The Development of Chemical Teaching Materials for Upper Secondary School: study lesson on detergent concept in Cambodia

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Abstract

A study lesson dealing with the detergent concept was carried out at an upper secondary school in Cambodia after a number of teaching materials concerning with detergent were prepared for classroom activities. Through the pre-/post tests and questionnaires responded by students, the lesson study was evaluated high appreciation and satisfactory. The activities prepared in the lesson study were applicable by students. It is also recommended that it can be appropriately introduced as part of curriculum at upper secondary schools in Cambodia and other developing countries which required teaching materials.

Keywords: detergent, volume of water drop, surface tension of water, knowledge improvement of students, Cambodia

1. Introduction

Science classroom activities are seldom seen in schools in Cambodia, whereas in a developed country, such as Japan, it is a common thing in a science classroom (Education in Japan, 1997). Students in more developed countries are accustomed to practical works of science lessons, such as carrying out observations and experiments in a laboratory. They can develop attitudes and abilities to investigate both in and outside classrooms scientifically. That is because there are enough human resources and teaching materials in the schools. Therefore, at the same time they could increase their understanding of natural phenomena, as well as have enough opportunity to connect theory to actual practice. However, in Cambodia, science was taught like subjects of literature, history, social study, and so on, to students (MoEYS/UNESCO, 2001). They don’t have many chances to do practical works such as science experiments in classrooms. The main reason being, Cambodia is newly developing country after being had a long civil war and the recent lack of teaching materials and human resources has had consequences to slow down science education development. Teachers themselves have not enough experiences and not been trained sufficiently as to how to conduct practical works in a science classroom.

It should be recognized that from 2000-2004, the Japanese International Cooperation Agency (JICA) runs a project called the Secondary School Teacher Training Project in Science and Mathematics (STEPSAM), collaborated with the Ministry of Education, Youth and Sport (MoEYS), to develop science and mathematics education throughout Cambodia at upper secondary level (Maeda 2002). For this effort, the project tried to develop simple teaching materials for science experiments which used only locally available materials in order to distribute to schools. Then, science classes were started to introduce a
number of practical works to students after having in-service teacher trainings by using resources provided by STEPSAM. However, only few practical works were developed and introduced according to the current textbook contents.

As a part to help the contribution of science practical works in classroom, a study lesson about detergent concept were introduced in front of students at Anuwat upper secondary school in Phnom Penh city, Cambodia. Several observation activities that were experiment activities which required simple apparatus were prepared in the study lesson (see Table 1).

The purpose of this paper is to report and to evaluate the study lesson activities which were considered as an implementation of the developed teaching materials in the classroom. This paper mainly consists of 3 parts that are, the outline of the study lesson; evaluation of the study lesson; and key issues.

2. The outline of study lesson

2.1 Objectives of study lesson

The study lesson is designed to achieve the following objectives:

1) To improve students’ knowledge related to detergent concept and surface tension of water.

2) To provide students learning activities and scientific observations in classroom.

2.2 Lesson plan

The study lesson was designed for four periods (1 period = 50 min) as seen in the following schedule.

<table>
<thead>
<tr>
<th>Period</th>
<th>Topics/Activities</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>-Pre-test</td>
</tr>
<tr>
<td></td>
<td>(1) Are soap and detergent same? Compare a number of their properties: Acidity or Alkalinity (pH), bubbling in soft and hard water, the change in acid solution (vinegar), dirt-removing ability</td>
</tr>
<tr>
<td>2</td>
<td>(2) Let’s make soap and detergent molecules; and (3) Demonstration of Surface tension of water (Let’s play with a water strider)</td>
</tr>
<tr>
<td>3</td>
<td>(4) Determination of affect of detergent on surface tension of water by observing size of sample drop; and (5) Determination of detergent amount in sample solution by using absorbance method.</td>
</tr>
<tr>
<td>4</td>
<td>-Discussion and analysis the results of experiment. -Post-test and questionnaire</td>
</tr>
</tbody>
</table>
2.3 Experiments

As seen in Table 1, several activities (experiments) were introduced. Experiments were planned under the consideration of the situation in Cambodian schools, where laboratory equipment is rarely available. That is, the experiments require mostly locally available materials such as plastic cups, plastic syringes. Nevertheless, due to the limit space, only the experiment of the determination of the affect of detergent on the surface tension of water is briefly reported in this paper.

