

Development of Guided Inquiry-Based Student Lab Worksheet on the Making of Pineapple Flavoring

G. Dwiyanti^{1,a)}, A. Suryatna, and I. Taibah

¹Department of Chemical Education, FPMIPA, University of Indonesia

^{a)} gebi.dwiyanti@upi.edu

Abstract. The aim of this research was to develop guided inquiry based student lab worksheet on making pineapple flavour and knowing the quality of worksheet that is being developed. Research methods that is being conducted is research and development that is limited by a preliminary studies (literature studies, field surveys, and preparation of the initial product) and development of the model (within limited testing). The results from analyze the books sources and fields survey showed that the characteristic of esterification lab worksheet that currently available still in the direct instruction form (cookbook). The optimization result of making pineapple flavour experiment that was conducted are the ethanol volume 3 mL, butyric acid volume 2 mL, sulfuric acid 5 drops, saturated NaHCO₃ solution volume 9 mL, and temperature of heating was 80°C. The characteristic of guided inquiry based student lab worksheet that was developed contained phenomenon and instructions that suitable with inquiry stages to guide the students in doing the experiment of making pineapple flavour. The evaluation of designated teachers and lecturers of the developed student worksheet were very good (96,08%). Lab-experiment feasibility achieved by using guided inquiry based student lab worksheets that is being developed based on the inquiry stages that conducted by student were found very good (97,50%) and accomplishment based on students' answer of the tasks in the worksheet were found very good (83,84%). Students' responses of the experiments using the developed worksheet are found very good (81,84%).

1. Preliminary

The chemistry has the nature as a product and as a process. The aim of the 2013n education curriculum is to prepare people of Indonesia to have the ability to live as individuals and citizens who has belief, is productive, creative, innovative, and affective also be able to contribute to the society, nation, state, and world civilization [1]. One of the methods that correspond to the nature of the chemistry and can be used to achieve the objectives of the curriculum in 2013 is the experiment method. In the learning with experiment method students not only get the concept (of the product), but students are also invited to experience the process in got the concept, so students later be able to apply the concepts they earn to contribute to society. Activities of students in learning with experiment methods can improve cognitive ability, metacognitive, psychomotor and attitude [2].

The 2013 education curriculum applies the scientific approach and learning by the pattern called 5 M which are observing, asking, collecting data, associating and communicating. One model that can be used is the inquiry model because the pattern of inquiry learning is similar to the 5 M pattern, which are questioning problems, formulating hypotheses, collecting data, analyzing the data, and making conclusions.



Learning by inquiry learning model is a student-centered learning because learning is compiled based on the principle of search and discovery through the process of thinking. [3] divides the inquiry learning model into three categories; *guided inquiry*, *inquiry-based design*, and *open-ended inquiry*. According to [4] learning by inquiry model can be implemented with the stages of observation, manipulation, generalization, verification, and applications. Type of inquiry appropriate to apply to the high school level learning is guided inquiry, because the guided inquiry learning provided more guidance for students, making it easier for students in solving a given problem.

One of the factors holders of the implementation of learning with experiment method is the availability of lab-worksheet.. According to [5] lab-worksheet is divided into expository lab-worksheet, guided inquiry lab-worksheet, and problem-based lab-worksheet differentiated based on the results, approaches and procedures. The results of analyze of the book sources showed that characteristic of esterification lab worksheet that currently available still in the direct instruction form (cookbook). Cookbook lab worksheet does not make students actively participate in learning because students simply follow the procedures indicated on the lab worksheet. Therefore we need a lab worksheets to make students play an active role, namely guided inquiry based lab-work-sheet.

A number of studies about the advantages of the use of guided inquiry based lab worksheet has been done by [6] on improving students' thinking skills, [7] on students' memory enhancement, [8] on improving students' understanding significantly, and [9] concerning the improvement of the level of student understanding.

