**JTK: Jurnal Tadris Kimiya 6, 2 (December 2021): 167-173**
**Website:** http://journal.uinsgd.ac.id/index.php/tadris-kimiya/index
**ISSN** 2527-9637 **(online) ISSN** 2527-6816 **(print)**

# The Application of Inquiry-based Worksheets on Secondary Metabolite Analysis of Indonesian Medicinal Plants

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Received: 24 September 2021; Accepted: 25 October 2021; Published: 31 December 2021

## Abstract

Secondary metabolites are part of the discussion of Natural Product Organic Chemistry which demands a practicum process in lectures. This research aims to determine process skills through the application of inquiry-based worksheets on secondary metabolite analysis of three types of Indonesian medicinal plants. In the worksheet, there were several expected goals, including developing students' abilities in designing experiments, conducting experiments, and communicating both orally and in writing. The method used in this research was a One-Shot Case Study with 18 students taking Natural Product Organic Chemistry courses. The instruments used were learning descriptions, inquiry-based worksheets, observation sheets, assessment sheets (psychomotor, presentations, and reports). The results of the worksheet application showed that the students' ability obtain an average value of 84.15 with a very good category. The ability to design experiments, conduct experiments, and communicate orally and in writing obtained results of 77.16 (good categories), 92.50 (very good), and 82.80 (very good), respectively. This inquiry-based worksheet can be used in the study of Natural Product Organic Chemistry, especially in secondary metabolites.

Keywords: inquiry-based worksheet, phytochemical screening, secondary metabolite

DOI : https://doi.org/10.15575/jtk.v6i2.12068

## 1. Introduction

The organic chemistry of natural products is a part of chemistry that is deeper studied in universities, which includes learning about secondary metabolites. Based on the preliminary study, it was found that the lecture material was delivered through presentations. However, in the implementation of the practicum, a worksheet was not given as a work reference in the student practicum, so that the practicum became less focused, students were less challenged in improving their thinking skills, working together, communicating, and being scientific. Meanwhile, the learning process in universities expects that students have life skills, which include improving thinking skills, being scientific, working together, and communicating (Arizona et al., 2013)

The learning process that demands life skills can use inquiry-based learning. This is based on a research report which states that inquiry-based learning through practicum methods can improve science process skills (Fajriani 2010). In line with this research, the study conducted by Wulandari (2011) shows that inquiry learning can improve critical thinking skills. As well as the results of a study by Budiman (2011) that inquiry learning can increase the mastery of concepts and learning motivation. Based on this, the researcher considers that in the organic chemistry practicum of natural materials, it is necessary to prepare inquiry worksheets to improve science process skills, critical thinking skills, and mastery of concepts.

An inquiry-based worksheet for the analysis of secondary metabolites of several Indonesian medicinal plants has been made by Ramdani (2016), and was declared to have met the requirements (valid). However, the worksheet has never been implemented before, so it is necessary to investigate its implementation.

In the worksheet, several expected goals included developing students' abilities in designing experiments, conducting experiments, and communicating orally and in writing. These three objectives are part of science process skills, where the main reason this skill is needed in learning chemistry is that chemistry is part of science. Another reason expressed by Kurnianto et al. (2010) is that process skills need to be applied in learning activities because it is very important to develop scientific attitudes and values. Science is developing very quickly, so not all facts are revealed by educators, and all concepts that have been scientifically investigated are not absolute, so they are still open to question and improvement (Kurnianto et al., 2010). The novelty of this study was to determine the application of worksheets based on secondary metabolite analysis of several Indonesian medicinal plants, which consisted of how students were able to design experiments, conduct experiments, and communicate both orally and in writing.

## 2. Research Method

The research method used was One-Shot Case Study. In this method, a group is given treatment, and the results are then observed (Sugiyono, 2014). The subjects of this study were 18 sixth-semester students of the Chemistry Education Study Program who took the optional course Natural Product Organic Chemistry at UIN Sunan Gunung Djati Bandung.

There were several research instruments used in this study. Worksheets as research data collectors were intended to guide students in doing a practicum. Psychomotor assessment sheets were used to track students' psychomotor abilities during practicum. The presentation assessment sheet was intended to see students' ability to communicate orally. The report assessment sheet was intended to see students' ability to communicate in writing.

The data obtained from the worksheets were data on student abilities in completing each stage of inquiry in the worksheet during learning. The data was processed by giving a raw score to each student's answer based on qualitative assessment criteria and converting the raw score into value.

## 3. Result and Discussion

### 3.1. Result

#### 3.1.1. Analysis Results of Students' Ability in Designing Experiments

The students' ability in designing experiments on the application of inquiry-based worksheets had an average value of 77.16. The details of the student's ability in designing experiments are shown in Table 1 (adapted from Kurnianto et al., 2010).

