Enhancing Collaborative Learning Skills via Blended Problem-based Learning in Chemistry Learning

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Abstract

Poor mastery of three representation levels of Chemistry (macroscopic, microscopic and symbolic) has affected students' academic performances. This is resulted from the traditional teaching that is teacher-centred and does not encourage students' active participation. Potentially, Blended Problem–based Learning (BPBL) approach that integrates both face-to-face and online learning platforms focuses on students' active involvement, especially collaborative skills (knowledge sharing, conflict resolution and reflective skills). Hence, the current study is aimed at exploring how BPBL can enhance these collaborative skills during learning activities in Chemistry learning. This study employed a qualitative approach - exploratory and explanatory case study. Through purposive sampling, two teachers and 20 students from two schools were selected. Data

from observations, students' documents and interviews were collected and analysed thematically. The findings suggested that BPBL approach can enhance the students' collaborative learning experiences and skills. Firstly, the students demonstrated that they were able to share knowledge by: a) agreeing on the objectives of the problem, b) sharing what they have learned, and c) evaluating their info and others. Secondly, the students were able to resolve conflicts as they demonstrated their ability to: a) identify how the information is collected, and b) reevaluate their own information and of others. Lastly, the students were able to conduct reflection during the lessons as they: a) reflect and identify concepts that they struggle with, b) make generalization of the current findings to other relevant problems, c) reflect their overall action plan in solving the learning issues, and d) evaluate their own performance and of the group members throughout the learning process. In short, this study has provided valuable information on how BPBL can help enhance students' collaborative learning skills during the teaching and learning process.

***Keywords**:* Problem-based Learning, Blended Problem-based Learning, Three Representations Levels of Chemistry

Introduction

Concerns on poor performances of Malaysian students in the Programme for International Student Assessment (PISA) were raised decades ago, starting in 1999. The Ministry of Education Malaysia aims to transform teaching and learning in hope to improve students' mastery of basic literacy and numeracy, core subjects (Mathematics and Science), and higher-order thinking skills (Ministry of Education Malaysia[1]. However, in reality, schools are still struggling to improve education delivery and outcomes, especially in Chemistry subject. Schools are still practising teacher-centered learning, which is an impediment to Chemistry concept and higher-order thinking skills development [1-4]. One of the problematic areas is mastery of three representations levels of Chemistry – macroscopic, microscopic, and symbolic [5, 6]. Previous studies have attributed this problem as a result from poor students' involvement in learning [3, 4, 7, 8] as they are inclined to construct their understanding of this concept inaccurately. Active involvement is vital in helping them develop their understanding, especially in linking macroscopic level with microscopic and microscopic with symbolic[9].

The current body of literature has appointed that collaborative learning activities in problem-based learning are essential to encourage students to share knowledge, resolve conflict, and reflect on their learning experiences in enhancing their mastery of this concept [10-12]. During this process, students internalise their understanding first, work on the problem given, and propose solutions based on their constructed Chemistry knowledge. By doing so, misconception or known as alternative concept formation can be detected and corrected through discussion and peer evaluation.

Literature Review

Blended problem-based learning (BPBL)

BPBL is a teaching approach that originated from traditional problem-based learning (PBL). The theoretical basis of PBL is rooted in the constructivist view of learning, such as [13-15]. They believed that knowledge is acquired by students through active involvement in learning and not directly 'transferred' from teachers. [13-15] further described that assimilation (a process of connecting prior to new knowledge) and accommodation process (a process of accommodating prior knowledge) could be

encouraged through active learning. Similar to PBL, this approach still preserves its active learning characteristics which emphasise on: a) student-centred learning, b) solution of an authentic problem that is not structured and allow more than one relevant solution, and c) active participation of students in self-directed and collaborative learning activities [16-18]. This capitalises the importance of social interaction as an important part of knowledge construction. The scaffolding in PBL is provided either through interaction between students and teachers or among themselves. Ideally, the BPBL preserves its traditional characteristics and extends the space of learning by offering both face-to-face and online platforms. Both platforms encourage social interactions for knowledge construction.

The importance of online platforms has been widely discussed in the literature. Previous studies have identified that this platform eases the teacher's job in monitoring students during learning [11, 19, 20]. Potentially, this platform will help to overcome issues in monitoring big size classrooms. The traditional PBL typically allows a small grouping of six to seven students in a group (Barrows & Tamblyn, 1980). Therefore, it is hard for teachers to closely monitor each group in a classroom [4, 12]). For instance, to support face-to-face learning, the use of online forum discussion will allow more time for students to further explore and construct their understanding outside the instructional hours at school. Students are encouraged to ask questions, express their ideas and discuss the content of learning as a continuation in face-to-face learning [21-23]. This, in turn, will help to encourage self-directed and collaborative learning.

