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# WATERCOLOR PRODUCTION& PAINTING PROJECT: INTEGRATION OF THE ARTS AND ACTIVE TEACHING STRATEGIES FOR THE UNDERSTANDING OFACID-BASE INDICATOR CONCEPTS

Jutharat Sunprasert[a], Thiti Jarangdet[b],
Tasanangkul Tulyakorn[c], Prof. Phannee Rattanachisit[d]
[abcd]King Mongkut's University of Technology Thonburi, Thailand
*Corresponding Email:* jutharat.sun@kmutt.ac.th

## Abstract

This study was conducted with the participation of twenty-six 11th grade students from the Engineering Science Classroom (ESC) in the first term of the academic year 2016.Chemistry has often been considered as one of the more difficult subjects for high school students. The hands-on activities and active teaching strategies are designed to develop the understanding of concepts in chemistry with the use of art, and soft skills such as creative thinking and problem solving and so on. The learning process was to have students work in groups of three, where they designed the vegetable extraction method to create the watercolor. All these extractions are organic solutions with attributes of acid-base indicators. These colors can be changed according to the pH level. Therefore, employing watercolor painting activity as a part of the lessons can help students understand the varying pH of the extract generating different colors. In this activity, students were also given a pre and post-test and questionnaire as a control. Results of this study showed the significant difference of the mean score of pretest and posttest ($p<0.05$). This learning activity led to a stronger understanding of the Acid-base content, thus, indicating that arts may have a positive correlation to students' chemistry learning experience.

***Keywords:*** Acid-base Indicator, pH level, Water Color Painting and Active Teaching Strategies.

## 1. Introduction

Learning and teaching scientific subjects in the senior high school level in Thailand mostly focuses on teaching content and also provides some practical lessons. Moreover, time spent in the classroom is normally quite limited, whilst the difficulty of the content for those scientific subjects increases. As a consequence, some students do not have enough conceptual understanding of scientific topics or misinterpret what is being taught. In addition to this, subjects are taught separately and in different groups, such as chemistry, mathematics, art; etcetera (The Basic Education Core Curriculum, 2551). Consequently, students cannot grasp the concept of applying knowledge from one subject to another, but treat each subject separately. Also, they do not realize the importance of applying scientific knowledge when going about everyday life.

The fundamental nature of chemistry is a topic that has been a part of the scientific curriculum at both junior and senior high school levels. Many concepts in chemistry seem complicated and difficult for the students to understand in terms of scientific knowledge. One reason for such difficulty is that some concepts deal with chemistry on a microscopic level and so this cannot always be understood by just looking at it (Kelly, R., et. al., 2005). Hence, instructors must transform and simplify non-visual concepts to chemical models or symbols to help students understand them clearly. One of the important topics that should

be simplified is the topic of acid-base. This topic concerns theories of reactions and this relates to particles such as $H_3O^+$and $OH^-$ in solutions. According to the results of studies, it was found that students do not understand the fundamental and intensive concepts of acid-base(Demircioglu G., et. al., 2005). Also, they cannot link this understanding to the concept of other subjects. A possible cause of this problem is that some instructors prefer teaching students only in class and this is not enough for learning. Although instructors provide the students with content in laboratories or with activities, it is not adequate to use in real life. Therefore, students have less motivation and engagement to study chemistry. Also, it seems they do not enjoy studying it. More importantly, some students feel afraid of studying science subjects, so that it is hard for them to study in the higher levels.

Learning by doing such as hands-on learning is one of the teaching methods. This concept aims to help students build their own knowledge and learning skills by doing the activities themselves(Ainsworth S., et. al., 2011). Also, this concept provides learners with experience and continuing education. The selection itself of an activity is important, as a well-selected activity as this can have a positive impact on students and help them understand concepts. Interestingly, many studies show that art can be a useful part of teaching for academics (Daphney C., et. al., 2015; Ainsworth S., et. al., 2011). Art not only helps students relax as it is enjoyable, but can increase their concentration in learning and help them idealize and grasp abstract concepts(Schwartz K., 2015).Thus, integration of Arts into chemistry courses using hands-on activity is worthwhile.

Watercolor painting is an art activity to help students learn about color and how it relates to chemistry (Eisenkraft A., et. al., 2006). It also helps students learn chemistry by thinking in art. There is no limitation of water color unlike commercial products. For example, vegetable extracts give excellent painting color such as red cabbage, black sticky rice, oleander flower, etc. All these extractions are organic solutions attributing acid-base indicators. These colors can be changed according the pH level. Therefore, employing watercolor painting activity as a part of the lessons can help students understand how varying the pH of the extract can generate different colors.

