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Experiences with a hands-on activity to enhance learning in the classroom

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ABSTRACT: In this article, the author's experiences with a bio-energy hands-on activity to enhance learning are presented. The study described here was the design and implementation of a laboratory activity to assist teachers in achieving their teaching objectives. The activity combines biomass energy and bio-ethanol knowledge; exploring voltage polarity; ethanol fuel consumption; exploring the effect of varying fuel concentrations; creating electricity with different types of alcohol; exploring the effects of temperature; data summary; and developing instructional materials. These laboratory processes were introduced in a Taiwanese junior high school. The processes effectively introduced students to bio-energy technology through hands-on activity. The objective of the activity was for students to gain, not only an understanding of the concept of energy education, but greater confidence in investigating, questioning and experimenting with renewable energy ideas. This hands-on activity proved effective in introducing students to the concept of bio-energy via activity evaluation.

INTRODUCTION

Traditionally, the renewable energy laboratory activity has not been part of the K-12 curriculum. Thus, it is not surprising that most teachers lack a firm understanding of bio-energy practices, uses and concepts. Few teachers learned about bio-energy laboratory activity while in school. Therefore, for a teacher to feel comfortable integrating it into their class generally will require that they engage in teacher professional development that focuses on bio-energy concepts and pedagogical strategies to teach this discipline [1]. Renewable energy is an ideal topic for junior high school classrooms. Teachers can use a unit on renewable energy to teach basic scientific principles: converting energy from one form to another or generating electricity. Energy efficiency and energy awareness has been known to be the most significant problem [2]. Teachers can incorporate laboratory activities on renewable energy into a unit on the environmental impact of energy use.

Teachers constantly are seeking new ways to actively engage students. Actively involving students leads to deeper questioning, improved attendance and longer lasting interest in the subject, compared with lecturing alone [3][4]. Hands-on activities and demonstrations have been developed and documented for teaching students [5]. Some laboratories use technology and hands-on manipulative tools to discover concepts and theorems [6]. Laboratory instruction helps students develop their experimental skills and ability to work in teams, learn to communicate effectively, learn from failure, and to be responsible for their own results [7]. Teachers often are expected to design instructional activities that integrate theoretical knowledge and promote students' creative thinking [8]. According to interview statistics, constructivist learners tend to explore deeply the involved concepts of laboratory activities, and it results in richer understanding [9]. Learning through hands-on activity has proved a great success. Educational gaming activity has been progressively perceived as a very effective tool for improving teaching-learning in education. The use of such play-based methodologies for education could promote several practical and communication skills of great value to students' future professional development. At the same time, it may motivate students and make them more aware of their own capabilities and the learning process.

In developing the experimental module for this student hands-on activity, the first goal was to capture and maintain the attention and interest of the student. To make the content attractive, a lot of attention was paid to constructing clear and straightforward ways of introducing teaching concepts. The philosophy of education gains its roots from Piaget's constructivism, which describes a learner as actively constructing knowledge instead of simply receiving knowledge transmitted from teacher to student. Hands-on learning environments are beneficial to student attitudes and learning [10].

Shyr developed several laboratory activities that provide convenient and flexible methods for teaching students about photovoltaic systems [11]. The key areas explored in laboratory activities were: experimental set-up, operating instruments, constructing photovoltaic cells, measuring irradiance, measuring light, measuring temperature change and data summary. Shyr presented a wind power system laboratory activity and an outline for evaluating student performance. The laboratory teaching activities introduce energy sources, wind energy technology, electricity storage, and wind power system testing [12]. Wind power system testing activity includes eight topics: setting up the experimental module; operating instruments; wind velocity measurement; rotor diameter activity; wind speed activity; blade angle activity; blade number activity; and data summary. Laboratory hands-on activity effectively introduced students to wind energy technology through activity participation.

