative concept. [35, 36], justified that this situation happened due to informal learning that occurred outside classroom, and thus affecting how these students form their understanding.

In addition, the formation of alternative concepts on symbolic level among students is also shown in Figure 8 below.

Facts	Ideas			Learning Issues	Actions
	Macroscopic	Microscopic	Symbolic		
<ul style="list-style-type: none"> <li>Ahmad has toothache when eating cold food</li> <li>Ahmad eat five time a day.</li> <li>Ahmad loves pickle.</li> <li>Ahmad brush his teeth when he is free.</li> </ul>	<ul style="list-style-type: none"> <li>Ahmad has sensitive teeth.</li> <li>Acid corrodes Ahmad's teeth.</li> <li>Ahmad has strong teeth.</li> </ul>	<ul style="list-style-type: none"> <li>Calcium, Ca</li> <li>Carbonate, CO<sub>3</sub></li> <li>Carbon, C</li> </ul>	<ul style="list-style-type: none"> <li>Glucose: C<sub>6</sub>, H<sub>12</sub>, O<sub>6</sub></li> </ul>	<ul style="list-style-type: none"> <li>Why Ahmad has toothache?</li> <li>What type of acid contains in pepsi?</li> </ul>	<ul style="list-style-type: none"> <li>Discussion with the groups' members</li> </ul>

Alternative concept

Figure 8: Students' alternative concept on symbolic level through FILA Chart (1)

Figure 8 shows an example of the FILA chart, which has been uploaded by students into online forum discussion. In the fourth column at symbolic idea, students have given answer as 'Glucose: C<sub>6</sub>, H<sub>12</sub>, O<sub>6</sub>'. This shows that the student assumed glucose (C<sub>6</sub>, H<sub>12</sub>, O<sub>6</sub>) can be separated simply into its compositions. Again, the teacher stimulated students to identify the alterantive concept by posing question as the following example taken from online forum discussion (Figure 9).

Student A: Why the symbol of hydrogen is H <sub>12</sub> ?
Student A1: H <sub>12</sub> is the fraction of glucose (C <sub>6</sub> H <sub>12</sub> O <sub>6</sub> )
Teacher: Can you simply separate an element from its compound?
Student A1: Yes, by electrochemistry and heating process.

Figure 9: Example of students' alternative concept on separation of element from its compound

Based on Figure 9, initially, Student A analyzed and evaluated the other group's answer by asking 'Why the symbol of hydrogen is H<sub>12</sub>?'. Student A1 was able to justify by explaining that: "H<sub>12</sub> is a fraction of glucose (C<sub>6</sub>H<sub>12</sub>O<sub>6</sub>)". The teacher prompted another question: "Can you simply separate an element from its compound?". The reason to this question was to direct the student to rethink on the answer given, which was identified as an alternative concept. Student A1 replied that it is possible to do so: "Yes, through electrochemistry and heating process". Even though the student's response is

categorized as an alternative concept for definition of chemical compounds (under chemical bonding topic), the teacher's question was able to direct students to rethink and provide justification to reflect their understanding. It is undeniable that students' understanding often based on alternative concepts especially for the concept of chemical bonding [8, 37] but later after undergone the BPBL learning, students were able to overcome this problem.

After discussing in online forum discussion, students analyzed and re-evaluated the facts, ideas and issues of learning in carrying out the reflection process. This reflection process allowed students to define ideas and learning issues that have been set before. Students also detailed microscopic ideas by not listing ideas based on alternative concepts. For example, students no longer used the term 'sugar acid' in the FILA chart as presented in Figure 10.

Facts	Ideas			Learning Issues	Actions
	Macroscopic	Microscopic	Symbolic		
<ul style="list-style-type: none"> <li>Ahmad has toothache when eating cold food</li> <li>Ahmad love to eat pickle</li> <li>Ahmad always drink pepsi</li> <li>Ahmad always use different tootpaste brand.</li> </ul>	<ul style="list-style-type: none"> <li>Pepsi contains an high maount of sugar</li> <li>Pepsi is an isotonik drinks</li> <li>Teeth also known as calcium carbonate</li> </ul>	<ul style="list-style-type: none"> <li>Calcium, Ca</li> <li>Carbonate, CO<sub>3</sub></li> <li>Carbon, C</li> </ul>	<ul style="list-style-type: none"> <li>Glucose (C<sub>6</sub>H<sub>12</sub>O<sub>6</sub>)</li> </ul>	<ul style="list-style-type: none"> <li>How cold food can give an effect to Ahmad's teeth?</li> </ul>	<ul style="list-style-type: none"> <li>Discussion with the groups' members</li> </ul>

**Figure 10:** The correction of alternative concept at microscopic level through FILA Chart (2)

Figure 10 clearly shown that students have changed the alternative concept at microscopic level ('sugar acid') to a more accurate answer which was Calcium (Ca), Carbonate (CO<sub>3</sub>) and Carbon (C) in FILA Chart 2. Students also changed the alternative concept at symbolic level as shown in Figure 11.

