Improving Students" Science Process Skill and Achievement through Experiential Learning: Biodiesel Production

Suyitno

Electric Education Programme, Faculty Engineering, State University of Jakarta

Abstract: ***This study aimed to investigate students' learning achievement and retention biodiesel production by using experiential learning. These experiments included: biodiesel production by using CaO catalyst. Twenty eight students at electric programme, during the fourth academic semester of 2012 were purposively selected as participants. The data collected, included students' learning achievement test scores of, learning retention scores 30 days after the implementation, and a survey of student satisfaction in learning experiential learning were analyzed. Pretest-posttest control group design was adopted for this study with two classrooms. Control group was taught by traditional lecture supplemented with readings on aggressive behavior of and other while experimental group was experienced with an intervention with the same period of time (three hours), and with the same contents and the same learning objectives as control group. Experimental skills test, students' group poster, questionaire, semi-structured interview, and classroom observation were used to gather data. The results revealed that students experiencing an intervention gained better both aggressive behavior understanding and experimental skills than the tradition.***

Keywords: Science process skill, experiential learning, biodieesel production,

1. Introduction

Science process skills allow individuals to solve the problems they face in daily life as scientists do. Science process skills in science education are skills that make students active, give them to learn research methods and the responsibility and provide a permanent learning.

Science process skills are defined by different researchers. Beauomant et al (2001) and Padilla et al. (1984) divided science process skills into two groups as basic process skills and integrated process skills. Basic process skills include observing, classifying, measuring, using numbers, building the space-time relationship, predicting, making conclusion and communicating. And integrated process skills are Interpreting, controlling variables, hypothesizing, defining operationally experimenting, formulating models inferring, communicating and concluding.

The compilation of all these skills is what we call "science process skills" which are always associated with scientific inquiry. The science process skill, as well as being a necessary tool to learn and understand the science, is also an important aim in science education. Not only the scientists, but also all individuals in the society should have these skills in order to be scientific literate, and to solve the problems encountered in daily life (Aktamis, 2009). In this context, the science process skills are defined as the skills which help to learn, provide to gain the discovering and researching ways and methods, increase the permanence of the learning, make the students active, improve the responsibilities of the students, and help them to understand the practical studies, improve the sense of taking responsibility on their own learning (Pekmez, 2000).

While numerous studies have investigated the impact of specific learning experiences on student outcomes, the results are often conflicting, implying that the learning assumptions adhered to may indeed depend on the context rather than strictly on learner age (Knowles,1970).Waheed et al (2016) studied the role of a subsidiary manager as a learning agent in host country networks. His found that experintial leearning To help firms effectively manager

Marieke et al (2016) finding from experimental skills test that students in experimental group showed a significantly higher posttest scores when compared to those of the control group. This is because the students in experimental group had opportunities to set hypothesis, identify variables, design and conduct experiment as well as collecting data whereas students in control group did not have chances to do hand-on activity, instead they were assigned to read article about aggressive behavior of the Taste Lessons Vegetable Menu

Ersen and Muchlis(2015) result show that cognitive process skills should more provide with science centers" visit. Increasing the number of hands-on activity can provide a positive contribution to the development of these skills.. Catherine(2014) found that while lecture and demonstrations yielded similar scores on adult knowledge, learners that engaged in a lecture after a demonstration scored significantly higher than those that engaged in a demonstration after a lecture. Further, lecture after demonstration yielded a significant increase in learners" mean score from before the lecture, while demonstration after lecture did not yield in a significant increase in learners" mean score from before the demonstration

Leslie(2009). This study explores the nature and process of learning in Second Life in a graduate interdisciplinary communication course in fall 2007. Literature suggests that 3-D virtual worlds can be well suited for experiential learning environments. In this study, the actual instructional effectiveness of Second Life as an experiential learning environment for interdisciplinary communication is empirically examined using mixed research methods of journal content analysis, surveys, focus group, and virtual world snapshots and video

The experience-based learning model was developed by David Kolb in 1980s, on the basis of Dewey theory concerned with learning by doing. This model more emphasizes on a learning model by learning activation to build knowledge and skill through direct experience or learning by doing. Experience in the context of "experiential learning" is a certain experience in which knowledge is transferred through certain approach such as observation and reflection and the educational process is administered as formal education program.

