Learning Acids and Bases Through Inquiry Based Website

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Abstract - Chemistry is not an easy subject to learn. Many people regard chemistry as being too hard, too abstract, too mathematical, and only for very bright students. As a result, a negative attitude has developed about chemistry with students claiming chemistry is boring. Besides, most of the chemical concepts articulated by macroscopic, microscopic, and symbolic. This led to conflict and confusion in learning chemistry. Thus, the purpose of this project is to develop a web based learning material on Chemistry Form 4 based on Integrated Curriculum for Secondary Schools (KBSM) syllabuses. This website enables users to learn on their own about the topic of Acids and Bases. Constructivism theory and inquiry based learning approach were integrated in the development of this website. The main subtopics contain in the website are “Concept and Chemical Properties of Acids and Bases”, “Role of Water to Show the Properties of Acids and Alkalis” and “Strength of Acids and Alkalis”. This website was developed using Macromedia Dreamweaver 8 as the main platform whereas Macromedia Flash 8, Adobe Photoshop CS2 as well as Sound Forge 7 were used as supportive software. Finally, it is hoped that this website will become as a reference for students to learn this subtopic and to overcome their misconception about Acids and Bases. Other than that, this website is also useful for teachers and other people to get information more about Acids and Bases.

I. INTRODUCTION

In the new millennium and the era of information technology, education field has moved rapidly towards the integration of technology specifically computers in the teaching and learning process. This is because computer has a great potential for enhancing teaching and learning outcomes. Michael [2] claims that, it is generally believed that ICTs can empower teachers and learners, promote change and foster the development of 21\(^{st}\) century skills. According to Bayrak [3], computer based learning is becoming widespread and it also has been important method especially in teaching difficult subjects in science for over two decades. It is because by using computers, it can motivate students and also can enhance, extend or reinforce their learning in science [4]. Computer based learning is a method, which uses computer as a tool to give students strengthens, motivation and new experiences in gaining knowledge. It also gives opportunities to both students and teachers to learn and teach more quickly in order to achieve an active learning with computer technology [3]. Many researchers have proven the well-crafted use of computer in the learning process compare to traditional method in many disciplines such as Biology [5] Geometry [6], Science [7,8], Chemistry [9], Statistic [10], Sport Science [11], Nursing [12].

Nowadays, learning process is moving towards online application [13, 14, 15, 16]. Online learning as define by Allan and Seaman [17] is when the course where most or all of the content is delivered online. Typically, have no face-to-face meetings in the classroom. According to them this trend is seemed to increase from year to year and until 2008, where there are about 4.6 million students are moving towards online learning. One popular online application has been for educational use is web-based learning. Many studies have shown a web-based learning benefits and the potential to enhance teaching and learning process [18, 19, 20]. In web-based approach, students are able to choose how, when, and where they want to participate in the learning process [4]. In addition, in the term of accessibility the web-based application can be accessed anytime, anywhere and around the globe. Mean that, students can access the website as long as they have a computer together with internet connection. These are agreed by Neo et al. [21] where they said that popularity of the web base learning is due to the concept of learning “anywhere” and “anytime”. Else, other benefit in web-based learning is, the content is easily updated. As compared to CD-ROM application, it must be reduplicated and distributed again. But, through web based, we just need the developer to update files from a local computer to a server-computer. When students connect to the web for the next time, they will already have the latest version [22].

ICT has been integrated into teaching many subjects such as chemistry and others. Bayrak and Dori [23] found that integration of ICT in the process of teaching and learning chemistry can enhance students' knowledge of concepts, theory and chemical structure. Another study also found that ICT provides a positive impact on student achievement as providing a learning environment related to them [24]. By learning via website, students are provided with activities and an environment that allows them to participate actively in the learning process as well as assisted by teachers and peers [25].

II. BACKGROUND OF PROBLEM

Chemistry is one of the branches of science that is important to learn because it enables students to understand the phenomena that occur around them [26]. However, chemical subjects closely related to abstract concepts, and this causes difficulties for students to learn [1]. Students perception towards chemistry as it involves many abstract concept and it’s difficult to imagine. According to Taber [26], students need imagination and higher order thinking to learn and master the chemical concept. Understand the chemical concept is not only known what happened, but students also must know how to apply and explain it clearly and easily. These are the difficulties faced by students when they learn chemistry [1].