Facts	Ideas			Learning Issues	Actions
	Macroscopic	Microscopic	Symbolic		
<ul style="list-style-type: none"> <li>Ahmad has toothache when eating cold food</li> <li>Ahmad eat five time a day.</li> <li>Ahmad loves pickle.</li> <li>Ahmad brush his teeth when he is free.</li> </ul>	<ul style="list-style-type: none"> <li>Ahmad has sensitive teeth.</li> <li>Acid corrodes Ahmad's teeth.</li> <li>Ahmad has strong teeth.</li> </ul>	<ul style="list-style-type: none"> <li>Calcium, Ca</li> <li>Carbonate, CO<sub>3</sub></li> <li>Carbon, C</li> </ul>	<ul style="list-style-type: none"> <li>Glucose: C<sub>6</sub>H<sub>12</sub>O<sub>6</sub></li> </ul>	<ul style="list-style-type: none"> <li>Why Ahmad has toothache?</li> <li>What type of acid contains in pepsi?</li> </ul>	<ul style="list-style-type: none"> <li>Discussion with the groups' members</li> </ul>

**Figure 11:** The correction of alternative concept at symbolic level through FILA Chart (2)

Figure 11 shows the correction that has been done by the students at symbolic level in FILA Chart (2). Students have corrected their alternative concept by giving a more accurate answer which was the correct molecular formula of glucose ( $C_6H_{12}O_6$ ).

During the face-to-face monitoring by teachers, the teachers initially failed to identify this alternative concept during the discussion. However, the integration of online learning, which was forum discussion, has allowed corrections for the alternative concepts. Clearly, the integration of online platform offers an advantage over existing PBL, and at the same time enhances the roles of teacher in monitoring students' learning. This is in line with the findings in [23, 38] study, where they appointed that online learning can enhance teacher roles in monitoring students throughout the learning process. It is very important to identify students' formation of alternative concept because it will lead to poor mastery of the topic, as they build up their understanding from their existing knowledge [13]. In short, it shows that teacher plays an important role to ensure that the understanding and knowledge are accurate in helping to master the subject. Hence, this can be achieved through BPBL.

Furthermore, it is found that through an online forum discussion, students can improve their accommodation process where they made changes to their initial understanding that were identified as alternative concepts [39]. Social interaction is an important factor in improving the accommodation process [39] and is highlighted in this study through the use of online forum discussion that allowed students to discuss with group members and the whole class. On the other hand, questions raised by teachers and students during online forum discussions are examples of scaffolding [18] which have helped them to identify and further correct their alternative concepts.

## CONCLUSION

As a conclusion, teachers acts as a mediator in order to stimulate students' thinking in justifying their responses during the implementation of BPBL. Hence, they indirectly help students to identify their alternative concept by asking probing questions. On the other hand, students have analyzed and evaluated other groups' answers in order to identify and correct their alternative concept. Clearly, the implementation of BPBL is found beneficial to overcome the formation of alternative concepts. Since the current study has proven that the implementation of BPBL was able to improve students' mastery on the three representation levels of Chemistry, it is suggested for future researchers to implement BPBL in the other school settings.

## Declaration of Conflict of Interest

The author declared no potential conflicts of interest with respect to the research authorships and publications of this article.

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Appendix 1

You are a dentist assigned to perform dental examinations at a school in the Kluang area. Ahmad, one of the students came to see you for advice on his dental problems. Here is the dialog.

- Dentist : Can I help you? What is your problem?
- Ahmad : I have toothache especially when eating something cold like an iced drink.
- Dentist : Can you explain how your daily diet works?
- Ahmad : I eat five meals a day and most of the food is rice. I also love citrus fruits and of course pepsi is always one of the drinks especially during sunny day.
- Dentist : I see. How many times a day do you brush your teeth?
- Ahmad : Not necessarily. I only brush my teeth when I am free. I also often change my toothpaste brand because I do not know which is best.

As a dentist, how can you help Ahmad? Please provide your full explanation.