<Apparatus and reagents>

50 mL Erlenmeyer flask, glass tube (inner diameter: 3 mm and outer diameter: 5 mm), 1 mL syringe, scale (can weight at least 0.01 g), 100 mL measuring flask, test tube, plastic dropper and absorbance machine (Type: CO7500).

A solution of 1.000 g of the commercial detergent (KAO brand, made in Japan) in 1000 mL was prepared. Then, it was diluted as follows to make five different sample solutions in various concentrations.

Sample A: dilute original sample two times.
Sample B: dilute sample A two times.
Sample C: dilute sample B two times.
Sample D: dilute sample C two times.
Sample E: dilute sample D two times.

Pure benzene and Cobalt-complex tablet (PONAL KITABS) are used in the determination of detergent concentration of each sample through absorbance method.

<Experiment procedure>

(A). Observation size of sample drop

Ten drops of a sample solution is dropped by a syringe into a 50 mL Erlenmeyer flask which already known the weight (Figure 1). Then, the flask is weighed again. Thus, the weight of ten drops of sample can be calculated. The same procedures are carried out for other detergent samples.

(B). Determination of detergent concentration in each sample solution

Each sample is diluted 100 times and then put 100 mL of diluted solution into a 100 mL measuring flask. Two tablets of Cobalt Complex (PONAL KITABS) are dissolved in the solution. After that 4 mL of
benzene are added and the solution is shaken about 30 seconds to well mix. After keeping the mixture about 5 min to allow the solution to separate into two phases, the upper phase is removed and put into a test tube with cap and then it is measured the absorbance by the absorbance machine at 550 nm. The absorbance value is later converted to the detergent concentration by using the following relationship:

$$\text{[Absorbance]} = 2.74 \times \frac{\text{[detergent]}}{\text{[ppm]}}$$

This relationship comes from the measurement of absorbance of various Sodium Dodecyl Sulfate solutions which known the concentrations at 550 nm by using absorbance machine, type: CO7500.

2.4 Experiment Result and analysis

<table>
<thead>
<tr>
<th>Sample</th>
<th>Weight of 10 drop sample (g)</th>
<th>Weight of 1 drop sample (g)</th>
<th>Volume of 1 drop sample (cm³)</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>0.453</td>
<td>0.0453</td>
<td>0.0453</td>
</tr>
<tr>
<td>B</td>
<td>0.521</td>
<td>0.0521</td>
<td>0.0521</td>
</tr>
<tr>
<td>C</td>
<td>0.618</td>
<td>0.0618</td>
<td>0.0618</td>
</tr>
<tr>
<td>D</td>
<td>0.667</td>
<td>0.0667</td>
<td>0.0667</td>
</tr>
<tr>
<td>E</td>
<td>0.690</td>
<td>0.0690</td>
<td>0.0690</td>
</tr>
<tr>
<td>Pure water</td>
<td>0.704</td>
<td>0.0704</td>
<td>0.0704</td>
</tr>
</tbody>
</table>

Note: By assuming that density of each sample solutions is equal to that of water (1g/cm³). Therefore, weight of 1 drop sample in gram (g) equal to volume of the drop in cubic centimeter (cm³). That's why the volume of 1 drop sample was shown in table 2.