The BPBL strategy

Adapted from the earlier work of [24]), the BPBL strategy (refer Figure 1) has four important steps: a) introduction of new learning problem to students, b) suggestions for problem solutions, c) problem follow-up and presentation, and d) reflection, which integrate both face-to-face and online learning platform. In the first phase (introduction of new learning problems to students), both 'starting a new group' and 'starting a new problem' are combined. Clearly, both group formation and assigning roles for each student in a group can be completed within this phase. This is to ensure that students are more focused on the main task of this phase which is to introduce students to a new learning problem, which require them to specifically analyse and understand the problem and how it can be presented in real-life settings, understand their roles as an individual and group, set learning objectives, completing the FILA (Facts, Ideas, Learning Issues, and Actions) chart, and propose the initial ideas for problem solutions [24].

In completing this, both face-to-face and online learning platforms are utilised. Upon presentation of the learning problem by the teacher, students need to work collaboratively in completing the FILA chart. This chart is a tool to organise their thinking [17, 24]. Students are expected to list down the facts of the problems in the 'Fact' column, their ideas or relevant hypotheses to be tested in the 'Ideas' column, learning issues that they encountered (in 'Learning Issues' column) and their action plan in solving the problem (in 'Action' column). Once they have completed this, they will upload the chart online. Compared to the face-to-face mode where students only discuss between group members, through this online discussion forum, students have the opportunity to discuss involving the whole class [3, 19, 25, 26]. Again, the discussion is encouraged on the online platform to revise further and amend all four aspects of problem solutions. Finally, they need to complete FILA chart 2, which is a revised version of the initial chart (FILA chart 1).

In the next phase, the ideas for problem solutions are further scrutinised. Students are encouraged to explore multiple resources from inside and outside the classroom. The infusion of the online platform is beneficial not only to support learning but also to develop

students' information and reasoning skills [27]. Once this process is completed, students move to the problem follow-up and presentation. The proposed solutions with justification and support from various resources are presented to the group. Again, the discussion is encouraged to reach a consensus for the relevant solution to the problem. Later, they have to present their findings to the whole class. In this process, students are allowed to ask questions, provide feedback and opinions on each presentation. Again, the importance of working-in-team skills is being emphasised here.

Finally, students need to reflect on the overall process of learning in the online learning platform. They are encouraged to touch on the problems and solutions that they have worked on. [17, 24] added that students should also be able to reflect on the similarity and differences of the learning problems with other problems that they encounter. This, in turn, helps them to make a generalisation and elicit their understanding of new knowledge [28, 29].

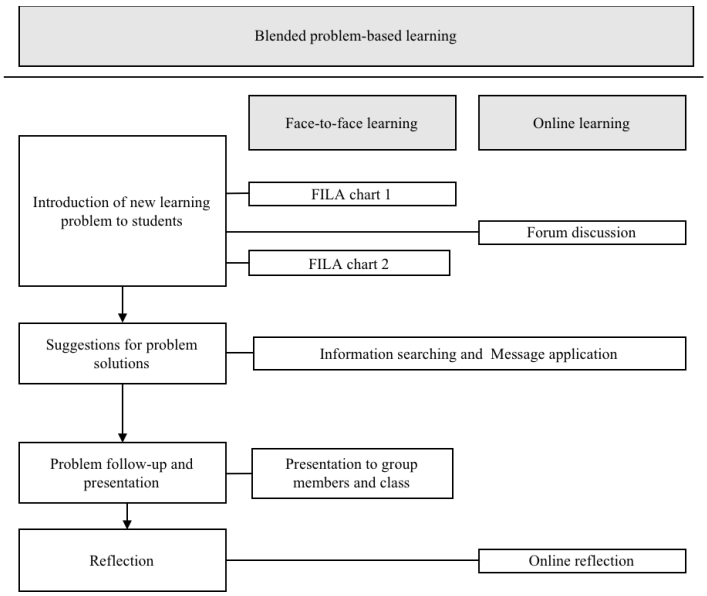


Figure 1: BPBL Strategy

Collaborative skills in BPBL

Collaborative skills are vital in BPBL. For [30], collaborative skills in BPBL refers to how students work in a team to solve a learning issue set for the lesson. Each member plays an equally important role in contributing to problem-solving. This definition is close to those by [17, 31]. They define it as social interaction among team members, teachers, and classmates in solving the learning problem and constructing their knowledge. This means that the cognitive load will be shared among them [17].

In the earlier work of [24], collaborative skills were identified in almost all phases of the PBL. For instance, in the 'starting a new group,' the collaborative skills are exemplified when students work together to establish ground rules, learning climate, and individual identities to help the group work effectively. Other skills such as distributing roles, gathering initial information, and identifying concepts that are lacking and among group members are evident in the 'starting a new problem' phase. In other phrases, the dynamic of collaborative works has expanded to sharing and criticising their knowledge and

information, demonstrating their understanding in producing a complete report on problem-solving, as well as reflecting and making generalisation of what they have learned in groups [17, 18, 32].