Chiu [27], states that several difficult topics in chemistry subject that cause misconception among students are

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chemical equation, oxidation and reduction, electrolysis, mass and acid and base. Misconceptions can be defined as judgmental in view of the tentative nature of science and the fact that many of these conceptions have been useful to the students in the past [28]. Misconception also can be interpreted as one response in which the ideas are not developed align with the actual concept [29].

Many concepts in chemistry are related to each other. One of the basic concepts of chemistry and important to learn is acids and bases topic [32]. Many studies have shown that many students have difficulties in understanding the concept of acids and bases [28, 29, 30, 31, 32, 33, 34, 35, 36].

The study conducted by Cros et al. [31] shows that students are not able to explain concrete phenomena that occur behind the reaction of acids and bases. Students also fail to give examples of weak acids and bases and claim that pH scale as a tool for measuring the degree of acidity only. His research in the next two years in 1988, also states that students defined acid as a substance that has a pH less than 7. This is contrary to the definition given by the Arrhenius that acid is a release of hydrogen ions (H⁺) when the substance reacts with water.

Ross and Munby [32] reported that students defined acid as a sour taste and produce heat. The difference between the theoretical definition of Bronsted and Arrhenius were misleading the students. The concept of donor and recipient of atoms was proposed by Bronsted-Lowry and the concept of donating and accepting hydrogen ions (H⁺),was used in the Arrhenius theory. Students found to be very difficult to see the continuity between these two theories in explaining the definition of acids and bases [34].

Hand and Treagust [33] has identified a number of misconceptions among students on the topic of acids and bases. They think that acid is a substance that only gives erosion of a material such as wood and iron and the process of neutralization is the process of removing acid. The study conducted by Barker [36], says that students like to explain the meaning of the acid using the word “eat” or corrosive materials without refer to the particle content. Although students know how to measure the pH and know the nature of corrosive acid, but students still find it difficult to relate the features and the properties of acids with the particles contain in the substance.

Next, in 1993, a study was conducted by Nakhleh and Krajcik [35], obtained three key ideas in the concept of acids and bases among the students. First, the acid and base does not respond each other, but only form a physical mixture. Second, when acids and bases react together, they will stick together to form a particle. The third concept, the students felt that the reaction of hydrogen ions, (H⁺) and hydroxide ions, (OH⁻) is only suitable to form a soluble salt rather than the reaction of neutralization. The study conducted by Horton [28] at Arizona State University also has listed two misconceptions that often occur among students. They claimed that chemical reaction occurs when acid is added to the base. Second, students also defined the process of neutralization is the process of repealing the hydrogen ion (H⁺) and hydroxide ions (OH⁻).

Chiu [29] in the study also proposed four students' misconceptions in this topic. First, students felt that the properties of the solution of acid and base were more or less the same. Second, students couldn’t explain the process of neutralization clearly. For example, they said that when the sodium bicarbonate and acetic acid were mixed together, they became neutral. Third, students assumed when there is more hydrogen molecules in the acid, the stronger the nature of the acid and then the fourth, the students assumed that hydrogen molecules can be dissolved in the ionic solution only. Referring to all the misconceptions that have been listed, students will have difficulty in learning related topics, such as chemical equations and chemical reactions as described by [30].

In addition, apart from the chemical concept that is difficult to be understood, the way of the content being delivered by teachers can also influence the effectiveness of student understanding. Chemistry methods should undergo a paradigm shift from traditional methods to alternative approaches such as collaborative learning, self-learning, and problem-based learning through interactive multimedia, which involves students actively in the teaching and learning process. Demircioğlu [30] suggested that teachers should use materials, aids and teaching strategies that encourage students to think actively, especially in helping students develop the concepts of acids and bases.

Thus, in overcoming students' misconceptions and boredom of the acids and bases subtopics, the developing of multimedia application such as website can improve the quality of learning. Nakhleh and Krajcik [35] has suggested that the best way for teachers to teach chemistry, especially topic that involve abstract concept such as acids and bases topic is via the computer-based activities. This is evidenced by Idris et al. [37] which students had improved in achievement from pre to post test when they have learned acids and bases subtopic using multimedia software.