<table>
<thead>
<tr>
<th>Sample</th>
<th>Absorbance</th>
<th>Detergent in diluted sample/ppm [x]</th>
<th>Detergent in original sample/ppm [x]×100</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>0.08</td>
<td>0.029</td>
<td>2.92</td>
</tr>
<tr>
<td>B</td>
<td>0.17</td>
<td>0.062</td>
<td>6.20</td>
</tr>
<tr>
<td>C</td>
<td>0.36</td>
<td>0.131</td>
<td>13.14</td>
</tr>
<tr>
<td>D</td>
<td>0.74</td>
<td>0.270</td>
<td>27.01</td>
</tr>
<tr>
<td>E</td>
<td>1.49</td>
<td>0.544</td>
<td>54.38</td>
</tr>
</tbody>
</table>

According to the results from Table 2 and Table 3, a graph showing the relationship between detergent concentration and the drop size of each sample are plotted as seen follows.
Graph in Figure 2 shows that the volumes of the drop decreased rapidly when concentration of detergent is increased. It is considered as the decreasing of surface tension of water while detergent was presented in water. It can be explained that the surface tension of water is caused by "cohesion" which is the force that causes the molecules of water to be attracted to one another. The molecules on the surface of water are pulled by other molecules on the sides and below the surface by hydrogen bonds, but there are no molecules pulling on them from the air above, which results in continuous tension (see Figure 3). This tension acts as an invisible "membrane" on the surface of the water. This allows some insects like a water strider or a light objects like a paper clip does not drown because it is being held up by this tension. This also causes drops of liquid like water to be spherical since its surface is being minimized. Surface tension is responsible for the shape of liquid droplets. Although it's easily deformed, droplets of water tend to be pulled into a spherical shape by the cohesive forces of the surface layer.

Contrarily, for a molecule at the interior of a medium, it would be equally attracted by all neighboring molecules. The effect is that it is attracted to all sides with the same force, so that the resulting force is zero.

Detergent, like dishwashing liquid, disturbs the formation of hydrogen bonds between the water molecules and allows them to "slip past" one another. The result, the surface tension was disturbed and lost. If a small amount of soap or detergent is added to the surface of water, the behavior of the surface changes that means most of hydrogen bonds between water molecules on the surface are cut. The change in behavior of the surface can be attributed to a change in the surface tension of water. Small objects, such as a paper clip, that may have floated on the water's surface are no longer able to after soap is added. For this same reason, volume of a water drop becomes smaller and smaller, while the concentration of detergent increases as seen in Figure 2. That is because the surface tension of water decreases. The attraction force between molecules on the surface of droplet becomes weak due to it is being disturbed by detergent molecules. Therefore, it cannot make the volume of the water drop any bigger.
Figure 3 Diagram shows a phenomenon that causes surface tension of water to occur.

3. Evaluation

The study lesson was evaluated through the pre-/post-test results and feedbacks collected from 41 students who attended the lessons in February 2005 and through the interview with some students after the class. The evaluation was made focusing on the objectives designed in the study lesson: (1) knowledge improvement of students, and (2) learning activities.

3.1 Knowledge improvement of students

In general, students’ knowledge about detergent concept and surface tension of water appeared to have improved through the study lesson. As seen in the Figure 5, students achieved higher scores in the post-test.

Figure 4 The comparison of pre-test and post test results

Note: The following questions were designed as multiple choice for both pre- and post-tests:

Q1. What does environment mean?  
Q2. What is soap made of?  
Q3. Which is a soap molecule?  
Q4. Which is a detergent molecule?  
Q5. What does hydrophobic mean?  
Q6. What does hydrophilic mean?  
Q7. How soap or detergent can remove dirt from clothes?  
Q8. What kinds of chemical bonds formed in liquid of water?  
Q9. What does surface tension of water mean?  
Q10. How soap or detergent affects surface tension of water?
This result appeared in accord with students’ understanding of each topic introduced in the study lesson (see Figure 5). Asking to how much they understood each topic, most of them responded “very well”, “Good” and “Fair”. Only one or two of them responded that they did not understand the topic 3 to 5.

![How much did you understand each topic?](image)

*Figure 5 Students’ understanding on each topic which had been taught.*

*Note:* The topic 1 to 5 is referred to all of the topics introduced in Table 1.