This study developed several laboratory activities that provide a convenient and flexible way for junior high school students in Taiwan to learn about bio-energy. These activities combine the biomass energy and bio-ethanol knowledge, exploring voltage polarity, ethanol fuel consumption, exploring the effect of varying fuel concentrations, creating electricity using different types of alcohol, exploring the effects of temperature, data summary, and developing instructional materials. The syllabus is also complemented via instruction Web and teaching materials. These hands-on activities help students gain bio-energy concepts. The current work also presents a development and validation process for technology design. This work accelerates the laboratory experiments to provide students the opportunity to conduct laboratory work within a set time. By minimising the time spent familiarising students with laboratory equipment and basic principles, they can complete the actual laboratory activity in the shortest possible time [13].

The remainder of this article is organised as follows: the next section gives the purpose and contributions overview. The following sections present: the knowledge of energy sources, the hands-on activities, the evaluation of the activities and, finally, conclusions are drawn in the last section.

PURPOSE AND CONTRIBUTIONS

Research published previously forms the basis of this article, describing the hands-on activity in detail [11][12]. This section points out the additional contribution of this article, and illustrates its didactic goal. This study introduces the apparatus, highlighting its simplicity and low cost, and describes the laboratory activity titled the bio-energy system. In that context, this study focuses attention on experiments aimed at acquainting the students with laboratory hands-on activities: the biomass energy and bio-ethanol knowledge, exploring voltage polarity, ethanol fuel consumption, exploring the effect of varying fuel concentrations, creating electricity using different types of alcohol, exploring the effects of temperature and data summary.

This article makes the concept of bio-energy basic and general, so as to be suitable for most junior high school students. This study first contributes a set of experiments on bio-energy and provides the necessary laboratory activities. The laboratory has to serve many students. Therefore, this study focuses on the syllabus, organising the activity and on resource allocation. Thirdly, this study also provides junior high school students with a variety of activities to broaden their knowledge of the bio-energy system. Finally, the laboratory activity makes the module easy to use by students. The activity helps students gain not only an understanding of generating electricity from bio-energy, but also a greater confidence in investigating, questioning and experimenting with renewable energy ideas.

ENERGY SOURCES

Students first are given an introduction to the different types of energy sources, which covers the following basic information. Major energy sources are currently in use throughout the world: wind, solar, hydropower, geothermal, biomass, bio-energy, hydrogen, ocean wave, petroleum, natural gas, coal, uranium and propane. Energy sources are classified as renewable and non-renewable. Renewable energy sources can be replenished within a short time while non-renewable sources may take millions of years to form, and their supplies are limited. The above energy sources can be classified into two categories: (1) Renewable Energy – wind, solar, hydropower, geothermal, biomass, bio-energy, hydrogen and ocean wave; and (2) Non-renewable Energy – petroleum, natural gas, uranium, coal and propane [14].

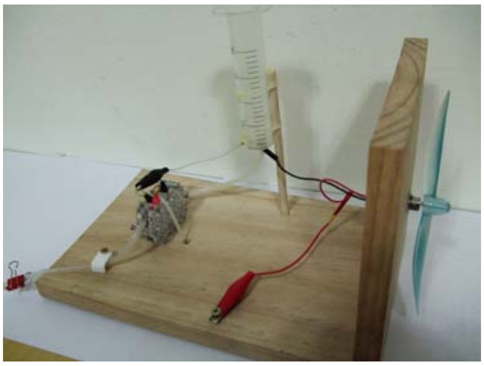
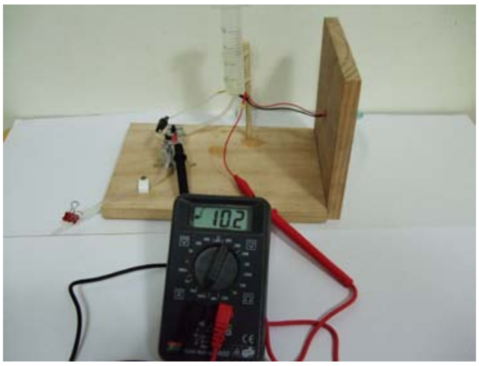
All energy sources have environmental, economic and societal costs. Advocates, governments and bureaucracies place different emphasis on the relative importance of these factors. The availability and cost of energy are determining factors in the economic health and growth of societies. The sooner clean, non-polluting renewable energy provides a significant proportion of energy needs, the sooner all can benefit from cleaner air and a stable climate.

