

Laboratory Activity Worksheet to Train High Order Thinking Skill of Student on Surface Chemistry Lecture

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Laboratory Activity Worksheet to Train High Order Thinking Skill of Student on Surface Chemistry Lecture

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Abstract. A worksheet has to be a set with activity which is help students to arrange their own experiments. For this reason, this research is focused on how to train students' higher order thinking skills in laboratory activity by developing laboratory activity worksheet on surface chemistry lecture. To ensure that the laboratory activity worksheet already contains aspects of the higher order thinking skill, it requires theoretical and empirical validation. From the data analysis results, it shows that the developed worksheet worth to use. The worksheet is worthy of theoretical and empirical feasibility. This conclusion is based on the findings: 1) Assessment from the validators about the theoretical feasibility aspects in the category is very feasible with an assessment range of 95.24% to 97.92%. 2) students' higher thinking skill from N Gain values ranges from 0.50 (enough) to 1.00 (high) so it can be concluded that the laboratory activity worksheet on surface chemistry lecture is empirical in terms of worth. The empirical feasibility is supported by the responses of the students in very reasonable categories. It is expected that the laboratory activity worksheet on surface chemistry lecture can train students' high order thinking skills for students who program surface chemistry lecture.

1. Introduction

Humans have a great curiosity and this is what distinguishes it from other beings. Curiosity begins early and is needed throughout life. Curiosity comes from the observation of phenomena or natural phenomena that exist around. If this observation continues to find a solution then this observation becomes an initiation in solving the problem. Habituation to be able to see problems and find solutions need to be given especially from an early age.

The purpose of science education is to assist individuals in using science process skills, in other words to define the problems around them, observe, analyze, hypothesize, experiment, summarize, and apply the information they have [1]. The easiest learning habit is through laboratory activities guided by a science-based laboratory activity worksheet to train students' high-order thinking skills.

High-level thinking describes abstract intellectual processes [2]. High-level thinking is thinking at a higher level than simply memorizing or conveying something to someone just as it is conveyed to others [3]. First, the levels of thinking cannot be unmeshed from the levels of learning; they involve interdependent, multiple components and levels. Second, whether or not thinking can be learned without subject matter content is only a theoretical point. In real life, students will learn content in both community and school experiences, no matter what theorists conclude, and the concepts and vocabulary they learn in the prior year will help them learn both higher order thinking skills and new content in the coming year. Third, higher order thinking involves a variety of thinking processes applied to complex situations and having multiple variables [4].

Physical chemistry in the chemistry department has a course that deals with colloid chemistry and surface namely surface chemistry. There are three materials discussed: viscosity, surface thermodynamics (surface tension and adsorption), and colloids. This subject of students is also required

to carry out laboratory activities with four practical titles namely viscosity, surface tension, adsorption, and colloid.

A worksheet is used as a 'prescription' system which consider students only need to carry out practicum procedures that available and not giving students the opportunity to develop their thinking skills. This evidence also has an impact on pre laboratory activities. Students only re-read the practicum procedures and only carry out as listed on the practicum procedure. No student has an initiative to add or replace materials and modify the practicum procedure. Whereas many things can be done for example the title of practicum viscosity, students may add another solvent to compare with the viscosity of the universal solvent (water) in determining the relative viscosity. Thinking, for the purposes of this inquiry, is defined accordingly as that operation in which present facts suggest other facts (or truths) in such a way as to induce belief in the latter upon the ground or warrant of the former [5]. Bloom stated that education should focus on mastery subject and the achievement of higher order thinking as a criticism of the use of utilitarian that simply meant learning as a means of transferring words [6]

Based on the description of facts and expectations that have been submitted, it is necessary to trained high-order thinking skills of students through laboratory activity. The laboratory activity worksheet developed should be both theoretical and empirical valid.

2. Methods

The object of this research is the Surface Chemistry Laboratory Activity Worksheet. The development of this laboratory activity worksheet follows the path of the 4-D Model development model [7]. This model consists of 4 development stages of Define, Design, Develop, and Disseminate, but in this research is limited to develop stage. There are 4 topics that will be conducted by students.

First topic is Viscosity. Viscosity is the resistance to flow which is a property of fluids, both liquids and gases. Second topic is surface tension. Surface tension (γ) is measured as the energy required to increase the surface area of a liquid by a unit of area. Then, the next topic is adsorption. Adsorption occurs when a molecule (adsorbate) that forms a bond to the surface (adsorbent). The last topic is colloid. All materials are capable of scattering light (Tyndall effect) to some extent.