In this case, we considered that because the students were fewer experiences in attending in such classroom which prepared a lot of activities (see Figure 6). Answering to the questionnaire that “have you ever done experiments before?” most of them responded “never” and “occasionally”. On the other hand, the topic 3 to 5 were dealt with the surface tension of water and the determination of the detergent concentration in the sample water by using absorbance machine which were extremely new topics to them. Therefore, maybe some of them felt nervous to hand on and felt not familiar with them. However, in general, we could say that the study lesson have been carried out successfully that the objective 1 could be greatly achieved almost for all students, even though they did not have any experiences before.

![Have you ever done experiments before?](image)

*Figure 6 Students’ experiences with conducting experiments in classroom.*
3.2 Learning activities
Learning activities of students during the study lesson was evaluated through extent of difficulty and degree of satisfaction of students.

3.2.1 Extent of difficulty
It could be said that students could participate in all of the activities without difficulty. They seemed to be able to learn without much trouble. As seen in Figure 7, responses to the question "were experiments easy for you?" About half of students said "easy" and others that said "fair", but no one said "Difficult".

![Figure 7 Easiness in doing experiments responded by students.](image)

According to the responds of students above, we could, therefore, say that the activities introduced in the study lesson were possibly applicable by students.

3.2.2 Degree of satisfaction
Students gave high satisfaction with all topics introduced in the study lesson (see Figure 8). At the same time, they showed great enjoyment with all of the activities (see Figure 9). Replying the questionnaire "did you enjoy the experiments?", most of them said "enjoy very much" and "enjoy".

![Figure 8 Students' satisfaction in each topic which had been taught.](image)

Note: The topic 1 to 5 is referred to all of the topics introduced in Table 1.
When we interviewed students and asked them to give their own opinions about the study lesson, they gave the similar opinions that they impressed and enjoyed the activities very much. They continued that they were surprised when they attended in this class because there were a lot of activities introduced to them. They suggested having such class activities more often, so that they can have more opportunities in the scientific observation and connect theory to reality.

4. Key issues

While study lesson achieved satisfying results, there are some key points which were found and suggested to be considered for improving the next lessons:

1. Time should be extended, so that students may have more times to conduct each experiment carefully and relaxingly. Making sure that, the teacher has more times to explain the key concepts and to interact with students.

2. The number of topics should be appropriated according to time allocation. Namely, many topics should not be introduced to students during short times.

3. The content and the activities used in the study lesson should be introduced into part of the science curriculum of upper secondary school in Cambodia. They can help students to link science phenomena to daily life.

4. Assistant teachers are very useful in science class, when group activities are introduced to students. They can help the main teacher to facilitate students’ activities additionally and equally throughout the classroom.

5. Conclusion

This paper reported the study lesson on detergent which has been done in the upper secondary school in Cambodia. The results indicated that students’ knowledge could be improved through the classroom activities. At the same time, all of the learning activities could be applicable by students and seemed to be able to sufficiently serve to science classrooms in Cambodia. The new topics which are the surface tension of water and the determination of detergent concentration in sample solution also could be transferred into students’ knowledge that can be seen through the good experimental results achieved by students in the
classroom. We hoped that this paper could provide an idea on class activity introduction concerning the detergent concept, especially for developing countries which required simple teaching materials.

References

高校段階への化学教材の開発：カンボジアにおける洗剤に関する研究授業の実践

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要旨:
洗剤に関する教材（洗剤量に応じて表面張力の低下により試料水の水滴の大きさが変化することを利用したもの）を開発し、カンボジアの高校で、カンボジアから来ている留学生と日本人中学校教諭が研究授業を行った。事前にならびに事後テストを実施したところ、生徒の受け入れ方は大変よく、また洗剤についての理解も深まったことがわかった。

キーワード: 洗剤, 水滴の体積, 表面張力, 生徒の知識改善, カンボジア