So that learning process can be more meaningfully implemented and can equip students to be able to contribute in the society in the future, then the material presented in the learning process should be based on everyday life. Esters have many uses in everyday life, such as a solvent for cosmetics and adhesives, as an ingredient in perfumes, and as food flavorings [10]. Based on the analysis of the authors, in West Java alone, especially in the area of Bandung many food industries that require the supply of food flavoring, such as mango banana, or pineapple flavoring. Therefore, it is necessary for students to do lab works on making food flavoring. Based on preliminary studies that has been done, esterification lab works in schools is still rare, and worksheets that are in school or in the student handbook are still in the form of a *cookbook* that is not yet appropriate for the learning to be applied.

Based on the problem analysis written above, it is necessary for a research concerning the development of students lab worksheet based on guided inquiry to be conducted. The aim of the research is to develop lab worksheet based on guided inquiry and to determine the quality of the lab worksheet. Authors conducted this research to develop the kind of lab worksheet mentioned above on making pineapple flavoring.

2. Methodology

The method used in this study is a research and development according to [11]. The stages of research are as follows: 1. A preliminary study and; 2. Development of a model (limited trial). Sources of data in this study are 13 high school chemistry books circulating in the city of Bandung, 7 high school chemistry teachers in Bandung and Cimahi, three lecturers from the Department of Chemistry Education FPMIPA-UPI, and 40 high school students. The instruments used in the form of sheet analysis worksheets, interview guides, design optimization, observation sheets enforceability stage, inkuiti, students' answers assessment rubrics, worksheets assessment sheet by teachers and lecturers, as well as the student questionnaire responses.

3. Results and Discussion

3.1. Results of Preliminary Study

3.1.1. Characteristics of Lab Worksheet Used in High Schools. Based on the research literature study on the characteristics of esterification lab-worksheet circulating in the field showed that of 13 books were examined only 6 books that contain lab esterification procedures and all procedures are still in the form of direct instruction or cookbook.

3.1.2. Lab Works in High School and kinds of Lab Worksheet Used. Based on the results of a field survey of the implementation and usage of esterification lab-worksheet at 10 high school in Bandung and Cimahi, there are only 7 school that doing experiment of esterification and lab- worksheets that are used are still in the form of direct instruction or cookbook.

3.1.3. Lab Worksheet Characteristics Developed in Conducted Research. To make a guided inquiry-based lab worksheets required an optimized reference lab procedure. Lab procedures that are used as reference material in the manufacture of guided inquiry-based student lab worksheet are created by [12]. Optimization is done to optimize the technical ethanol volume, volume of butyric acid, the amount of concentrated sulfuric acid droplets, heating time, the volume of a saturated solution of NaHCO_3 , and the heating temperature. After the optimization of several variables that have been made, then the optimum results obtained from the experiment of making pineapple flavoring as contained in Table 1.

TABLE 1. Results of optimization on the making of pineapple flavoring

Ethanol Volume (ml)	Butyric acid volume (mL)	The amount of sulfuric acid droplets (drops)	Heating Time (min)	Volume NaHCO_3 Saturated (mL)	Heating temperature ($^{\circ}\text{C}$)
3	2	5	5	9	80

Characteristics developed lab-worksheet containing: 1. Title of the identity of the experiments to be performed; 2. The phenomenon that contains a picture of a situation / problem that can lead students to a question about the problems that must be resolved through lab work to be performed; 3. Direction in formulating the problem; 4. Referrals in making hypotheses; 5. Tutorial experiment containing questions for the design of experiment, direction to determining the material, tools, tool sets and experimental procedure.; 6. Referral to experiment; 7. Referral to data analysis contains questions that lead students to load the relationship between the data obtained from the students experiment with the concepts that have been owned by the students, so that with the analysis of this data will facilitate students in making conclusions; 8. Tutorial prove the hypothesis; and 9. Referral to make conclusions.