In the context of the BPBL implementation, [3] further categorised these skills into three relevant clusters: a) knowledge sharing, b) conflict resolution, and c) reflective skills. Similar to previous studies, knowledge sharing is a continuous process of assimilating and accommodating knowledge that happens in group activities ([17, 18, 32]. This includes the ability to work as a group in: a) agree on the objectives of the problem, b) share what they have learned, and c) evaluate their info and others.

Undoubtedly, the conflict will appear during group work [33-35]. Hence, conflict resolution is another important skill in collaborative learning activities [36]. [37] defines conflict resolution as a group effort in comparing and contrasting ideas, knowledge or facts, and discussing solutions to overcome the learning conflicts. In resolving conflict, [24] mentioned that students should be able to: a) reevaluate their own information and of others, b) identify how the information is collected, and c) critique its sources. This process will allow students to restructure their knowledge and understanding and provide a relevant solution to the learning problem.

Lastly, reflection refers to a process of evaluating their knowledge and actions – individually and as a group in solving the learning issues. Reflective skills take place in all phases of BPBL [3]. It is inseparable to the previous clusters of skills. Students are expected to: a) reflect and identify concepts that they struggle with, b) make generalization of the current findings to other relevant problems, c) reflect their overall action plan in solving the learning issues, and d) evaluate their own performance and of the group members throughout the learning process. Central to the development of problem-solving skills, reflective skills help students to work as a group to establish connections between the problem they are working on with problems that they have encountered before [3, 25, 28]. This will lead to generalisation on how they can apply the new knowledge in a different relevant context.

The current study

Undeniably, BPBL emphasises on collaborative learning skills in finding the solution for a learning problem. However, previous studies on a similar area, especially in the Malaysian context, majorly focus on its effectiveness ([38, 39]. Therefore, there is a need to investigate further how BPBL can enhance collaborative learning skills in Chemistry learning. This study is aimed at answering these research questions:

1. How can BPBL enhance knowledge sharing skills among students during collaborative learning activities in Chemistry learning?
2. How can BPBL enhance conflict resolution skills among students during collaborative learning activities in Chemistry learning?
3. How can BPBL enhance reflective skills among students during collaborative learning activities in Chemistry learning?

Methods/Methodology

Research Design

The current study employed a qualitative approach, precisely, exploratory and explanatory case study in exploring and understanding how BPBL can enhance collaborative learning skills in Chemistry learning. This design is suitable as it seeks to explore and describe a studied phenomenon in greater detail [40-42].

Research Participants

Initially, 69 fully residential schools across Malaysia were identified based on purposive sampling technique, in ensuring the research participants were suitable for the study [43]. These selected schools:

1. are the benchmark of academic excellence by the Ministry of Education Malaysia (2012) as the ;
2. are able to facilitate the data collection process as the students have tight learning schedule;
3. have students who take Chemistry subject.

Next, only two schools were selected for this study by using the simple random sampling technique. The sampling process is continued by taking only one class from each school. As a limitation of the research, only the data of two groups from each school were selected, analysed in detail. The final sampling includes two teachers and 20 students. The BPBL strategy was conducted for 12 weeks and focussing on two problems: a) toothache (acid-base topic), and b) air pollution (redox reaction topic). The overall learning process is based on the BPBL strategy (as illustrated in Figure 1 of the previous section) which is proposed by [25].

Data Collection and analysis

Data were collected from three sources: a) in-class observation, b) students' documents, and c) open-ended interviews. For the observation, the researchers took the roles of non-participant observers in order to preserve their natural learning settings and avoid bias [40]. During the observation, basic details (physical settings, time, date, and attendance) and detailed observations (exact time, researcher's observation, and students' verbal communication, as well as interpretation) were recorded [32, 40]. Besides, the teaching and learning process was recorded via video recorder enables researchers to closely review and analyses students' verbal and non-verbal actions [44].

As for the students' documents analysis, three important documents were collected and analysed; a) FILA charts, b) solutions of the learning problem, and c) journal reflection. FILA chart is a learning instrument that requires students to identify: fact (F), idea (I), learning issue (L), and action (A). Relevant to the local context, FILA-MMS is found relevant for this study. [4]expanded the existing FILA chart proposed by [24] by including the three representation levels of chemistry (macroscopic, microscopic, and symbolic) in the 'Idea' component. An example of the FILA Chart is shown in Table 1.

Table 1

The items of the FILA chart.