In brief, the aim of this study was to focus on using art to teach chemistry on the topic of acid-base concepts. Watercolor painting was used as the main activity in teaching.

## 2. Objective

1. To investigate if the painting activities can enhance students' understanding about acid-based concepts.
2. To investigate the effectiveness of teaching chemistry by integrating artistic activity into students' scientific knowledge.
3. To encourage students to realize the link between art and chemistry.
4. To apply scientific knowledge in everyday life.

## 3. Methodology

*Course design*

We are developing and integrating several teaching methods in an effort to improve students' attitudes toward understanding acid-base concepts which involves a hands-on approach, including art activities and laboratory experiments, questions-based and lecture-based teaching. The course is designed based-on3mainly expected outcomes which are 1,understanding the acid-based concepts, 2,understanding the meaning of art and chemistry, and 3 and applying the scientific knowledge in everyday life. This course has also integrated 10 learning goals and soft skills (Bellanca, J., et. al., 2010; Özmen H., et. al., 2012). These are listed in below.

*1. Calculate and explain the pH values of acid and base solutions when they know the composition value of $H_3O^+$ and $OH^-$ together with how to prepare acid and base solutions at different pH levels.*
*2. Explain the ionizing ability of strong acids, strong bases, weak acids and strong base solutions.*
*3. Explain the acid and base reaction when dissolved in water together and specify these kinds of ions.*
*4. Explain the properties of buffer solutions and understand the reaction of buffer solutions when added to acidic and alkaline solutions.*
*5. Understand that pH is an indicator of acidity and/or basicity of a solution and associate the pH level to acidity and basicity, the range of colors on an indicator and apply this knowledge to daily life.*
*6. Explain the meaning of a neutralization reaction and write equations for these reactions.*
*7. Develop a positive attitude and skill toward scientific experiments.*
*8. Understand and acknowledge links between science and art.*
*9. Understand and visualize the picture between acid and base reactions with colors.*
*10. Develop capabilities in scientific thinking processes and practical skills.*

In the study, the whole learning goals and soft skills were taught and applied in different teaching approaches. Furthermore, the approach of the course design contains a variety of activities for the students to do. It is worthy to note that the instructor will attempt to integrate theory with practice during the teaching and learning process, and intends to keep some parts of the tasks as open-ended problems to challenge the students to study it themselves. The course design is shown in Figure 1.

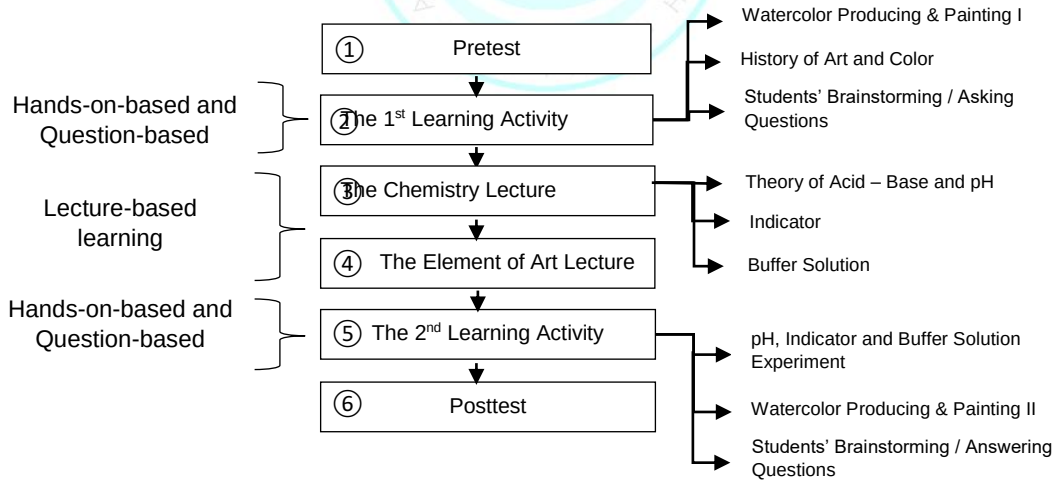


Figure 1: course design

As seen from figure 1, the procedures of teaching are as follows:

①,⑥*Pretest and posttest*; Both the pretest and posttest was used before and after learning. The pretest was used to determine the students' background knowledge. It was very important to know students' background knowledge as it can then be used as a guideline to create suitable lessons. The posttest was also used to assess the students' gain in cognitive ability after learning through the new approach.