3.2. Research Findings on Model Development.

3.2.1. Assessment of Teachers and Lecturers on Developed Guided Inquiry-Based Lab Worksheet on Making Pineapple Flavoring. Assessment of teachers and lecturers on the quality of developed guided inquiry based lab worksheet. Assessment is done by seven high school Chemistry teacher in Bandung and Cimahi and 3 lecturers in the Department of Chemistry Education FPMIPA UPI. Results of the assessment of teachers and lecturers against developed guided inquiry based student lab worksheet can be seen in Figure 1.

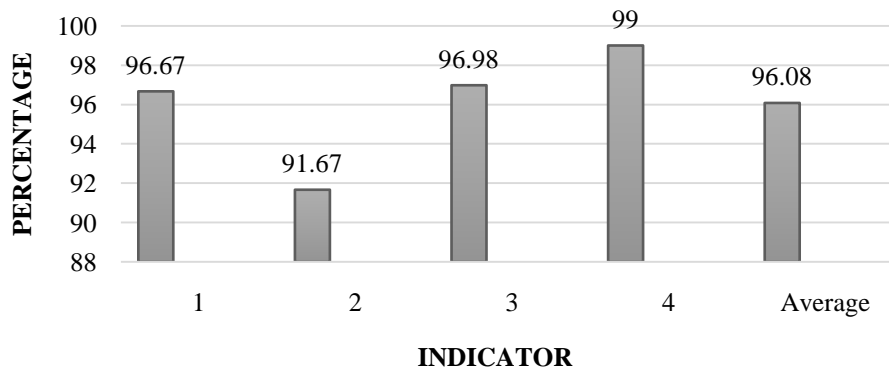


FIGURE 1. Diagram assessment of teachers and lecturers on developed guided inquiry-based student lab worksheet. 1. Conformity with the core competencies and basic competencies; 2. Compliance with the esterification material; 3. The effectiveness of the sentence in developed lab worksheet; 4. The layout and appearance of developed lab worksheets

Based on the diagram in Figure 1 can be seen the results of assessment of teachers and lecturers on developed lab worksheet with an average of 96.08%, which according to [13] belongs to the category of very powerful, meaning the developed lab worksheet has very good compliance to core competencies and basic competencies also esterification teaching material, sentences used are very effective, and the layout and appearance are very good.

3.2.2. Lab Experiment Feasibility. Lab-experiment feasibility using the worksheets were developed aiming to see the extent of adherence to lab work done by the students with the help of direction in developed lab worksheets .. Lab-experiment feasibility using developed lab worksheets viewed from two aspects of the assessment, the feasibility of the stages of inquiry and the students' answers to tasks that exist in the developed lab worksheet.

a. Feasibility of the Stages of Inquiry. To determine the experiment enforceability of use worksheets that were developed based on the stages of the inquiry conducted by the students is done by observing the practical activities undertaken by students. Therefore, placed one observer in each group of students. This is done so that any observer can observe student activities carefully and focus. Figure 2 shows the results of feasibility of the stages of inquiry.

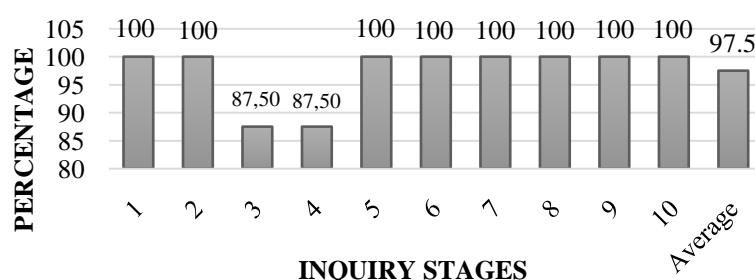


FIGURE 2. Diagram of the assessment results of feasibility of the stages of inquiry 1. Formulate the problem; 2. Make a hypothesis; 3. Choose the material; 4. Select the tool; 5. Make a sketch of tools set; 6. Conducting the experiment; 7. Write the observations; 8. Analysis of observation data; 9. Proving the hypothesis; 10. Make conclusions.