Item	Description
Fact	Information synthesis that is derived from the learning problem
Idea	Conjectures formation that is developed based on the learning problem and facts. The conjectures need to cover the macroscopic, microscopic, and symbolic level, when necessary.
Learning issue	List of things to know and understand in solving the learning problem
Action plan	List of actions that are relevant in solving the learning problem

Next, data were analysed thematically, according to Braun and Clarke (2006), as shown in Figure 2.

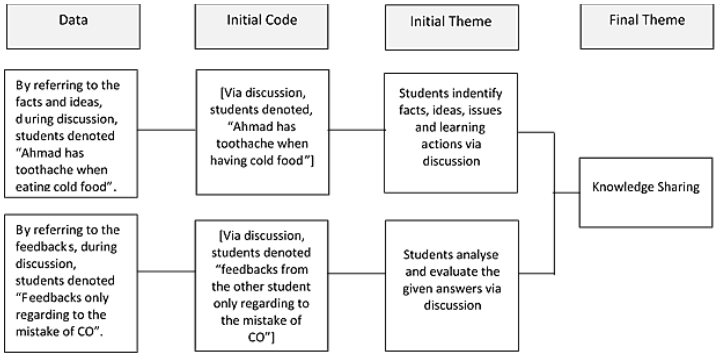


Figure 2: Example of the thematic analysis of data

Result and Discussion

Knowledge Sharing

In this study, knowledge sharing happened at almost all phases of BPBL. Students demonstrated their ability to: a) agree on the objectives of the problem, b) share what they have learned, and c) evaluate their info and others.

In the toothache problem, the teacher played an important role in facilitating this process. Direct feedback by the teacher during the face-to-face discussion has helped students to be more focussed in achieving this agreement. Teacher asked: *"What is the chemical concept underlying the problem?"*

As a result, students started to focus the discussion in finding the underlying concept of this problem. For instance, a student asked: *"Is Pepsi an isotonic drink?",* which in turn led to a detailed discussion and finally they agreed on the objective of the problem which was acid-base concept. Undeniably, the face-to-face mode in BPBL is still important especially in helping students to familiarise themselves with this strategy and directing their discussion to be more specific and focussed [3, 25, 45].

On the contrary, in the air pollution problem, it was found that students started with limited knowledge of the chemical concept related to the problem and did not require help from their teacher. Evidently, every member of the group actively contributed their ideas and this discussion has led to an agreement that the problem was related to the acid-rain (redox reaction concept), as indicated by the following excerpt: *"The problem is not related to corrosion but it is related to contamination which is acid rain. I still remember, I have read the facts from our textbook."*

Table 2

The items of the FILA chart

Facts	Ideas			Learning Issues	Actions
	Macroscopic	Macroscopic	Symbolic		
Ahmad has toothache when eating cold food	Pepsi is the carbonated drinks which contain phosphoric acid	Calcium, Ca Carbonate, CO3 Carbon, C	Glucose $C_6H_{12}O_6$	How could food can give an effect to Ahmad's teeth?	Discussion with the group members Seek clarification from expert experts Surf the internet
Ahmad love eat pickles	Pepsi is an isotonic drink				
Ahmad always drink Pepsi	Teeth also known as calcium carbonate				
Ahmad always use different toothpaste brand					

On the other hand, students demonstrated that they were able to share what they have learned especially in the online forum discussion. As a group, students completed the FILA chart 1 and further discussion was conducted. The use of this platform has widened the discussion and allowed students from other groups to discuss and share their opinions. Very differently, the previous studies such as [4, 8, 45, 46] only focussed on small group discussions. The current study provides evidence of how this process has become more critical and helped the students to amend alternative concepts.

The online discussion has led to identification of an alternative concept (at microscopic level) in the chart for the toothache problem. For instance, in Table 2, Group 2 has written *"sugar acid corrodes Ahmad's teeth and causes him to have sensitive teeth"* which was an alternative concept.

Table 3

Example of alternative concept at the microscopic level of chemistry in FILA chart 1

Facts	Ideas			Learning Issues	Actions
	Macroscopic	Macroscopic	Symbolic		
Ahmad has toothache when eating cold food	Pepsi is the carbonated drinks which contain phosphoric acid	Sugar acid corrodes Ahmad's teeth and causes him to have sensitive teeth	Calcium, Ca Carbonate, CO_3 Carbon, C	How could food can an effect to Ahmad's teeth?	Discussion with the group members
Ahmad love eat pickles	Pepsi is an isotonic drink				

Ahmad always drink Pepsi	Teeth also known as calcium carbonate				
Ahmad always use different toothpaste brand					

However, one of the members of Group A asked for clarification on the term used - "sugar acid". This has helped the students to justify their answer by defining 'sugar acid' as acetic acid (CH_3COOH) as presented in Figure 3.