HANDS-ON ACTIVITIES

Methodologies for hands-on learning in the classroom have been proposed to help shift the focus from the teacher to the student [15]. The teaching methodology in laboratory activity is threefold. The teacher first demonstrates how students can relate already familiar concepts to bio-energy associated with other renewable energy. This step helps students grasp the underlying idea behind the energy information they have gained from previous learning. Second, students are shown how they can use this acquired knowledge to construct a set of experiments on the bio-energy that presents necessary laboratory hands-on activities. As a final part of this laboratory activity, students are asked to apply the already-known concepts to the new application to which they had been exposed in the earlier part of the activity.

The purpose of this hands-on activity is for students to construct a bio-energy system. The defined activities are at an appropriate level for junior high school students. A panel of experts, including experienced researchers, university professors and experienced engineers, evaluated these activities; they concluded that the teaching materials and experimental equipment were suitable for students. Eighty junior high school students in Changhua in Taiwan participated in the natural and live technology course for one hour a week over a period of six weeks. Table 1 shows the topics and contents for hands-on activity.

Table 1: The topics and contents for hands-on activity.

Activity	Topic	Contents
1	The biomass energy and bio-ethanol knowledge 	a) Bio-energy is the energy derived from the biomass. So bio-energy can be electricity as produced from biomass. It can be any kind of energy produced from biomass. Biomass is the fuel and bio-energy is the energy contained in the fuel. b) Bio-fuels are generally in the form of alcohols, esters, ethers and other chemicals produced from biomass. c) The two main types of bio-fuel are bio-ethanol and biodiesel. Bio-ethanol fuel is mainly produced by the sugar fermentation process. Biodiesel can be produced from straight vegetable oil, animal oil/fats, tallow and waste cooking oil. d) The mechanism is as follows: Anode: $(1) C_2H_5OH \rightarrow CH_3CHO + 2H^+ + 2e^-$ $(2) C_2H_5OH + H_2O \rightarrow CH_3COOH + 4H^+ + 4e^-$ $(3) C_2H_5OH + 3H_2O \rightarrow 2CO_2 + 12H^+ + 12e^-$ Cathode: $4H^+ + 4e^- + O_2 \rightarrow 2H_2O$
2	Exploring voltage polarity 	a) Connect the positive (red) crocodile clip to the positive side of the fuel cell (red "+" mark), then connect the negative (black) crocodile clip to the negative side of the fuel cell (black "-" mark). It will be noticed that the fan turns clockwise. b) Now repeat the process. This time, however, connect the positive (red) crocodile clip to the negative side of the fuel cell (black "-" mark) and connect the negative (black) crocodile clip to the positive side of the fuel cell (red "+" mark). You will notice the fan turns counter-clockwise. c) The current flows from positive to negative, creating a clockwise spin of the fan. By inverting the polarity connections, the current flow reverses and makes the fan spin in the opposite direction.
3	Ethanol fuel consumption 	a) When the fan begins to run slower or stops running completely, this means the ethanol present in the fuel cell chamber is mostly consumed. In normal temperature conditions, the majority of the ethanol inside the fuel cell chamber turns into acetic acid, which is the main component of vinegar. Investigate the consumed fuel (acetic acid) when the fan begins to run slowly. b) Place a piece of *pH* paper under the outlet of the purging tube. c) Open the valve slowly by sliding the switch towards the right side, and release a drop of the solution on to the *pH* paper, and then close the valve. The paper colour will be seen to change quickly to reddish. d) Dip a new *pH* paper into the solution container. It will be noticed that the colour of the *pH* paper changes very little.