III. OBJECTIVES OF STUDY

The objectives of this project is to develop an interactive acids and bases web sites based on form four Integrated Curriculum for Secondary Schools (KBSM) with the following features: -

i. Implementation of constructivism theory and inquiry based learning as an approach.  
ii. Incorporate multimedia elements such as text, graphics, audio, video and animation.

IV. DEVELOPMENT PROCESS

The process of developing a website especially in the education requires a long period and systematic planning. This is to be done to ensure that the website is achieving the objectives that have been set. A developer must follow several steps as a guide in designing a website. For the purpose to develop this website, developer chooses the Hannafin & Peck (1998) model. Rationally, this model consists of three phases as well as easy to follow and the assessment phase can be done continuously.

This model is simple and suitable for use in computer-based learning. This model consists of three phases, which are Need Assessment Phase, Design Phase and Development and Implementation Phase. Besides the three main phases in this model, there is another phase called Evaluation and Revision phase that is continuous to every phase of the three above. The evaluation process is an on going process. This
is to facilitate developer to improve website from time to time. In addition, by repeating the process of evaluation the developer can ensure that the website achieve the goal.

A. Need Assessment Phase
This phase involves the analysis of user, the learning environment, the content of the topic, objectives to be achieved, and the goal of teaching. Analysis of users, especially students, is including their prior knowledge, gender, age, level of learning and learning style.

a. Analysis of user
The target group for this website is form 4 and 5 students of secondary schools. However, other students can also use this website to obtain information of acids and bases subtopic. Before learn this topic, students have their previous knowledge about "Periodic Table of Elements" and "Chemical Bonding" which, in this subtopic, the students learn the characteristics of elements, compounds, and also the formation of the compounds.

b. Analysis of content
This phase is to identify the problems’ faced by students in the acid and base topic. The objectives to be achieved by students after using this website are :
• State the meaning of acid and alkali according to Arhenius theory.
• List the properties of acid and alkali compound.
• Explain the role of water to show the properties of acid and alkali.
• Explain the relationship between pH and the strength of acids and alkalis.
• State the differences between strong acid and weak acid and the differences between strong alkali and weak alkali.

In addition, this phase is needed to determine appropriate strategies and an approach that is align with the objectives to be achieved. Therefore, the application of constructivism as the learning theory with inquiry based learning approach is in place to achieve the objectives that have been targeted.

B. Design Phase
The phases include in the design phase are information design phase, interaction design phase and interface design phase. In the information design phase, the flow chart of the website was produced and the developer implements the theory and approach chosen for the site which is aligning with the learning objectives. In this context, the presentation of information or the content in this website is following the learning objectives. In this context, the presentation of information or the content in this website is following the learning objectives. In this context, the presentation of information or the content in this website is following the learning objectives. In this context, the presentation of information or the content in this website is following the learning objectives.

For each subtopic, learning process begins with a picture or a situation that raises questions and curiosity among user. This feature is applied in the "Have You Ever Wondered?" section. Subsequently, a number of hypotheses formed by users are shown in the section of "I Think That ...". From the hypotheses that have been listed, students can do the investigation in the "Let's Investigate" section. Finally, after students completed their investigation, students can test what they have learned in "What Have I Learned?" section.

To the right of each page, developer specifies the learning objectives that must be achieved by the students and the students’ prior knowledge. Besides, the developer provides a listing of science information in "Pit Stop "corner", so that user can see how acids and bases exist around them. Finally, there are the navigation buttons provided for the users such as forums, chat and e-mail. This navigation is applicable whether after or while they are in learning mode. This also enables users to interact with friends or other users.

V. THE WEBSITE OF ACIDS AND BASES
This website contains six menus such as Home, Learn, Quizzes, More Info, Help, and Web Master. This website is developed by applying the theory of constructivism and inquiry as the learning approach. In addition, to the use of text and diagrams, the use of multimedia elements such as animation, video and audio as well as a medium to convey the information for this topic acids and bases.

C. Development and Implementation Phase
The development process is carried out with the help of programming system, authoring, graphics, audio, video, software and others. Software used to develop this website is Macromedia Dreamweaver 8. Else, the Macromedia Flash *, Adobe Photoshop CS2 and sound Forge 7 also have been used to develop animations, edit pictures and record sounds.

For the interface design phase, developer creates the interfaces that can connect between the users and computer. The interface consists of several elements such as background screen, panels, buttons, and multimedia elements such as text, graphics, animation, audio and video.