Kolb(1984) theorized that learning can only occur when learners first grasp information, either through a concrete experience or through abstract conceptualization, and then transform that information, either through active experimentation or reflective observation. Teacher can either guide students in grasping knowledge through providing them with a direct, hands-on experience, or with a concept taught in a more abstract method, such as lecture can then direct students in knowledge transformation by providing.them with an opportunity to experiment or to reflect. In this learning method a student is demanded to be active and has critical attitude in doing activity to get an understanding and meaning of the activity by doing. Furthermore, the student is also requested to describe the knowledge in both oral and written. In the realization, the experience-based learning model on the basis of Kolb Cycle is divided into 4 stages, i.e. (i) objective determination, (ii) reviewing, (iii) objective validation, and (iv) learning by doing.

The role of laboratories is important in the acquisition of science process skills on the part of students. As is well known, laboratories play a central role in science education. Science educators report that learning tends to be more effective thanks to the use of laboratories (Hofstein & Lunetta, 1982). In addition to the aforementioned importance of laboratories, the experimental techniques used in laboratory applications are crucially significant. Many techniques are used in order to increase the effectiveness of laboratory applications. In parallel with modern learning approaches, the techniques used in laboratories have been transformed in recent years into high level structured activities based on open-ended research rather than teacher-centered ones..

2. Biodiesel

Biodiesel as one promising alternative to fossil fuel for diesel engines has become increasingly important due to environmental consequences of petroleum-fuelled diesel engines and the decreasing petroleum resources. Biodiesel can be produced by chemically combining any natural oil or fat with an alcohol such as methanol or ethanol via transesterification reaction in the presence of acid catalysts. Methanol has been the most commonly used alcohol in the commercial production of biodiesel. Lots of researches on biodiesel have shown that the fuel made by vegetable oil can be used properly on diesel engines (Lai et al, 2016). In fact the energy density of biodiesel is quite close to regular diesel.

Biodiesel production has attracted considerable attention in recent years due to the global energy crisis and awareness in environmental pollution. To date, biodiesel conversion from vegetable oils has been the primary route for biodiesel production (Sivakumar et al., 2011). However, production of vegetable oil based biodiesel competes with food production by engrossing agricultural cropland. A major obstacle to the commercialization of biodiesel production is the high cost associated with the oil feedstock, which makes up nearly 75–85% of the total production costs (Demirbas, 2009). Therefore, low-cost feedstocks such as used cooking oil, spent oil, grease, or low-quality oil are regarded promising high potential feedstocks for biodiesel production (Li et al., 2014).

Many different types of catalysts are used for the production of biodiesel via transesterification reaction, including homogeneous catalysts, heterogeneous catalysts and some enzymes. Although the transesterification reaction rate is relatively fast by using homogeneous catalysts (e.g. NaOH and KOH), but, it has high corrosive nature, it is hard to be separated from the product, it is unable to be reused, and huge amount of wastewater is generated Arun (2015). In contrast, heterogeneous catalysts have the advantages over the homogeneous catalysts, such as, it is easy to handle, separate from the biodiesel product and reuse, which can significantly lower the biodiesel production cost. Among several types of heterogeneous catalysts, CaO-based catalysts have gained more attention as the heterogeneous basic catalysts for biodiesel production because of its non-toxicity, high basic properties and low solubility in biodiesel (Yan et al, 2009)

Biodiesel production process has been successfully intensified with recently developed processing technologies including pyrolysis, dilution, micro-emulsion, transesterification and esterification (Atabani,2012).To enhance the transesterification reaction applied of ultrasound, microwave and supeerfluid critis CO_2 (Mohd Razealy et al, 2016)

In depth understanding of biodiesel production requires the program to incorporate the selected topics of the following disciplines: catalysis and photocatalysis, purification technology, waste and water treatment. In this research it is aimed to determine sscience process skill teacher candidates" use of integrated process skills to find a solution to a problem they faced through an example of a biodiesel production. Also determining Science and Technology teacher candidates" readiness levels when they apply integrated process skills is sub-goal of the research.