Based on Table 1, students got very good results at making observations with an average value of 92.50. At this stage, students wrote down the main contents of the discourse. The discourse presented was a discourse on secondary metabolites in medicinal plants.

At the stage of asking questions, each group wrote at least two problem formulations related to the discourse of secondary metabolites of medicinal plants. The questions asked by students were less relevant to the expected answers. Students did not ask questions about the characteristics of secondary metabolites of medicinal plants, so the average score obtained was 2. At this stage, students were guided by giving questions that stimulated students to formulate problems according to the practicum that will be implemented. The stage of asking questions got an average value of 66.67.

**Table 1. The Average Value of Students' Ability to Design Experiments in the Inquiry Worksheet Stage**

| Group | Stage | | | |
|---|---|---|---|---|
| | Designing Experiments | | | |
| | Making Observation | Asking Question | Making Hypothesis | Designing Experiment |
| 1 | 83.33 | 66.67 | 66.67 | 88.09 |
| 2 | 100.00 | 66.67 | 58.33 | 85.71 |
| 3 | 93.33 | 66.67 | 66.67 | 76.18 |
| 4 | 93.33 | 66.67 | 60.00 | 96.18 |
| Average | 92.50 | 66.67 | 62.92 | 86.54 |

At the stage of making hypotheses, students obtained the lowest score of 62.92 in the good category. Students made hypotheses based on inaccurate problem formulations made at the stage of asking questions, so students were also less precise in making hypotheses.

At the stage of designing experiments, students discussed in groups to determine the title, objectives, principles, make a flow chart of the experiment, and determine the independent, control, and dependent variables on the practicum that will be carried out. Students had difficulty in determining the independent, dependent, and control variables. The stage of designing experiments got an average value of 86.54.

### 3.1.2. Analysis Results of Students' Ability in Conducting Experiments

The students' ability to conduct experiments on the application of inquiry-based worksheets was interpreted very well with an average value of 92.50. The details of the student's ability in conducting experiments are shown in Table 2 (adapted from Kurnianto et al., 2010).

The stage of conducting experiments was categorized as very good which was indicated by 89. Students conducted the experiments based on the experimental design made previously. Students had been able to carry out experiments well, starting from preparing tools and materials, pipetting reagents, and testing the phytochemicals of medicinal plants. But, some of the students were still untidy when taking the extract due to the sticky sample extract. However, students carried out practicum activities independently until the final process.

**Table 2. The Average Value of Students'Ability to Conduct Experiments in the Inquiry Worksheet Stage**

| Group | Stage | |
|---|---|---|
| | Conducting Experiment | |
| | Conducting Experiment | Data Analyzing and Discussing |
| 1 | 93 | 97.91 |
| 2 | 88 | 96.87 |
| 3 | 89 | 91.67 |
| 4 | 86 | 97.50 |
| Average | 89 | 95.99 |

The data analysis and discussion stage got an average value of 95.99 with a very good category. After conducting the experiment and getting the data, students immediately recorded it in an observation table which included aspects of each stage treatment of the procedure and the observation results. This made it easier for students to analyze the data so that the data obtained was neat and detailed.

### 3.1.3. Analysis Results of Students' Ability in Communication

The student's ability to communicate experiments on the application of inquiry-based worksheets as a whole had an average value of 82.80. The details of the student's ability to communicate experiments are shown in Table 3.

The last stage was communicating orally and in writing, which is the inquiry stage in making conclusions. The conclusions stage consists of three indicators; making tentative conclusions based on experimental results, presenting experimental results, and making experimental reports.

**Table 3. The Average Value of Students'Ability to Communicate Experiments in the Inquiry Worksheet Stage**

| Group | Stage |
|---|---|
| | Communication |
| 1 | 93 |
| 2 | 88 |
| 3 | 89 |
| 4 | 86 |
| Average | 89 |

At the stage of presenting, as a whole, each group was able to present the experimental results well. Where the presentation's content had met the assessment points, students also could speak in front of the class.

The highest indicator was found in the indicator of making an experimental report because the discussion in the report supports the experimental data, and students write down observational data based on the relevant theory. Students must describe their practicum results by writing the title, objectives, principles, tools, materials, procedures, observational data, practicum results discussions, conclusions, suggestions, and bibliography. Overall, students were able to explain the experimental results of the secondary metabolite analysis of several Indonesian medicinal plants by making a practicum report.

**Table 4. The Average Score of Students' Ability in the General Stages of Inquiry-Based Worksheet**

| Stage | Average Value |
|---|---|
| Designing | 77.16 |
| Conducting | 92.50 |
| Communication | 82.80 |
| Average | 84.15 |

Overall, the ability of students to communicate orally and in writing was very good, because students were able to make conclusions in this lesson. The average values obtained in applying an inquiry-based worksheet with the general stages of designing experiments, conducting experiments, and communicating are presented in Table 4.