Before conducting experiments, students answered questions that consist of high order thinking skill in pretest. After conducting experiments, students were given posttest that also consist of high order thinking skill. The differences in high-order thinking skills before and after using laboratory activity worksheet were analyzed by calculating the difference in posttest and pretest (N Gain score), calculated by the formula

$$g \geq \frac{\%G - \%G_{max}}{100\% - \%S_i} = \frac{(\%S_f - \%S_i)}{100\% - \%S_i} \quad (1) \quad [8]$$

Table 1. N gain score interpretation

<g>	Criteria
<g> <0.3	Less
0.7 > <g> ≥ 0.3	Enough
<g> ≥ 0.7	High

[8]

20

3. Results and Discussion

3.1. Worksheet Development

The learning achievement of Surface Chemistry course is that after graduating from course, the students are able to understand the surface characteristics of capillarity, surface thermodynamics, adsorption, surfactant, detergent, emulsion, base and aerosol, chemisorption and catalyst so as to develop a conceptual framework to formulate the action or Alternative actions in solving chemical problems in life. Conceptual framework can be gained if students already achieve knowledge by their own way. Conceptual framework that they must gain as follows in equations (2), (3), (4) and (5). When a liquid

flows through a tube, layers of liquid slide over each other and intermolecular forces cause resistance to flow. Viscosity (η) is the ratio of shear stress (τ) to shear rate (D) as equation (2) [9].

$$\eta = \tau / D \quad (2)$$

For water surface tension can be measured by (3)

$$\gamma_w = \gamma_w^d + \gamma_w^h \quad (3)$$

Associative Adsorption occurs when a gas molecule adsorbs without fragmentation. While dissociative Adsorption occurs when a gas molecule adsorbs and fragmentation occurs.

$$\theta = \frac{N_s}{N} \quad (4)$$

where N_s = number of surface sites occupied by adsorbate and N = total number of substrate adsorption sites. When $\theta = 1$, a mono layer exists.

One characteristic of colloid is Tyndall Effect. The noticeable turbidity associated with colloidal dispersions are a consequence of intense light scattering [9].

$$I/I_0 = \exp[-\tau l] \quad (5)$$

where I_0 is the intensity of the incident light beam, I_t is the intensity of the transmitted light beam, l is the length of the sample and τ is the turbidity.

Task analysis is used to identify the task completion stages in accordance with the subject matter of the Surface Chemistry Course. The task analysis are observing the phenomenon, Formulating the problem, Determining the hypothesis, Defining variables, Defining tools and materials, Developing trial procedures, Analyzing and making Conclusion

Concept Analysis aims to identify key concepts to be discussed, systematically compile and detail relevant concepts. The result of this concept analysis is a concept map of Surface Chemistry subject matter and selected materials that can represent the material being studied.

The learning outcome indicators that will be the basis for the preparation of the laboratory activity worksheet are investigating the relative condensed number of a liquid by using water as a comparison, Measuring surface tension of solution with capillary pipe method, Determining θ according to Freundlich on the acid adsorption process by activated carbon, and Understand the colloidal system and its use in daily life

In addition to the pretest and posttest issues, at this stage of design is also prepared Chemistry Laboratory Activity Worksheet. Preparation of this practice guide is called draft 1. Draft 1 is then reviewed in order to gain Draft 2. Draft 2 of the Surface Chemical Laboratory Activity Worksheet was then validated and applied to students currently enrolling the Surface Chemistry course. Validator assessment results are presented in Table 2

Table 2. Result of Feasibility Assessment of Surface Chemistry Laboratory Activity Worksheet

	Aspect to assess	Scoring range	Percentage range	Criteria
1.	Construct	3 - 4	83.33 – 100.00	Very worth
2.	Content	3 - 4	91.67 – 100.00	Very worth
3.	Language and readability	3 - 4	83.33 – 100.00	Very worth
4.	Conformity of High order thinking skill			
	a. Meet inquiry components	3 – 4	83.33 – 100.00	Very worth
	b. Meet the analytical component	4	100.00	Very worth
	c. Meets component evaluate	4	100.00	Very worth
	d. Meet the component of creating	4	100.00	Very worth

Based on the data in Table 1 it can be concluded that the Surface Chemistry Laboratory Activity Worksheet is very feasible or very worth. In terms of construction, the Surface Chemistry Laboratory Activity Worksheet complies with the students' thinking level. This worksheet can also actively involve students as students are asked to find a solution to the problems presented or the issues they must

address. For the Content aspect, the Surface Chemistry Laboratory Activity Worksheet presents phenomena that support the material. Truth content and content updates are also rated between good and excellent.