3. Method and Sampling

3.1 Sample Collection

The study was carried out in the academic year of 2011-2012 at the electric education programme in State University of Jakarta. The sample group consists of a total number of 68 senior undergraduate students at the. This study was carried out within course of Renewable energy. In this course, some theoretic information related to science process skill was given to the teacher centre. The data was collected by using document analysis technique. This technique has comprised the analysis of written documents which give information about the target situation In the context of the course of the Renewable energy that teacher centre were taught about science process skill theoretically, they were required to determine science process skill in the experiments which they selected. The experentian learning activities related to biodiesel production were implemented for four weeks, and four hours a week. Students were asked to participate in the following process: 1) complete a pre-achievement test related to biodiesel production , 2) perform experiential learning activities related to biodiesel production , in which they were required to submit a group experiential learning activity plan and report prior to and after finishing each activity, and 3) complete a post-achievement test related biodiesel production (parallel to pre-test).

3.2 Laboratory experiment

A laboratory-scale biodiesel reactor of one litre (l) capacity was developed for the production of biodiesel from waste cookingoil by the calcium oxide (CaO) catalyst Methanol was chosen as the alcohol used for the transesterification of waste cookingoil because of its low cost and the alkaline catalyst CaO was chosen since it is cheaper and reacts much faster than acid catalysts. Different variations of methanol (10, 15, 20 and 25 %), CaO (0.5, 1.0 and 1.5 %), reaction time (30, 60, 90 and 120 min) and reaction temperature (30, 45 and 60ºC) were adopted in order to optimize the experimental conditions for maximum ester (biodiesel) yield.

3.3 activities in biodiesel production

Four activities related to biodiesel production (12 hours) were these included : 1) Raw materials used for biodiesel production, (three hours). 2)Types of catalysts (three hours), 3) Biodiesel production technologies (three hours), 4) Physical properties of biodiesel (three hours).each activity was designed as a experential learnin that required student to participate in the four essential feature of inquiry.

3.4 Data Collecting Tools

The collect data in this study consisted of two main tools
1) Achievement test of biodiesel production .The test consisted of 20 multiple choice and 10 essays. The reliability of the test calculated by the Alpha Cronbach was 0.82 and the validity test calculated by
2) Science process skills rubric system. Rated science process skills from their plan prior to the activity and reports after the activity.

3.5. Data Analysis

The collected data in this study included pre- and post-achievement test scores related to volumetric titration and integrated process skills. Paired-sample t-test analysis was performed to identify mean differences between the pre- and post-achievement test scores for this one group pretest and post integrated science process skills were analyzed in terms of means and SDs. Percentages of mean scores in the ranges of 0-50, 51-60, 61-70, 71-80, and 81-100 were interpreted as very poor, poor, fair, good, and excellent respectively.

4. Result and Discussion

The study results were categorized into two aspects, achievement scores and integrated science process skills.

4.1 learning achievement scores related to biodiesel production

The paired-samples t-test analysis indicated that students obtained a post-achievement score (mean 81.56, SD 9.01) significantly higher than the pre-achievement score (mean 16.36, SD 9.01) related to biodiesel production at *p*-value less than 0.05 (Table 2). In addition, the post-achievement score for each topic was statistically higher than the pre-achievement score at *p*-value less than 0.05. The highest gains in content knowledge were in the topics of Raw materials used for biodiesel production23.60%) and Types of catalysts (20.33%), while the lowest gains were in the topics of Biodiesel production technologies (18.88%) and physical properties(18.75%). These results may have been due to the fact that there was just a model (no experiment) illustrating the complexometri and argentometri so the students might not have been able to understand the concepts as well as the topics with corresponding experiments. In addition, there are many factors influencing yield production such as pH, temperature, type of catalyst, time,ratio methanol, so students may have become confused about influences of yield production when two or more factors were present in the reactions being considered.