Based on Table 4, overall, the ability to design experiments obtained the lowest average value of 77.16, compared to conducting and communicating orally and in writing. This is because students are not familiar with designing experiments independently. Students usually carry out practicums with materials, tools, and procedures that have been provided so that when carrying out practicums using inquiry-based worksheets, students have little difficulty and lack of understanding. However, the application of inquiry-based worksheets on secondary metabolite analysis of several Indonesian medicinal plants went well, according to research data where the ability of students to design, perform and communicate orally and in writing obtained an average score of 84.15. Thus learning by applying inquiry-based worksheets can be applied to students who take the Natural Product Organic Chemistry course, especially in secondary metabolites.

### 3.2. Discussion

The assessment of students' abilities in designing experiments includes making observations, asking questions, making hypotheses, and designing experiments. At the observation stage, each group wrote down the main contents of the discourse by reading the available discourse on the worksheet to foster interest in conducting an investigation. By the statement of Astuti and Setiawan (2013) that this activity aims to attract the attention and interest of students to conduct investigations. This activity will bring students to determine knowledge or concepts for themselves.

At the stage of asking questions, each group wrote at least two problem formulations related to the discourse on secondary metabolites of medicinal plants. At this stage, students were guided by giving questions that stimulated students to formulate problems that are relevant to the practicum to be carried out. This follows Maija and Bostrom's statement (2012) that students are encouraged to ask questions based on short discourses presented by educators about phenomena or events in everyday life.

The stage of making a hypothesis required students to solve problems in the discourse so that some students still have difficulty answering them. This is also followed Maryati et al. (2015) that to obtain a hypothesis relevant to the problem, an appropriate hypothesis must be selected and become a priority in the ongoing investigation.

At the stage of designing experiments, students had difficulty in determining the experimental variables. This is because some students still have difficulty in determining the problem formulation and hypotheses so that in determining the experimental variables, it is not following the expected answers. This is in line with the results of research by Supasorn and Waengchin (2014), which shows the weakness of students in making hypotheses, that they have not shown a relationship between two interrelated things, between manipulation and response variables.

At the stage of conducting experiments, students were able to carry out experiments well, starting from preparing tools and materials, pipetting reagents, and testing medicinal plants' phytochemicals. However, some students were still untidy when taking extracts due to sticky sample extracts. However, students carried out practicum activities independently until the final process. This is following the statement of Kurniasih and Berlin (2016), that inquiry can make students optimally involved in learning activities, the optimum direction of activities in the learning process, and students can develop self-confidence about what is found in the inquiry process. This is in line with the research result by Rokhmah and Madlazim (2015), that learning activities using inquiry-based worksheets make students feel happy during the learning process and have good practical skills.

At the data analysis stage, the indicators of write down the experimental results, students recorded in the observation table, which includes aspects of the treatment of each procedure stage and the results of observations. This makes it easier for students to analyze the data so that the data obtained is neat and detailed. According to the characteristics of the inquiry worksheet itself (Johnstone & Shuaili, 2001) that the results of observations have not been determined previously so that the results of observations made by students can vary, with an inductive approach, by observing complex/special examples so that students can find principles or concepts learned, experimental procedures, and further developed by students.

The last stage is communicating orally and in writing, consisting of the inquiry stage to make conclusions. The conclusion stage consists of three indicators; make tentative conclusions based on experimental results, present experimental results, and make experimental reports. At the presenting stage, each group presented the experimental results well. This is in accordance with Ango (2002) statement that communication skills during presentations are skills in conveying thoughts, ideas, research results, and all kinds of important information to others. These skills include reading pictures, diagrams, graphs, and tables from experimental results.

At the stage of making an experimental report, students explained their practicum results by writing the title, objectives, principles, tools and practicum materials, practicum procedures, observational data, discussion of practicum results, conclusions, suggestions, and bibliography. This is in accordance with Wartono (2003) that students must compile and explain the results of their practicums that have been carried out clearly and systematically into reports. This practicum report is made by each student.

## 4. Conclusion

Through the application of inquiry-based worksheets on secondary metabolite analysis of several Indonesian medicinal plants, the students' ability to design experiments obtained an average value of 77.16. The students' ability to conduct experiments was categorized as very good with an average score of 92.50. The ability of students to communicate orally and in writing obtained an average value of 82.80.

Based on the results of this study, two of the three abilities measured, which are the ability to conduct experiments and the ability to communicate, showed results with an average value of 92.50 and 82.80, but the ability to design experiments was still not satisfactory, so students need to train themselves a lot how to design experiment.

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