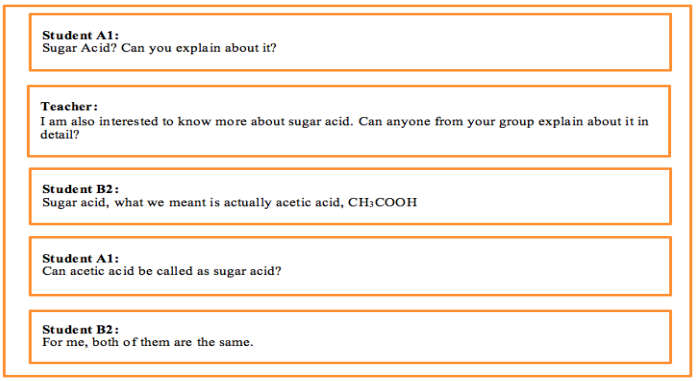


Figure 3: Example of students' knowledge sharing in FILA chart 1 via online forum discussion

However, this justification was still inaccurate and considered as an alternative concept. Through the sharing session, Student A1 further asked: *"Can acetic acid be called as sugar acid?"*. This is an example of how students demonstrated the ability to evaluate their info and others through online forum discussion. As a result, the group has amended their response in the chart, as illustrated in Table 3.

Table 3: Student corrected the alternative concept according to the feedback in the FILA chart 2

The alternative concept is formed based on their existing knowledge derived from their everyday encounters that are not aligned with scientific concepts [47]. Clearly, in this study, the students applied their existing knowledge in suggesting "sugar acid" as acetic acid.

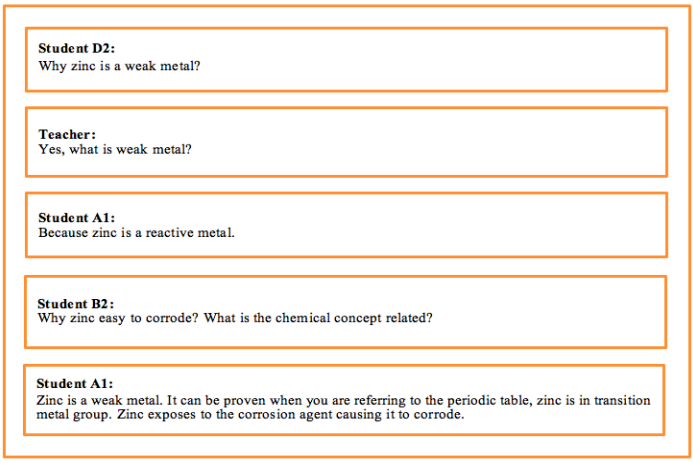
The findings from the interview further described that the formation of the alternative concept was corrected by the students and this provides evidence that knowledge sharing through collaborative activities can help students to reevaluate their responses and avoid the formation of alternative concepts.

Interviewer : *Why your group changed the term 'sugar-acid' used in FILA chart 1 compared to FILA chart 2?*

Student C2 : *Because we were not confident about our answer.*

Interviewer	:	*Okay, it was because your group was not confident with the answer. But, it must be something that triggered your group to change the term. What is sugar-acid really about?*
Student B2	:	*An acid that mixes up with sugar.*
Interviewer	:	*An acid that mixes up with sugar? Sugar acid corrodes teeth in FILA chart 1, but your group changed it to 'glucose' in FILA Chart 2. Why?*
Student C2	:	*We assumed the sugar contained in Pepsi is a kind of acid. But, when we discussed it via an online forum, we changed our answer.*

From the interview, it was found that students have changed their answer which was an alternative concept (in FILA chart 1) to a more accurate answer in the FILA chart 2 after knowledge sharing with the whole class. During the discussion of FILA chart 1 (discussion that only involved small groups), the alternative concepts were not identified. However, it was a different case during the online forum with the whole class. Students were able to detect alternative concepts and correct them. This indicates that students not only accomplished the process of assimilation of new knowledge but also the process of accommodation in correcting alternative concepts to generate the best solution [17, 24]. Indirectly, this helps to facilitate the process of integrating new knowledge into existing knowledge [14] and further enhancing students' mastery of the Three Representation Levels of Chemistry concept.



Moreover, the use of asynchronous discussion forums during online learning mode allows more time for students in sharing knowledge. This allows students to analyse and evaluate each question posed, before giving their feedback (Gao, Zhang & Franklin, 2013; [12, 48]. With more time allocation, the knowledge formation is more detailed where they can justify each idea or answer that has been given. Figure 4 below provides an example of how this process happened in this study.