②*The 1st learning activity*; This activity covered 2 approaches of teaching and learning processes. These are hands-on-based and question-based learning. The hands-on-based learning was used to attract students' attention and encourage students to learn chemistry concepts by using art as an activity. Instructors combined hands-on activities, watercolor production and painting, with laboratory activity to engage students and improve students' understanding of the acid-base concept. Watercolors from red cabbage water were produced by students. Red cabbage is a natural substance which was used in this activity and is not hazardous to students. They created various colors by using acid and base solutions, dropped in natural solution. They did not really know what all of the solutions were. Then, students brought their color to paint a picture. In question-based learning, the instructor tried to engage students with questions and class discussion. Students brainstormed and took part to ask the questions regarding the observation of the watercolor production activity. However, instructors did not respond the students' questions. Instructors just asked students to ask questions related to this activity together with recorded whole questions for students to respond to next time.

③*The chemistry lecture;* During the lessons, instructors tried to make a student-centered instruction based on the 1st learning activity, discussions and oral explanations. Chemistry lecture process was used to explain the important concepts related to acids and bases and then written on the board. For example, when they mixed primary color solution followed by color mixture theory, and why it didn't follow the theory. For this question, the teacher could base the class on color around the needs of the students. In this class, they would learn the pH indicator topics listed below.

3.1 The pH indicator conjugates acid-base form that makes the color solution.
3.2 The calculation of pH solution to predict the color of pH indicator when it is added to the solution or mixed.
3.3 The strong-weak acid-base that makes a different pH value of solution at the same concentration. Therefore, the students could understand it by color of pH indicator at the same concentration even with different compounds.
3.4 The buffer solution, the students could understand its properties which keep pH at a nearly constant value by mixing between excess weak acid and strong base in pH indicator solution, and then add other acid-base to it. The students would see the color which didn't change.

④*The element of art lecture; The* instructor started to discuss the chemistry behind arts such as the definition of art, how to create materials that are used in art and how chemistry is related to art. Furthermore, students learned techniques on how to apply water color in their work and basic of visual components of color such as form, line, shape, space, texture etc.

⑤*The 2nd learning activity*; Students returned to the laboratory and repeat the activity that was similar to that of the1st learning activity. Students made laboratory activity relate to the textbook by themselves. They extracted from a natural vegetable that was red cabbage by using ethanol solution to make an indicator. Then, they prepared (for example , HCl) a base (for example, NaOH)and a solution from pH1 to pH14 by calculating acid-base formula and measured pH of each solution by using pH meter. In each solution, red cabbage is added to water and then the pH is checked after each addition and color change. This could be done by using acid - based solution to adjust the color. Afterwards, students brought their color to paint a picture. In the last step, all the students' questions asked last time were re-asked to students. They discussed and shared their previous and new knowledge together. Finally, they helped each other respond to the questions. Moreover, the teacher emphasized important points of the acid-base topics in order to make students understand more clearly. Posttest will be conducted immediately after they finish this final activity.

*Participants*

The subjects in this study were 27 students from the 11th grade. There were8 males and 19 females from the Engineering Science Classroom who enrolled in the first semester in academic year 2016.

*Assessment*

This research used a pre-posttest questionnaire to determine the effectiveness of art-based chemistry activity on students' conceptual understanding of acid-base indicator concepts.

1. Pretest and Posttest

Pretest and Posttest were developed by the authors to assess students' conceptual understanding and application of concepts in chemistry. This test was composed of two parts. Part 1 consisted of 4 multiple-choice questions, where students chose more than one answer from 10 answers in each question with a brief explanation of their choice. Part 2 consisted of an open-ended question.

Part 1;

Each multiple-choice question was worth 5 points. Students' responses were based on understanding basic scientific concepts which were: the definition of acid, definition of base, definition of indicator and acid-base reaction. Students must not only possess basic knowledge, but should also be able to explain, and integrate this knowledge in other fields, as well as applying it in real-life. Furthermore, the points awarded were categorized using the following:

5 points, correct choice accompanied by a complete correct explanation.
4 points, correct choice accompanied by a correct but incomplete explanation.
3 points, wrong choice accompanied by a complete explanation.
2 points, wrong choice accompanied by an incomplete explanation.
1 point, correct choice but wrong explanation.
0 point, wrong choice accompanied by a wrong explanation.