Based on the diagram in Figure 2 can be seen on the observation of the feasibility of the stages of inquiry conducted by the students gained an average of 97.5% according to [13] belongs to the category of very strong, meaning feasibility of the stages of inquiry is very good and lab- worksheets developed capable of directing students conduct inquiry stage.

b. Students' answers to the task given in lab worksheet. Results of the assessment of the students' answers to the tasks that exist in the developed lab worksheet shown in Figure 3.

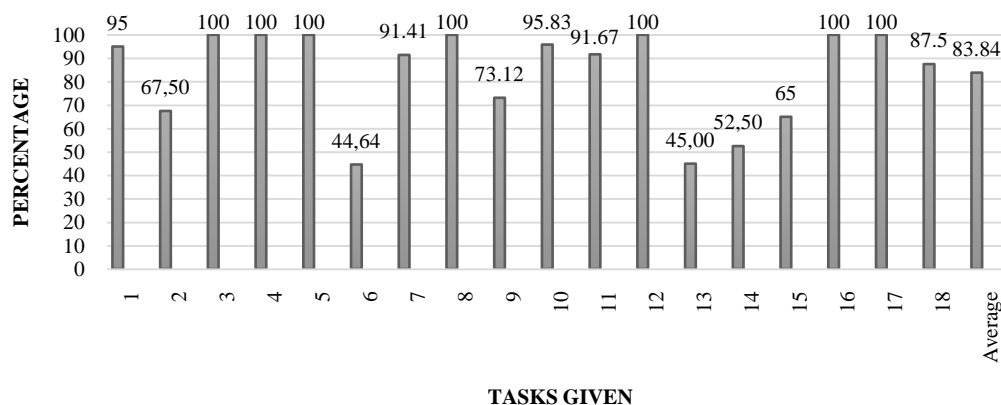


FIGURE 3. Diagram assessment students' answers to tasks given in the developed lab-worksheet 1. Formulating the problem; 2. Making a hypothesis; 3. Answering the question of the direction of the experiment 1; 4. Answering questions referrals experiment 2; 5. Answering questions referrals experiment 3; 6. Answering a question the direction of the experiment 4; 7. Selecting experimental tools; 8. Drawing tools set developed lab; 9. Designing an experiment; 10. Filling the observation table 1; 11. Filling the observation table 2; 12. Answering the question of data analysis 1; 13. Answering the question of data analysis 2; 14. Answering question 3 data analysis; 15. Answering question 4 data analysis; 16. Answering the question of data analysis 5; 17. Proving the hypothesis; 18. Making conclusions

Based on the diagram in Figure 3, it can be seen the average score on the assessment of the students' answers to the tasks contained in the developed lab worksheets is 83.84%. According to [13], the result belongs to the category of very powerful. That is feasibility of the experiment use developed lab worksheet based on assessment of the students' answers to the tasks contained in the developed lab-worksheet has been very good and the developed lab-worksheet capable of guiding students to discover concepts esterification.

3.2.3. Students responses to the use of the guided inquiry-based lab worksheet. The results of the students' response to use of the developed lab worksheets can be seen in Table 2.

TABLE 2. Percentage of Student Responses

Aspect measured	No.	Statement	Percentage (%)
The response of students to the esterification material	1.	Esterification teaching material can be understood easily	83.12
	2.	Esterification teaching material interesting to learn	88.75
	3.	Esterification material related to everyday life	78.75
The response of students to the implementation of experiment using developed lab worksheet	4.	The ease in formulating the problem	77,50
	5.	Ease in making hypotheses	81.25
	6.	Ease in determining the tools and materials	83.12

7.	Ease of sketching tools	78.75
8.	The ease of making an experimental procedure	78.75
9.	Ease of doing experiment	81.25
10.	The ease in filling the observation table	85.62
11.	Ease in analyzing the data	73.12
12.	Ease in making inferences	76.25
13.	Satisfaction in formulating the problem	88.75
14.	Satisfaction in making hypotheses	79.38
15.	Satisfaction in making the experimental procedure	85.00
16.	Satisfaction in using based guided inquiry lab-worksheet to the understanding of concept.	90.00
The average percentage of aspects of the students' response to LKS (%)		81.84

In Table 2 looks percentage score for ease of analyzing the data is 73.12%. It shows students are not too easy in analyzing the data because for analyzing observational data students need to connect this data with the concepts that have been students have until students can discover a new concept. This is in line with the values obtained in the students answered questions on data analysis (Figure 3).