The questionnaire items regarding Students" knowledge of biodiesel production are provided in Table 2

Table 1: Questionnaire items about biodiesel production

No	Question item
1	What are the raw materials used to make biodiesel?
2	What different production biodielsel from non edible oil and edible oil
3	Can you make energy/fuel with bio-based
4	Can you give example catalyst homogen and catalyst heterogen
5	Why types of heterogeneous catalysts, CaO-base have gained more attention for biodiesel production?
6	Why alkaline and acidic catalysts not usually used for biodiesl production ?
7	What the type process production of biodiesel ?
8	What that mean transesterification reaction ?
9	What would be the benefits of having a biodiesel ?
10	What are the physical properties biodiesel

Table 2: Pre- and post-achievement test scores related to biodiesel production

Topics	Ideal score	Pre test		Post test	
		Mean	S.D	Mean	S.D
Raw materials	15	6.00	1.06	23.60	1.27
Type of catalyst	15	5.84	1.38	20.33	1.18
Biodiesel production technology	15	1.98	4.54	18.88	4.04
Physical properties biodiesel	15	2.54	2.04	18.75	2.58
Total	60	16.36	9.01	81.56	9.08

4.2 Integrated science process skills

Science activity plans and reports were scored in terms of integrated science process skills by the use of the rubric developed by the authors. The study showed that the students achieved a good level (74.52%) inintegrated science process skills. Students were identified e at the skill of identifying and controlling variables and good at defining operationally (68.00%), formulating hypotheses (72.00%), and experimenting skills (74.00%). Interpreting data and drawing conclusion (74.52%). This may have been due to the fact that they had opportunities to practice the skills of identifying and controlling variables, defining operationally, formulating hypotheses, and experimenting skills, which were more emphasized byinstructors during their middle and high school careers. However, they had only a few opportunities to practice theskill of interpreting data and drawing conclusion since many instructors often skipped this time-consuming step. Asa result, the skill of interpreting data and drawing conclusion was less developed.

Table 2: Integrated science process skills

Integrated science process skills	*Ideal Score*	Score			Interpretation
		Mean	S.D	%	
Defining operationally	10	6.80	1.56	68.00	fair
Hypothesizing	10	7.20	1.85	72.00	good
Identifying variables	10	7.15	2.06	71.50	good
Experimenting	25	18.50	2.67	74.00	good
Interpreting data	25	16.30	4.88	65.20	good
Communicating	20	12.45	3.24	74.522	fair

From the data analysis, the four year science undergraduates of the electric engineering education, Jakarta, are facing the problem of defining the scientific skills, especially the understanding of „inference‟, „hypothesis‟ and „definition of operation‟. While in term of communicating the skills, they show weaknesses in writing the intrepreting of operation and the table of results, as well as making measurements. According to Chiappetta & Koballa (2006), "a hypothesis is a generalization that relates to a class of objects or events whereas an inference is related to a specific object or event" . A hypothesis is an "educated guess" (Abruscato, 2004). To formulate a hypothesis, it should be based on observations and inferences. Inferring is to use logic to draw conclusions from what is observed. From the excerpt presented earlier regarding hypotheses and inferences, none of the undergraduates tried to relate observations with inferences and to related inferences with hypotheses. As for defining operationally, Martin et al. (2009) stated that it is to describe what works; explain how to measure variables in an experiment, relationships between observed actions to explain phenomena and to explain relationships by generalizing to other events not observed.