In terms of language and readability, the Surface Chemistry Laboratory Activity Worksheet uses language appropriate to the student's age, and has used good and correct Indonesian. The terms used are correct, easy to understand, and steady in their use. In general the language and readability aspects get good and excellent judgment from the validators. Approximately 83.33% to 95.83% of students also consider that the language used is easy to understand and uses the term steady, good, and correct.

Aspects of conformity with high-level thinking empowerment get good and excellent judgment from validators. The Surface Chemistry Laboratory Activity Worksheet has been assessed to have fulfilled high-level thinking components including analysis (C4), evaluation (C5), and creating (C6).

In the Surface Chemistry Laboratory Activity Worksheet consists of 4 topics. On the topic of viscosity, students are asked to observe the phenomenon, look for appropriate literature to solve the problem. The next step is to formulate the problem, develop the hypothesis, determine the variables, asks them to determine the variables they will use in the investigation. The determination of these variables should also consider the availability of tools and materials in Physical Chemistry laboratory at Chemistry Department. In other words, that variable can be done in Physics Chemistry laboratory in Chemistry Department. Students work in groups with 3 group members. After students look at the tools and materials available in the laboratory, then they determine the procedures they will do.

On the other three topics, there are some student workflow differences after they have searched for the appropriate literature, they must specify experiment variables before formulating the problem formulation. This is done because the given phenomenon is not as detailed on the topic of viscosity. Finding problems and hypotheses is a very important activity in improving the creativity of science [1]. The sequence of pre-laboratory activities should be done by the students so that they have a stock before carrying out lab work in the laboratory. In this way it is expected to activate their ability to understand problems and make problem solving that their high-level thinking skills become more honed. This is supported by the revelation that higher-order thinking is thinking at a higher level than simply memorizing or conveying something to someone just as it is conveyed to others [3].

3.2. Higher-Order Thinking Skills

There were 24 students divided into 8 groups consisting of 3 people. In the implementation there were 2 groups that got the topic of viscosity and surface tension, 3 groups got adsorption topics, and 3 groups that got the topic of colloid.

After students got pretest, they received a Surface Chemistry Laboratory Activity Worksheet. Each group must complete each stage listed in the Surface Chemistry laboratory activity worksheet before the practicum takes place. During this time span, each group was allowed to discuss the group's thoughts to the Surface Chemistry lecturer. Once each group was considered ready and the procedures prepared by the students already pay attention to the tools and materials available in the laboratory, then each group could implement the settlement plan in the time set. In Figure 1 shows exemplary part in the worksheet that shows high order thinking skills.

SURFACE TENSION

A. Phenomenon
Ana inserts a paper clip of metal on the water in the glass without sinking. When Ana adds detergent on the edge of the glass, the paper clip was moving away from the location of the addition of detergent was then drowned. At other times, Ana dips two handkerchiefs into two containers of water with different temperatures. After 5 second later she lifted it from the water. She saw were two handkerchiefs that have different levels of wetness. Ana thought that this is due to differences in surface tension of water. How do you calculate the surface tension of the water? How to prove it?

Read the literature that you think could help prove whether that happens in the phenomenon is due to the surface tension.