Of all aspects of Table 2 shows the average response of students to the implementation of developed lab-worksheet get a percentage score of 81.84%, which according to [13] classified as category is very strong or very good.

4. Conclusions

Based on the results of research and discussion explained above, conclusions reached are as follows:

1. Characteristics of lab worksheet of esterification circulating in the school are still in the form of direct instruction (*cookbook*).
2. Optimization results of experiment procedure of making pineapple flavoring are the volume of ethanol is about 3 mL, the volume of butyric acid by 2 mL, the amount of sulfuric acid droplets as much as 5 drops, the heating time for 5 minutes, the volume of solution of saturated NaHCO_3 as much as 9 mL, and the heating temperature of 80°C .
3. Characteristics of guided inquiry based student lab worksheets on making pineapple flavoring are as follows:
 - a. Contains phenomenon that guide students to formulate the problem regarding the making pineapple flavoring.
 - b. Contains direction that correspond to the stages of inquiry to guide students doing making pineapple flavoring.
4. Assessment of teachers and lecturers against guided inquiry based student lab-worksheet on making pineapple flavoring is in accordance with core competence and basic competence, is in accordance with the esterification, the use of the phrase in the lab-worksheet has been very effective and has the layout and appearance of lab-worksheet has been excellent.
5. Feasibility of the stage of inquiry using guided inquiry based student lab-worksheet on making pineapple flavoring that conducted by student were found very good and accomplishment based on students answer of the task in the lab-worksheet were found very good.
6. Students' response to the implementation of the guided inquiry based student lab-worksheet on making pineapple flavoring were found very good.

References

- [1] Kemendikbud 2013 *Permendikbud No. 69 Year 2013 About Standard Process SD/MI, SMP/MTs, SMA/MA, and SMK/MAK*. Jakarta: Ministry of Education and Culture.
- [2] Hofstein, A., 2004 The Laboratory in Chemistry Education: Thirty Years of Experience with Developments, Implementation, and Research. *Chem. Educ. Res. Pract.*, 5, 247-254
- [3] Mohrig, et al. 2009 Synthesis and Hydrogenation of Disubstituted Chalcones. A Guided-Inquiry Organic Chemistry Project. *Journal of Chemistry Education*. 86(2). 234

- [4] Wenning, C.J. 2011 The Levels of Inquiry Model of Science Teaching. *J.Phys.Tchr.Educ.* 6(2), 9-16
- [5] Johnstone, A. H. and Al-Shuaili, A 2001 *J of U. Chem. Ed.*, 5, 42-51.
- [6] Wulandari, AD, *et al.* 2013 *Journal of chemical education research and practice*, vol. 1, No. 1, p. 18-26
- [7] Domin, D.S. 2007 *Chemistry Education Research and Practice*, 8 (2), p. 140-152.
- [8] Sessen, B. A. dan Tarhan, L. 2013 *Research Science and Education* .43, p. 413-435.
- [9] Wang, H.P., *et.al* 2014 *Journal of Modern Education Review, USA*, 4 (2), p. 112-118.
- [10] Toon, TY and Kwong, CL 2004 *Chemistry Matters for GCE 'O' Level*. Singapore: Federal
- [11] Sukmadinata N S 2012 *Methods of Education* (Bandung: Youth Rosdakarya)
- [12] Rahayu, I. 2009 *Chemistry for Class XII High School / Madrasah Aliyah Program Natural Sciences* (Jakarta: Ministry of National Education)
- [13] Riduwan 2007 *The scale of measurement of the study variables* (Bandung: Alfabeta)