VI. THE IMPLEMENTATION OF CONSTRUCTIVISM THEORY IN THE WEBSITE
This website implements the constructivism theory because this theory emphasizes student-centered learning. Thus, developer implements the features of this theory that
has listed by Kassim and Kamaruddin [38], Aris et al. [39], Valerine [40]. Table 1 shows where the 12 constructivism characteristics were applied in the website.

TABLE 1
THE IMPLEMENTATION OF CONSTRUCTIVISM THEORY IN THE WEBSITE

<table>
<thead>
<tr>
<th>Constructivism characteristic</th>
<th>Implementation in the website</th>
</tr>
</thead>
<tbody>
<tr>
<td>Encourage student with inquiry process through research or experiments</td>
<td>The &quot;Let's Investigate&quot; section allows students to investigate and find the answers to the problems given at the beginning. Investigation may be made by accessing the website, view video and animation. There are also the experiments that help students to find the answers and to develop a new concept.</td>
</tr>
<tr>
<td>Encourage students to ask questions and dialogue with other students and teachers.</td>
<td>Chat room, forum and email are provided. So students can communicate with other students or teachers. This section also allows students to exchange ideas, share knowledge and make reflection after or during the learning process.</td>
</tr>
<tr>
<td>Students have the opportunity to give any views on any concept.</td>
<td>Use of collaboration and communication tools. Chat room and forums allow students to collaborate (see figure 5).</td>
</tr>
<tr>
<td>Students reflect on the learning process</td>
<td>Students can access the data or information from various perspectives. The websites, animation and video give various learning resources to students.</td>
</tr>
<tr>
<td>Teacher ask student to stimulate students to answer the question.</td>
<td>Students are freely to choose the topic that they want to learn by themselves. Students are free to choose any subtopic available on the website according to their needs.</td>
</tr>
<tr>
<td>Use of collaboration and communication tools.</td>
<td>Students make a hypothesis. The &quot;I Think That...&quot; section help students to develop several hypotheses to a given problem. (see Figure3). Hypothesis formed will be investigated in the &quot;Let's Investigate&quot; section.</td>
</tr>
<tr>
<td>Students can access the data or information from various perspectives.</td>
<td>Helping students to make the relationship between the topics before and the topic will be learn. &quot;Content Relationship&quot; help students to see the relationship between each subtopic they wanted to learn.</td>
</tr>
<tr>
<td>Students are freely to choose the topic that they want to learn by themselves.</td>
<td>Help students to relate the content with their life. The &quot;Pit Stop&quot; section provides the information about the relevance of science topics in their daily life.</td>
</tr>
<tr>
<td>Have a concept map that helps students to illustrate the whole topic.</td>
<td>Have a concept map that helps students to illustrate the whole topic. &quot;Content Mapping&quot; is provided to help students to see the whole topic and also to get information. (see figure 2)</td>
</tr>
<tr>
<td>The learning process for all three subtopics in this website is according to the inquiry model that proposed by harwood [41]. He states that the characteristics of inquiry learning were make an observation on the problem given, forming questions, scan the existing knowledge, make a hypothesis, conduct an investigation, make a reflection on what they have learned and lastly share with others.</td>
<td></td>
</tr>
</tbody>
</table>

A. "Have You Ever Wondered?" section

For the three subtopics in this website, the developer provides the difference situation for each subtopic. It can be image, animation or simulation that raises the question in students’ mind. For example, for the subtopic "Role of Water to Show The Properties of Acids and Alkalis", developer provides an animation of the changes of red litmus paper to blue colour when it was placed in a wet soap. After making an observation, the question “Why does the litmus paper turn from red to blue colour when it is in contact with wet soap?” was formed (see Figure 1).  

B. "I Think That..." section.

"I Think That ..." is a section where the developer lists a number of possible hypotheses that students consider when making an observation on the images or situations given in the section before. Besides, students also had an opportunity to reflect on their prior knowledge in the "Flash Back" section. Four hypotheses are listed and students are required to guess which one is the correct answer. The "Which one is true" button will take students to a new page that allows them to do an investigation to prove their hypothesis. (see Figure 3)

C. "Let's Investigate" section

This section helps students to find answers regarding the problem given by using a number of multimedia elements such as animation and video. Answers to the questions and hypotheses that were formed will be investigated and proved in this section. All the multimedia elements also help students to develop a new knowledge related to the topics studied.