Part 2;

Each open-ended questions was worth 10 points. Student must give 2 examples each of acid and base. Each example that the student gives is a practical classification of acid-base in real-life. Furthermore, the points awarded were categorized using the following:

2.5 points, correct answer for each of example acid and base (total 4 example).
0 point, wrong answer for each of example acid and base.
2. Questionnaire

Methods of assessment include the observation of students' performance as well as self-assessment. The students' assessment questionnaire was administered to investigate the level of enhancement of the students' knowledge after activities. The questionnaire was separated into3 parts. Firstly, students were asked to compare acid-based concepts, knowledge between before and after learning in the 2$^{nd}$activity. Secondly, a total of ten questions were asked to provide and evaluation of the course as a whole and the students' perceived benefit from it. This score based on 5-point Likert scale: strongly disagree (1), disagree (2), undecided (3), agree (4) and strongly agree (5).Finally, an open-ended question was used in the questionnaire to assess understanding of the relation between art and chemistry concepts through hands-on activities.

## 4. Result and Discussion

The art-base chemistry activity was modified by instructors to fit into the learning goals and soft skills and suit the students who were following this activity. After making watercolor and painting pictures, students' results should display a beautiful array of colors ranging from violet blue color to yellow, green, blue, violet and red.

Table 1 : Correspond Color to Approximate PH Range

| pH range | 1 to 4 | 5 to 6 | 7 to 9 | 10 to 12 | 12 to 14 |
|---|---|---|---|---|---|
| Color | Red | Violet | Blue | Green | Yellow |

In table 1,it was concluded that the colors correspond to each pH range. Students asked and discussed the questions relating to their observation when they finished in both activities. The examples of students' questions were "*Why did the color of red cabbage water change to various colors such as red, green, etc. when they added some solutions?", Which solutions are the indicator?", "How do they know what properties of plants can be extracted as an indicator?" "Why color change didn't follow the principle of color combination"*.

We found that the use of hands-on laboratory activities in teaching of acids and bases increased students' understanding. Students can answer their questions after they finished the 2nd leaning activity such as *"Red cabbage water indicator changes color because indicator is an organic compound that had acid-base form. When the solution was more acidic than the indicator, it was acid form. When the solution had more basicity than the indicator, it was base form.", "Indicator solution was the color solution", "The Indicator usually was the plant that had another color other than green.", "The color changed depending on acid-base indicator form. When combining the different color solution, the $H^+$ concentration wasn't constant, therefore color would change by acid-base indicator form."* In this section the results are shown for our teaching and learning activity consisting of 2 sections which are pre-posttests and questionnaire results.

The pretest occurred before any instruction and the posttest occurred on the last day. The pre-posttest consisted of identical questions. We first discuss the result of the first four multiple-choice questions (no.1-4) and then of the open-ended questions (no.5) that were as follows;

1. Select one or multiple answers from list of choices and briefly explain "What is the meaning of a pH indicator"

- ☐ To exhibit the color more than one color.....
- ☐ To identify acid-base concentration.....
- ☐ An ingredient of watercolor.....
- ☐ A salt compound.....
- ☐ The colorless matter that cannot give the color.....
- ☐ A colorless matter in some conditions .....
- ☐ A concentration sensor.....
- ☐ A natural product.....
- ☐ A synthesis compound.....
- ☐ Every substrate that have color.....

2. Select one or multiple answers from list of choices and briefly explain "What is the meaning of acid"

- ☐ It is reported with pOH value.....
- ☐ The substrate that react with base.....
- ☐ The substrate that have color.....
- ☐ The factor that change a color in some case.....
- ☐ A solvent extraction of color compound.....
- ☐ The substrate which give $H^+$.....
- ☐ The substrate which receive $HO^-$.....
- ☐ Every acid is only liquid state.....
- ☐ To give a new compound when react with other substrate.....

☐ The substrate that effect to chemical structure of some chemical substrate.....

3. Select one or multiple answers from list of choices and briefly explain "What is the meaning of base"

- ☐ It is reported with pH value.....
- ☐ To give a color when react with acid .....
- ☐ The substrate that have color.....
- ☐ An ingredient of watercolor.....
- ☐ A solvent extraction of color compound.....
- ☐ The substrate which recieve $H^+$.....
- ☐ The substrate which give $HO^-$.....
- ☐ It can change a color of some color compounds.....
- ☐ It is a factor that can use to extract some natural product.....
- ☐ The substrate that effect to chemical structure of some chemical substrate.....

4. Select one or multiple answers from list of choices and briefly explain "What are the effects of color-change".

- ☐ The light that matter emit.....
- ☐ A chemical structure.....
- ☐ An interaction of molecule.....
- ☐ The energy that release from chemical reaction between acid and base .....
- ☐ The ratio of concentration between acid and base.....
- ☐ An organic compound.....
- ☐ An inorganic compound.....
- ☐ The energy that proton in atom emit.....
- ☐ The energy that electron in atom emit.....
- ☐ The energy that neutron in atom emit.....