It is to give interpretations of a concept by stating it in terms of what to be done and observed. For this, the understanding among the undergraduates is not too far from the correct definition, however, in practice, not many of the undergraduates correctly stated the definitions of operation in their laboratory reports. Moreover, six out of 12 undergraduates did not write the definitions of operation in any of the laboratory reports analyzed in this research. It could be that the undergraduates perceived that this is not an important part of a scientific investigation because when they were asked during the focus group interview about the purpose to state the definition of operation in an experiment, they said, they did not think that it is necessary to report it.

4.3. Questionnaire on perception of the learning unit

The ten-item questionnaire consists of four criteria; (1) perception on learning approach; (2) perception on learning activities; (3) perception on the science process skills; and (4) perception on the cooperative work was developed and administered to students after completing the intervention (Cronbach‟s alpha = 0.80). Each item consisted of five responses on the Likert scales: strongly agree (5), agree (4), undecided (3), disagree (2), and strongly disagree (1).

Results from questionnaire on perception of the learning unit, classroom observation, and semi-structured interview supported that students have positive attitude toward a developed learning unit. Mean scores from questionnaire ranged from 3.78-4.21 with the highest criteria of cooperative work while the others are nearly the same. The results from semi-structured interviews of the five volunteers‟ students in experimental group also supported the summary. Most students satisfied to use a hands-on activity to enhance experimental skills. Excerpts from the students are as follows: "From this experiment I think understand more about biodiesel aggressive behavior.

"I learned and construct of knowledge by doing experiments myself"

In my previous learning, teacher usually showed power point presentation and read from text book. In doing experiment I study in the real situation and gain the laboratory skill."

I have learnt so much with "doing"

The sessions with „real kids‟ rather than only reading about theories. I have never coached outside of university, so this has been almost perfect for me.

„It was an enjoyable process to collaborate across disciplines such as chemistry, and \physic'"'

Working on this project has provided many opportunities to engage and adapt my communication skills. And because of this, I have gained new perspectives on diversity and teamwork.

„I understood quickly what a delicate situation this was and that in order to avoid''‟

mutiny and potential cataclysmic stall of the project, I changed my WV [worldview] such that my own emotions would not interfere with the sudden stream of information that was coming my way .

5. Conclusion

From this research, it is apparent that science undergraduates at Open Unierciti do not have the correct understanding of interpreting data, communicating and definitions of operation. However, in writing laboratory reports, it seems that they do not face too much of a problem to write the correct inferences and hypotheses. It could be argued that they do not need deeper understanding to be able to state the inference and hypothesis of an experiment. On the other hand, it could also be argued that they might copy a part of the report from text books, reference books or from the past year reports obtained from senior undergraduates – as suggested by some undergraduates involved in the focus group interview. If the later is the stronger possibility, it will not help the undergraduates in improving their scientific skills. Sharifah & Lewin (1993) argued that the less students involved in planning a scientific investigation, the poorer their mastery of scientific skills. If these pre-service teachers fail to master the scientific skills to a level that they can inculcate these skills to their students in the future, the students will only learn science as any other subjects in schools.

It is also the duty of the lecturers to provide opportunities for undergraduates to acquire such skills. One of the ways to achieve this is to let the undergraduates perform real scientific investigations from planning until reporting. During the focus group interview, the undergraduates stated that they actually learn deeper about scientific skills when they were put into a new situation of scientific investigation. They need to read the related materials about a new experiment that they are going to carry out. On the day of conducting the experiment, good questioning from the lecturers also highly facilitate the learning of scientific skills because questions that probe the undergraduates to want to find out more will lead them to plan and perform more investigations. It is through and time to explore as much as they like about a topic using the facilities in the laboratory.

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References

[1] Aktamis, H. (2009). lköretim düzeyinde bilimsel süreç becerilerini kazandrma yöntemlerinin örneklerle incelenmesi, *lk□retmen E□itimciDergisi*, 30, 52-56

[2] Akbar.2016. A review of cleaner intensification technologies in biodiesel production. Journal of Cleaner Production : 1-13

[3] Arun N, Sharma RV, Dalai AK.2015. Green diesel production by hydrodeoxygenation of bio-based feedstock: strategies for design and development of catalyst. Renew Sustain Energy Rev.48:240–55.