Figure 4: Examples of students analysing and evaluating other group answers on microscopic ideas

Based on Figure 4, the discussion began when Student D2 asked: *"Why zinc a weak metal?"* Student A1 then gives a brief justification by stating 'Because zinc is a reactive metal'. Student B2 from the other group, asked for justification on the relationship between the phenomenon and the chemical properties of zinc, where he probed questions: *"Why does zinc easily corrode? What is the chemical concept related?"*. Student A1 linked the problem of fast-leaking zinc (a phenomenon at the macroscopic level) with the chemical properties of zinc (microscopic level) by stating that: a) zinc is a weak metal, b) zinc is a transitional element, and c) zinc has no barrier to the rusting agent which causes it to rust

easily. This shows that students are able to connect between macroscopic and microscopic ideas in justifying the questions posed by students from the other groups.

The ability of students in connecting macroscopic ideas with microscopic ideas through this online forum discussion proves that the collaborative learning process can improve students' mastery in the Concept of Three Representation Levels of Chemistry. This is in line with the findings of [9-11, 44]. Thus, it is relevant to state that this situation has increased the knowledge sharing that allows students to give detailed justification to each answer [1, 13, 37, 48]. This situation is different from face-to-face learning, where students have to justify an answer immediately. This causes the development of ideas to occur less during the discussion session, thus reducing the sharing of knowledge formation between students as the findings of a study by [26, 41, 45].

In addition, through the integration of face-to-face and online learning mode, students have the opportunity to select various references, either printed or online references [25, 49, 50]. The information was analysed in groups to ensure its accuracy and validity. This allows more collaborative works to be conducted by students during learning. For example, it was found that students were not only depending on textbooks but also online resources to help assist in solving the learning issue. Moreover, students shared their resources and information via the message application. This allows them to further enhance their knowledge sharing. Figure 5 provides evidence of this process.

Figure 5: Examples of knowledge sharing between students via the *Message* application

Date: ---

Student A1 : This is the link that might be useful to get the information; http://prezi.com/3qrviyvr5c/isu-pembelajaran-tampalan-gigi-daripada-amalgam/

Student B1 : Thank you.

Date: ---

Student B1 : Hi, A1. Pepsi have a high acidity level. Its pH is around 3-4 which it is strong enough to dissolve teeth.

Student A1 : http:// izaziz23.blogspot.my/2020/10/tentang-coca-cola.html

Student B1 : The pH of coca cola is 3.2 which is a strong acid. It can cause your teeth and bone dissolve easily. This drink also can cause our teeth become darker.

Based on Figure 5, it is evident that students were sharing information that they have found on the internet with their peers. They worked together to understand the microscopic representation as they discussed the relationship between the pH value of one of the carbonated drinks, Coca-Cola, which is 3.2 with its degree of acidity and its effect on teeth.

Clearly, the message application has been fully utilised by students to conduct a close discussion with their peers or teacher for knowledge sharing. Differently, the students in [17, 18, 41] study only use the internet for information searching. The collaboration between students has indirectly enhanced scaffolding in which students work together to explain related information obtained from different sources. This helps to enhance the interaction between students thus and their ability to reach the zone of proximal development (ZPD) in solving problems as discussed in the Social Constructivism Theory [15]).

Conflict Resolution

Another important skill for learning is conflict resolution [34]. In this study, students faced a number of learning conflicts as they express their opinions actively during the learning sessions ([51]. Typically, conflicts exist when students have different opinions and ideas that they derived from different sources ([25, 52]. The findings of the current

study indicated that conflict resolution only required students to: a) identify how the information is collected, and b) reevaluate their own information and of others.

In the air pollution problem, students were presented with a situation where a statue was 'melted' and the students started to brainstorm in their assigned group on this problem. For instance, a member of Group 2 (Student A2), mentioned that the problem scenario was related to corrosion. However, there was a disagreement between the members during the face-to-face discussion. Student B2 argued that:*"The problem is not related to corrosion but it is related to contamination which is acid rain*." Student A2 defended that corrosion was the factor to this problem as the statue was made from metal: *"The statue was made from metal. Metal corrodes"*. However, Student B2 justified that the problem was caused by acid rain and she mentioned that: "*I still remember, I have read the facts from our textbook".* This is an evidence of how conflict resolution was utilized where the student identified her source of information as a point to justify her argument. This indicates that the student was aware of the source of information and able to use the information to justify her argument. As a result, the other students positively responded to her as they agreed that the chemical concept tested was related to the concept of acid rain.

On the other hand, students demonstrated their ability to reevaluate their own information and of others. One of the groups (Group 1), used the term 'weak metal' to describe the characteristics of zinc in FILA chart 1, as presented in Table 4.

Table 4

FILA chart 1 for problem 2

Facts	Ideas				
	Macroscopic	Macroscopic	Symbolic	Learning Issues	Actions
Smoke emissions in city X increased due to the opening of the plan.	Zinc benches and roof corroded	The smoke released from the plants consist of fine particles.	The smoke released from the plants consist of fine particles.	What is the chemical composition in polluted air?	Discussion with the group members
Agricultural areas become less fertile, benches and stone table are damaged zinc roof leaks		Zink is a weak metal		What are the factors that lead to the occurrence of acid rain?	