5. What are examples of acidic and basic substances? Give more two examples.

Table 2: Pretest and Posttest Score on Students' Knowledge

| Question Topic | Pretest (Mean±SD) | Posttest (Mean±SD) | p-value |
|---|---|---|---|
| The meaning of acid-base indicator | 10.75 ±4.26 | 17.33 ± 4.68 | 0.000 |
| The meaning of acid | 13.33 ± 4.80 | 18.38 ± 5.24 | 0.001 |
| The meaning of base | 11.88± 5.34 | 14.96 ± 4.44 | 0.035 |
| The effects of color-change | 9.46 ± 3.65 | 12.58 ± 5.05 | 0.018 |
| The examples of acidic and basic substances | 9.27± 1.38 | 9.90± 0.51 | 0.042 |

In Table 2, we summarized the pre-posttest results. One way (factor) ANOVA revealed a statistically significant difference between the mean score of pretest and posttest at the p-value 0< 0.05. In the lecture section, students learned chemistry concepts such as the buffer effect, and strong-weak acid-base. It was more abstract. Students could not visualize or understand the chemistry concept or application of buffer. After the students had finished the learning activities, the results from students' discussion and posttest were presented which showed students understood the chemistry concepts more clearly. Students were able to evaluate paint color in the context of acid-base/ pH and each type of indicator. For example, students had more to discuss, and could visualize the chemistry concept etc. This gave them a clear picture of the effect of pH/indicator, change of paint color and an ability to understand the chemistry concept such as strong-weak acid-base, calculation of pH, how the

buffer solution can keep pH constant more easily. Hands-on activity can create a new learning environment that can help students to construct their knowledge. Moreover, question-based and lecture-based learning can also develop logical and inquiry skills.

Table 3: Student Self-Assessment Score in Each Question Topic of Acid-Base Concepts

| Question Topic | Pretest (Mean±SD) | Posttest (Mean±SD) |
|---|---|---|
| Calculate pH values when they know the composition value of $H_3O^+$ and $OH^-$ together | 4.30 ± 0.56 | 4.43 ± 0.59 |
| Explain acidity and basicity of a solution by using the pH values | 4.09 ± 0.60 | 4.26 ± 0.54 |
| Prepare acid and base solutions at different a pH level | 4.13 ± 0.63 | 4.26 ± 0.69 |
| Explain the ionizing ability of strong acids, strong bases, weak acids and strong bases solutions | 4.04 ± 0.71 | 4.13 ± 0.63 |
| Explain how to colors change of indicator | 3.96 ± 0.71 | 4.09 ± 0.67 |
| Use the range of colors on an indicator refer pH level/ acidity and/or basicity of a solution | 4.17 ± 0.65 | 4.30 ± 0.63 |
| Apply indicator knowledge to daily life. | 3.74± 0.69 | 4.00 ± 0.67 |

Students were asked to self-assess their knowledge by answering the following questions with strongly disagree (1), disagree (2), undecided (3), agree (4) and strongly agree (5).The questionnaire asked the students to compare skill and knowledge between before and after learning in 2$^{nd}$activity. The questionnaire results are presented in Table 3. As can be seen, there are seven questions which asked students to provide an evaluation of how they understand the acid-based concepts and students' perceived benefit from it. The mean score for each posttest indicated that most students' ability to obtain an understanding of acid-based concepts had increased. Although the overall mean score of posttest was higher than pretest, the difference between the two was not statistically significant.

## Conclusion

The results show that painting activities can enhance students' understanding about acid-based concepts and encourage students to realize the link between art and chemistry. For example, students can conclude that red cabbage juice is an indicator that changes color because its hydrogen ion concentration changes when dropped in each pH solutions. Furthermore, students understood that acids produce ions in aqueous solution (pH < 7) and based contain hydroxide ions (pH > 7). At a pH 7, both of acids and based was neutral. Students were able to evaluate paint color in the context of acid-base/ pH and each type of indicator. For example, students had more to discuss, and visualize regarding the chemistry concept etc.

However, this hands-on activity has some limitation regarding the red cabbage color. When students painted the color onto fabric, it would fade until it becomes colorless. Namely, researchers may improve our approach to acid-base concepts by integrating other arts activities and new teaching methods. Moreover, researchers may also improve assessment methods by using pre, post-interviews to gather more information about students' views and conceptions related to acids and bases for improving their understanding about the actual concepts.

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