[4] Atabani.A.E., A.S. Silitonga, I.A. Badruddin, T.M.I. Mahlia, H.H. Masjuki, S. Mekhilef.2012. Renew. Sustain. Energy Rev. 16:2070–2093.

[5] Beaumont-Walters, Y., & Soyibo, K. (2001). An analysis of high school students' performance on five integrated science process skills.*Research in Science and Technological Education,* 19(2),133-145.

[6] Catherine W. Shoulders,Jarred D. Wyatt, Donald M. Johnson .2014.Demonstrations and lectures about solar energy in Arkansas: The importance of experiential learning.Energy Research & Social Science 4: 100–105

[7] Demirbas, A.H., 2009. Inexpensive oil and fats feedstocks for production of biodiesel. Energy Educ. Sci. Technol. A – Energy Sci. Res. 23:, 1-13

[8] Ersen and Muchlis.2015 The Investigation of The Effect of Visiting Science Center on Scientific Process Skills. Procedia - Social and Behavioral Sciences 197: 1312-1316

[9] Harlen, W. (1999). Purposes and procedures for assessing science process skills. *Assessment in Education: Principles Policy and Practice*, 6(1), 129-145

[10] Hofstein, A. & Lunetta, V. N. (1982). The role of laboratory work in science teaching: Neglected aspects of research. *Review of Educational Research,* 52 (2), 201-217.

[11] Knowles.J. MS. The modern practice of adult education: from pedagogy to andragogy. Englewood Cliffs, NJ: Prentice Hall; 1970

[12] Kolb, D. A. (1984). Experimental learning: Experience as the source of learning and development. Enlewood Cliffs, NJ: Prentice Hall

[13] Leslie Jarmon , Tomoko Traphagan, Michael Mayrath, Avani Trived.2009. Virtual world teaching, experiential learning, and assessment: An interdisciplinary communication course in Second Life Computers & Education 53. 169-182

[14] Li, M., Zheng, Y., Chen, Y., Zhu, X., 2014. Biodiesel production from waste cooking oil using a heterogeneous catalyst from pyrolyzed rice husk. Bioresour. Technol. 154, 345–348

[15] Marieke C.E. Battjes-Fries , Annemien Haveman-Nies, Ellen J.I. van Dongen, Hante J. Meester , Rinelle van den Top-Pullen, Kees de Graaf, Pieter van "t Veer.2016. Effectiveness of Taste Lessons with and without additional experiential learning activities on children"s psychosocial determinants of vegetables consumptionAppetite 105 : 519-526

[16] Mohd Razealy Anuar, Ahmad Zuhairi Abdullah.2016. Ultrasound-assisted biodiesel production from waste cooking oil using hydrotalcite prepared by combustion method as catalyst Applied Catalysis A: General 514 (2016) 214–223

[17] Padallia, M. J., Okey, J. R., & Garrad, K. (1984). The effects of instruction on integrated science process skills achievement. *Journal of Research in Science Teaching*, 21(3), 227-287.

[18] Pekmez, E.. (2000). *Procedural understanding: teachers" perceptions of conceptual basis of practical work.* Unpublished PhD dissertation,University of Durham, UK.

[19] Sivakumar, P., Anbarasu, K., Renganathan, S., 2011. Bio-diesel production by alkali catalyzed transesterification Sanger, M.J. (2007). The effects of inquiry- based instruction on elementary teaching mayors chemistry content knowledge . *Journal of ChemicalmEducation*, 84(6), 1035-1039

[20] Waheed Akbar Bhatt,, Jorma Larimo, Dafnis N. Coudounaris.2016.The effect of experiential learning on

subsidiary knowledge and performance Journal of Business Research 69 1567–1571
[21] Yan S, Kim M, Salley SO, Simon Ng KY. 2009.Transesterification over calcium oxide modified with lanthanum. Appl Catal A: Gen.360:163–70.