B. Supported literature (and its source literature citations)

C. If you want to conduct experiment so you have to figure out the variables

1. Manipulated variable

2. Respond variable

3. Control variable

D. Make problem formulation

E. Make hypothesis

Figure 1. Exemplary part in the worksheet

Table 3. Pretest and Posttest Scores

Student No.	Laboratory Topic	Pretest		Posttest		N Gain	Category
		Score	Mastery	Score	Mastery		
1	Adsorption	29,2	NM	95,8	M	0,94	High
2	Adsorption	25,0	NM	95,8	M	0,94	High
3	Adsorption	20,8	NM	100,0	M	1,00	High
4	Adsorption	25,0	NM	100,0	M	1,00	High
5	Adsorption	25,0	NM	95,8	M	0,94	High
6	Adsorption	25,0	NM	95,8	M	0,94	High
7	Adsorption	29,2	NM	100,0	M	1,00	High
8	Adsorption	12,5	NM	100,0	M	1,00	High
9	Adsorption	29,2	NM	100,0	M	1,00	High
10	Colloid	16,7	NM	95,8	M	0,95	High
11	Colloid	25,0	NM	95,8	M	0,94	High
12	Colloid	25,0	NM	83,3	M	0,78	High
13	Colloid	16,7	NM	83,3	M	0,80	High
14	Colloid	16,7	NM	100,0	M	1,00	High
15	Colloid	25,0	NM	100,0	M	1,00	High
16	Colloid	20,8	NM	100,0	M	1,00	High
17	Colloid	25,0	NM	62,5	M	0,50	Enough
18	Colloid	25,0	NM	87,5	M	0,83	High
19A	Surface Tension	33,3	NM	100,0	M	1,00	High
20A	Surface Tension	20,8	NM	79,2	M	0,74	High
21A	Surface Tension	45,8	NM	100,0	M	1,00	High
22A	Surface Tension	29,2	NM	100,0	M	1,00	High
23A	Surface Tension	41,7	NM	100,0	M	1,00	High
24A	Surface Tension	41,7	NM	100,0	M	1,00	High
19B	Viscosity	70,8	M	100,0	M	1,00	High

Student No.	Laboratory Topic	Pretestt		Posttest		N Gain	Category
		Score	Mastery	Score	Mastery		
20B	Viscosity	54,2	NM	100,0	M	1,00	High
21B	Viscosity	87,5	M	100,0	M	1,00	High
22B	Viscosity	70,8	M	95,8	M	0,86	High
23B	Viscosity	66,7	M	100,0	M	1,00	High
24B	Viscosity	83,3	M	100,0	M	1,00	High

18 I= not mastery; M=mastery

Based on Table 3 it can be seen that some students have had a good initial trajectory about high-order thinking skills. From the data it can also be seen that the N Gain values range from 0.50 (enough) to 1.00 (high) so it can be concluded that the Surface Chemistry Laboratory activity worksheet is feasible in terms of empirical. Inquiry studies emphasize the importance of helping students understand the key structures or ideas of a discipline so that students actively engage in learning and learning are through personal discovery [10].

The students' ability in designing an experimental procedure scores between 3 and 4. In the activity of preparing the hypothesis one student got a score of 1, whereas in general the score obtained by students between 3 and 4. Students who scored 1 on the activities of composing the hypothesis did not progress from the pretest score. This is because the student was not active in the learning activities in the classroom. The activities of preparing hypotheses and designing procedures are included in the cognitive domain of C6 (creating) and are included in indicators to measure students' high-order thinking skills. This is in line with the opinion of [11], stating that the indicator in measuring students' high-level thinking skills in the C6 (cognitive) cognitive domain is designing a trial procedure and hypothesizing. This empirical feasibility is also supported by student responses. Table 3 shows the percentage of 'yes' responses from 24 students who were the subject of the study.

Table 4 Student Response to Surface Chemical Laboratory Activity Worksheet

Aspect	Percentage
Generating motivation / interest / curiosity.	87.50
Asking you to be creative in solving problems	95.83
The Surface Chemistry Laboratory Activity Worksheet begins with a phenomenon and proceeds to solve the problems contained in the phenomenon	91.67
The phenomenon presented supports the matter.	87.50
You are asked to look for truth content (facts, concepts, principles, laws, theories and scientific processes) through literature and experiments	95.83
Content is up-to-date.	87.50
Beginning with the observation of phenomena in order to understand a concept	100.00
Meet the analytical component	95.83
Meets component evaluating	87.50
Meet the component of creating / creating	100.00
Average	91.01

Based on Table 4 it is known that students respond very well to the Surface Chemistry Laboratory Activity Worksheet. However, 29.17% of students assume that the Surface Chemistry Laboratory Activity Worksheet format (size, etc.) is not appropriate. This is because the column to write literature review of the literature is less broad so that students are still writing on other papers.

4. Conclusions and Suggestion

4.1 Conclusion

The Surface Chemistry Laboratory Activity Worksheet is said to be worthy of its theoretical feasibility and empirical feasibility. This conclusion is based on the findings: Assessment of validator of theoretical feasibility aspects in the category is very feasible with the range of assessment of 95.24% to 97.92%. High order thinking skill of students from N Gain values ranges from 0.50 (enough) to 1.00 (high) so that it can be concluded that the Surface Chemistry Laboratory Activity Worksheet is feasible in terms of empirical. The empirical feasibility is also supported by the responses of the students in very reasonable categories.

4.2 Suggestions

The use of the Surface Chemistry Laboratory Activity Worksheet takes more time when students consult about their flow of thinking in completing the problem-solving procedure. For other researchers expected to anticipate the limitations of time allocation.

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