The use of an non-scientific term (weak metal) has become an argument among groups during online forum discussion as shown in Figure 6. Student D2 initiated the conversation by asking why zinc is called 'weak metal'. Student A1 justified that the term was used as he believed that zinc is a very reactive metal. Besides, a student from the

other group, (Student B2) asked why zinc is easily corroded and the chemistry concept underlying this phenomenon. Student A1 justified that zinc is a weak metal and it can be proven in the periodic table as zinc in the transition metal group.

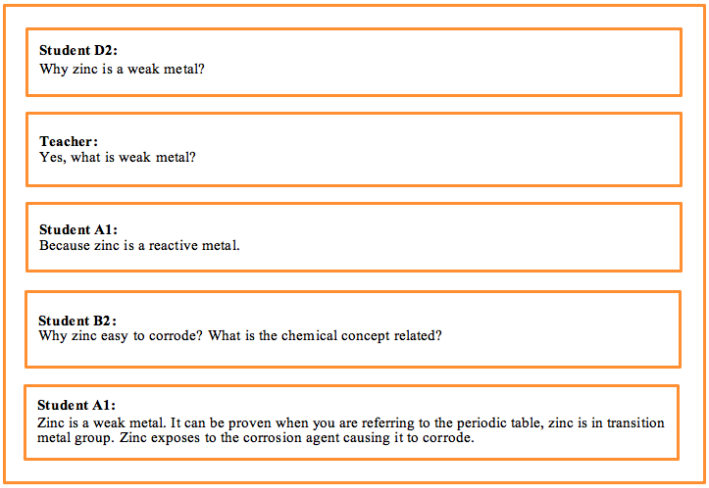


Figure 6: The argument between students about the use of 'weak metal'

However, this non-scientific term has been changed by the students in FILA chart 2as shown by table 5

Table 5

FILA chart 2 for problem 2

Facts	Ideas				
	Macroscopic	Macroscopic	Symbolic	Learning Issues	Actions
Smoke emissions in city X increased due to the opening of the plan.	Zinc benches and roof corroded	Carbon monoxide consists of C^{4+} And O^{2-}	The smoke released from the plants consist of carbon monoxide CO	What is the chemical composition in polluted air?	Discussion with the group members
Agricultural areas become less fertile, benches and stone table are damaged zinc roof leaks				What are the factors that lead to the occurrence of acid rain?	

Clearly, in FILA chart 2, the term 'weak metal' has been omitted by the group. The student of that group omitted the term because they has reevaluate their own information and of others as evidenced in the following interview excerpt:

Interviewer : *Why did your group omit the term 'weak metal' in the FILA Chart 2?*
Student A1 : *Our group omitted that term because we had discussion about it again and we felt that the term is not accurate to be used.*

Clearly, through the online platform, students have demonstrated their ability to reevaluate their information and improve their answer. This is an important effort to help avoid the formation of an alternative concept that might hinder accurate understanding of the issue.

Interestingly, the findings have also indicated that the students were able to critique the resources. For instance, Student A1 modified her statement on the acidity level of Pepsi by referring to the source provided by Student B1 (refer to Figure 5). Student A1 provided the link as he slightly disagreed with his friend's statement. This process indicates that a conflict resolution has been achieved by providing a relevant source to help illustrate the abstract concept and avoid the formation of alternative concepts. This finding is in line with [18, 24] as they clearly stated that in resolving a conflict, students need to know how information is obtained from a reliable source.

Very differently, a number of researchers have found that students were more inclined to avoid conflicts during learning and did not use their findings from their independent reading to justify their argument [4, 8, 52]. Thus, the findings of this research provide another dimension to the literature as the students were found to be more critical in evaluating and analyzing the information. Conflict resolution skills are important to the collaborative learning process in developing their understanding and problem solving skills. In fact, this skill is required in ensuring that the collaborative learning process takes place smoothly throughout the learning process.

Clearly, through the online platform, students have demonstrated their ability to reevaluate their information and improve their answer. This is an important effort to help avoid the formation of an alternative concept that might hinder accurate understanding of the issue.

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Reflection

In this study, students were given vast opportunities to discuss as a group and class in completing the FILA charts. The infusion of an online learning platform has allowed students to continue to discuss and achieve a relevant solution to the learning issue. Through both learning platforms, students demonstrated their ability to conduct reflection

by a) reflect and identify concepts that they struggle with, b) make generalisation of the current findings to other relevant problems, c) reflect their overall action plan in solving the learning issues, and d) evaluate their own performance and of the group members throughout the learning process.

In the toothache problem, it was found that students were able to reflect and identify concepts that they struggled with, and through discussions, they were able to improvise their answer in the FILA chart 2 as shown in Table 6.