D. "What Have I Learned?" section

After the learning process, students will test to choose several answers to the problems given before. There are several answers that have been listed. Students must select the correct number of the answers. In addition, students can also see whether the initial hypothesis is formed in the "I Think That .." section was rejected or accepted. Students can choose the answers by pressing the "Let's Check Your

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Figure 2 : Content Mapping

Figure 3 : "I Think That..." section
Answer” button, then students need to enter the answer by typing the number in the space provided. (see Figure 4)

E. Chat and Forum section

To enable students reflect on their learning, the developer has provided a forum site. Students can also discuss and share the knowledge with others. In addition, this forum is designed for students to provide feedback, comments or suggestions on the topics they have learned. What important is, via this forum the developer can see the effectiveness of student learning and see whether they are having a problem or not. Besides forum, chat rooms were also provided by the developer to allow students to collaborate with others while learning mode occurs. (see Figure 5)

![Image of the What Have I Learned interface](image)

**Figure 4 : “What Have I Learned” interface**

**Figure 5 : Chat room**

VIII. EVALUATION OF THE WEBSITE

A. Evaluation by the design expert

The evaluation for the web page design was carried out by three experts. The instrument used was a questionnaire Table 2 is the result of evaluation made by them.

<table>
<thead>
<tr>
<th>No</th>
<th>Information design</th>
<th>1</th>
<th>2</th>
<th>3</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>The content presented is easy to understand</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>2</td>
<td>Delivery of content and the information is well organized</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>3</td>
<td>The software is easy for students to understand concepts related to the basic concepts of &quot;Acids and Bases&quot;</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>4</td>
<td>The question given in the website easily understood by students</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>5</td>
<td>The language is easy to understand</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>6</td>
<td>Example given is realistic and clear</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>7</td>
<td>Users can control the speed of presentation of information in this website</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>8</td>
<td>Users are not lost when exploring the website</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>9</td>
<td>Users easy to explore and get the required information</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
</tbody>
</table>

B. Evaluation by the content expert

The content experts were expert teachers for chemistry subject. They had more than ten years in teaching chemistry. For this evaluation purpose, developer interviewed three expert chemistry teachers. They said that the main advantages found in this website are the implementation of constructivism theory and inquiry approach where students are actively involved to develop their own knowledge. This is because, this theory is implemented student-centered learning, students learn via exploration, student learn independently and able to construct their own knowledge. For the inquiry purpose, the situation given at the beginning raises curiosity among students and the investigation process to prove the hypothesis are some of this inquiry features. The results of the interviews with experts also found that application of the theory and approach in this web site make it a new learning medium.

In addition, forums and chat rooms provide opportunities for students and users to collaborate with others. Besides, it can be used to exchange ideas, suggestions, and reflection on the topics that had been learned. Hence, apart from the use of text and graphics, this website also integrates other multimedia elements such as animation, audio and video. Animation that was developed help students and users to understand the topics being taught. They also stated that the multimedia elements like this make students more fun and enjoyable to learn.

However, the experts suggest to integrate the experiment by simulation in order to make students investigate by their own. This is because students can run the experiment and make it try and error in approving their hypothesis. This make students become more critical and creative thinker.

C. Evaluation by the learning theory and learning strategy expert

The expert of the constructivism theory was agreed that the website was implemented all the constructivism characteristic as listed in Table 1. For the evaluation for strategy in the website, Table 3 is the result made by the experts.

<table>
<thead>
<tr>
<th>No</th>
<th>Learning strategy</th>
<th>1</th>
<th>2</th>
<th>3</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>The forum and chat room help students to understand more</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>2</td>
<td>The objectives are stated clearly and can be achieved</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>3</td>
<td>The approach selected is suitable with the topic</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>4</td>
<td>Users are encouraged to be creative and</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
</tbody>
</table>
IX. CONCLUSION

As a conclusion, hope that the developed website could be used as an alternative by students and teachers to study the topic "Acids and Bases". Hence, this website also expects to be one of the support teaching materials in schools today. This is because the website allows students to learn by themselves at any time and any where. In addition, the use of English as the medium can also help to improve students’ confidence as long as they learn using English in Science and Mathematics subjects.

REFERENCES