4	Exploring the effect of varying fuel concentrations	a) Make different concentrations of ethanol fuel in the initial mix. For a 15% solution, add 9 ml of pure ethanol and fill water to the level of 60 ml. b) Through experimentation, it will be found that increasing or decreasing the concentration of the ethanol does not noticeably make the fan run faster.
5	Creating electricity using different types of alcohol	Using a 15% ethanol solution and 30% ethanol solution separately, check the run time of the fan. Try using different types of alcohol, such as wines made from grapes or rice instead of the ethanol/water solution as described earlier.
6	Exploring the effects of temperature	Use a hair drier to blow hot air towards each side of the fuel cell or place a warmer ethanol/water solution into the ethanol storage tank. It will be observed that the fan operates at a faster speed.
7	Data summary	At the end of these topics, summarise the data by answering the following questions: a) Write the balanced equation for the chemical reaction that it performs. b) Explain when the fan will turn clockwise. c) Explain how the difference in *pH* paper colouring indicates the change of the acidity level. d) Does the fan run faster when the concentration of ethanol is increasing? e) Does the fan run for longer when the ethanol solution is increasing? f) Does the fan run faster when the temperature is higher?

ACTIVITY EVALUATION

This study utilises activity evaluation to increase standards in terms of teaching, learning and student achievement. Evaluation quality has a marked impact on student willingness to work hard and encourages teachers to focus on ways of improving individual learning attitudes. Evaluation occurs continually because assessing oneself and others are common practice [16].

Based on literature reviews and referring to related research and questionnaires, a laboratory activity evaluation questionnaire is presented in this article. Ten experts were then asked to review the first draft of the questionnaire before it was modified and finished.

The current work introduced this laboratory activity to 80 students in a junior high school. In a continuing effort to improve laboratory activity programmes, the teacher asked students to complete the evaluation items for the hands-on activity as presented in Table 2. In this table the evaluation items and a summary of student feedback are included. The numbers in the table represent the mean, *M*, and the standard deviation, *SD*, of students' responses. Students responded to the items of the questionnaire on a Likert scale, ranging from 1 for *strongly disagree* to 5 for *strongly agree*.

Table 2: Evaluations for hands-on activity.

Evaluation Items	M	SD
1. The activity guide was organised	3.73	0.954
2. The activity guide was easy to follow	3.69	1.026
3. The activities goals were clear	3.60	0.963
4. The activities were more interesting	3.72	0.993
5. The activities were appropriate for your level	3.56	1.135
6. The background information was useful in understanding the content area	3.93	1.028
7. The background information was clearly written	3.56	0.926
8. The key terms were explained, understandable and useful	3.64	0.971
9. The rubrics provided easy-to-measure guidelines	3.63	0.960
10. The materials were well supplied	3.76	0.958
11. The materials helped in the teaching of the activities	3.60	1.001
12. The assessments, overall, provided useful feedback on your progress	3.64	0.958
13. The activities, overall, were useful and motivating	3.71	0.970

This study also develops a laboratory activity for helping junior high school students learn bio-energy concepts, including practices and applications. The results of this study indicate that the proposed laboratory activity is successful. Most students responded positively to these laboratory activities and had no difficulty with the overall activity. Overall student satisfaction with the learning activities was high.

CONCLUSIONS

This study was offered in winter semester of 2009 to 80 students. In keeping with the advances in bio-energy conversion technology and the continued growth in renewable energy, it is important and timely to develop bio-energy hands-on activity. The students can carry out the laboratory activity during class to learn the concepts of renewable energy. The evaluation results indicate that the proposed hands-on activity is successful in meeting teaching-learning objectives. The students in this study were generally excited about, and receptive to, these activities. Students participating in these laboratory activities found them extremely informative and enjoyable.

The materials presented here can be used as the starting point for other teachers who consider offering a similar activity or course on other renewable energy sources.

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