Table 6

The Changes of Macroscopic Idea in FILA Chart 2 compared to FILA Chart 1

Macroscopic Idea in FILA chart 1	Macroscopic Idea in FILA chart 2
Pepsi contains a high amount of sugar	Pepsi is the carbonated drink which contain phosphoric acid and citric acid

Table 6 shows that students have changed their answer at macroscopic level (Idea) in FILA chart 2 compared to FILA chart 1. This indicates that the reflection process happened and has helped students to further understand the Chemistry concept. As a result, their answer in FILA chart 2 was more accurate. To support, the following interview excerpt provides evidence of how this process happened.

Interviewer : *In FILA Chart 1, your group stated that "Pepsi contains a high amount of sugar" but in FILA Chart 2, your group has changed it into "Pepsi is the carbonated drink which contains phosphoric acid and citric acid". Why and how your group changed the statement?*

Student A2 : *We changed the statement since we got more information.*

Interviewer : *Where did you get the information?*

Student B2 : *We get the information from the discussion of FILA Chart 1 with the other group.*

From the above excerpt, it is found that students have done reflection after receiving feedback from other group members during the online forum discussions. This allows students to amend their answer in the FILA chart 1 and come out with more accurate responses in the FILA chart 2.

In addition, the inaccurate response in the FILA Chart 1 has directed students in Group A to reflect their overall action plan in solving the learning issue. In the FILA Chart 2 (a detailed FILA Chart 2 is presented in Table 3, in previous section), the students listed three suggestions for their action plan, which were: a) discussion with the groups' members, b) seek clarification from experts, and c) surf the internet.

Table 7

The Changes of Action Plan in FILA Chart 2 compared to FILA Chart 1

Action plan in FILA chart 1	Action plan in FILA chart 2
• Discussion with the group members	• Discussion with the group members • Seek clarification from experts • Surf the internet

From the above table (Table 7), the students have reflected on the issue they struggled with and proposed a new action plan. From only one suggestion 'discussion with the group's members' in FILA Chart 1, they proposed additional suggestions: 'seek clarification from experts', and 'surf the internet'.

Moreover, in the BPBL, students can evaluate their own performance and of the group members throughout the learning process. Findings from the document analysis (reflective journals) indicated that 16 out of 20 students perceived that group collaboration can be enhanced for future learning. An example of the student reflection on the overall process is: *"From BPBL, I can improve the way I collaborate among teammates in a group in future".*

These findings are in line with the main goal of reflection which is to give students the opportunity to suggest how the learning process they have gone through can be improved and applied to different situations [16, 17, 24, 53]. Very differently, Abu Bakar (2016) found that students in his study were unable to reflect on their learning experiences. In this study, the integration of online learning mode is found to be relevant to help students revisit the lessons and works uploaded online, reflect and amend their work to achieve the target learning objectives. The advantages offered can increase the ability of students to recall the collaborative learning process such as the interaction in online discussion forums as well as information exchanging between group members through the *message* application.

Conclusion

This study describes in detail how the BPBL can enhance the collaborative learning process in three skills namely a) knowledge sharing, b) conflict resolution and c) reflection. It was found that the BPBL has encouraged students to conduct knowledge sharing by: a) agreeing on the objectives of the problem, b) sharing what they have learned, and c) evaluating their info and others. For conflict resolution, the BPBL has allowed students to: a) identify how the information is collected, and b) reevaluate their own information and of others. On the other hand, it was found that students were able to conduct reflection during the lessons as they: a) reflect and identify concepts that they struggle with, b) make generalization of the current findings to other relevant problems, c) reflect their overall action plan in solving the learning issues, and d) evaluate their own performance and of the group members throughout the learning process. Clearly, the integration of both face-to-face and online platforms has encouraged students to collaborate during the lessons. The findings of the study confirms the Radical Constructivism Learning Theory [14] in which through the integration of both modes has allowed students to improve their

assimilation and accommodation process in mastering the Concept of the Three Representation Levels of Chemistry.

On the contrary, in the traditional PBL, scaffolding was typically given by their own group members [8, 45]. Very differently, asynchronous discussion forum in the BPBL has allowed students-within and inter groups, to share their opinions and suggestions to enhance their understanding. In addition, students were given freedom to revisit and reread their responses and of others even outside the instructional hours. The BPBL has definitely enhanced their collaborative skills and allowed them to reach the zone of proximal development (ZPD) where students in groups can solve the given problems. In fact, this is in line with the Social Constructivism Theory emphasised by [15]. Besides, the findings of the study have added flesh to the literature on the importance of students in identifying reliable sources or reference in conflict resolution. In addition, it was also found that the process of collaborative learning can be enhanced by raising questions at a high cognitive level – application and evaluation, during the discussion. This allows for a more detailed and in-depth argument.

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