

# Development of Process Oriented Guided Inquiry Learning Worksheets (POGIL) to Improve Critical Thinking Skills and Science Process Skills

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**Abstract:** This study aims to determine the feasibility of POGIL-based LKPD to empower students' critical thinking skills and Science Process Skills. The type of research used is research and development with research procedures using the ADDIE model (Analysis, Design, Development, Implementation, Evaluation). This research is limited to the feasibility test of POGIL-based LKPD at the development stage. The assessment of the results of the validity test and the practicality test of the questionnaire is interpreted on a Likert scale. Based on data analysis, the following results were obtained: product validity test in the form of POGIL-based LKPD by media experts obtained an average of 87% with very feasible criteria and 78.3% by material experts with feasible criteria. Practicality tests conducted by Biology teachers get an average of 84.35% and students 85% with very decent criteria.

**Keywords:** Critical thinking ability; LKPD; POGIL; Science process skills

## Introduction

One of the skills needed to build a nation and state is 21st-century skills (Ernawati, 2022). The Partnership for 21st Century Learning (P21) has developed a learning framework in the 21st century that emphasizes learning and innovation skills that students must possess (Afandi et al., 2019). The 21st-century skills that have been formulated by the National Education Association are "The 4Cs" which include critical thinking, communication, creativity, and collaboration skills (González-Pérez, 2022).

The 2018 Program for International Student Assessment (PISA) survey found that Indonesia was ranked 71 out of 79 countries. The PISA assessment includes reading, science, and mathematics (Septiani, et al., 2022). Thus, the low results of PISA, especially in science, indicate that Indonesian students still have

difficulties in applying concepts, analyzing, integrating information, and drawing conclusions (Nisa et al., 2019). It is suspected that students in Indonesia have low critical thinking skills.

Critical thinking is the ability of students to reason orally and in writing (Živkovića, 2016). According to Ennis, critical thinking skills have indicators including basic clarification, basic support, inference, further clarification, and strategies and tactics (Rusyana, 2014).

The results of the preliminary study through observation and scrutiny of students' work documents at SMA N 1 Seyegan obtained information that around 53% of students were not able to draw conclusions and provide further explanations when given questions in the form of descriptions. In addition, the results of interviews with biology teachers at SMAN 1 Seyegan obtained information that students still had many difficulties in drawing conclusions, which included the

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process of preparing and considering induction and deduction making a decision, and considering the results. Based on the preliminary study, it is suspected that students have low critical thinking skills. Ideally in learning, a learner should have sufficient critical thinking skills to be able to follow the lesson well.

Factors causing low critical thinking skills are possible learning activities that are still dominated by the system of delivering material by teachers to students who tend to be informative. The material presented only focuses on theoretical material following the teacher's handbook and the teacher does not familiarize students with being involved in the process of learning activities. In addition, learning is limited to memorizing activities and recognizing and explaining facts. According to Browne et al. (2018), when students learn passively only by memorizing and remembering information, it will be difficult to involve students allowed to acquiring skills, one of which is critical thinking skills.

Biology is a science that studies living things and their environment from various perspectives to problems that are not only related to facts but also include abstract matters such as metabolic processes, hormonal systems, and others (Gobel et al., 2023).

In addition to critical thinking skills, learning Biology also requires basic scientific activity skills, or science process skills (Tahya et al., 2022). Science skills are important skills that must be owned by every student in carrying out investigative or practicum activities (Arantika, 2018). Science process skills that students must achieve in learning consist of observing, classifying, communicating, predicting, concluding, and measuring skills (Wazni & Fatmawati, 2022). The results of the interviews also show that during the last two years from 2019 to the end of 2022, students have never carried out practical activities directly in the laboratory or class. This is due to the Covid'19 pandemic which requires learning to be done online. This resulted in students not being able to make observations and search for data optimally.

KPS is a constructivist learning that can be used in Biology learning, but not all material is suitable for use in its implementation (Zulyadaini, 2017; Achor et al., 2018) argues that some methods do not allow students to acquire science process skills. Therefore the use of Student Worksheets (LKPD) in learning is an alternative for students in learning activities. According to Suryanda et al. (2016), Biology Learning Worksheets can be teaching materials that support students in learning Biology both material and practice.

Student worksheets can improve student learning activities because there are activities that must be carried out both individually and in groups. LKPD can also make students more active so that learning materials are

easy to obtain (Rahayu et al., 2027). This is in line with the learning objectives of Biology which emphasize the active participation of students in the learning process (Mumtaza & Zulfiani, 2023).

In addition to teaching materials, it is also important to choose an appropriate learning model for delivering material to students (Septiani et al., 2022). One learning model that combines critical thinking skills and scientific process skills, is Process-Oriented Guided-Inquiry Learning (POGIL). POGIL is a learning model that combines guided inquiry and collaborative learning (Rodziguet, Hunter, Scharlott, & Becker). POGIL is a learning model based on constructivism principles which makes students more active because of group interaction in solving problems (Syafe'i & Mawardi, 2022).

Many previous studies have provided solutions related to the problem of low critical thinking skills and students' science process skills in implementing learning. One of the studies conducted by Andani (2019) states that critical thinking skills can be improved through the Guided Inquiry learning model, but when compared to the POGIL model students' critical thinking skills are superior to the implementation of Guided Inquiry, this is based on differences at the learning stage. Another study was conducted by Devi et al., (2019) which stated that there was an increase in students' critical thinking skills after the POGIL model was applied, where students got the opportunity to be actively involved in terms of concept discovery through the concept discovery stage.

The use of the POGIL model in addition to improving students' critical thinking skills is also able to improve students' science process skills. The difference between this research and the previous research is that this research is a development research by making innovations in the form of LKPD in printed form and it uses the POGIL model syntax with the addition of information from various sources such as YouTube videos which can be accessed using QR. code. So it is hoped that the development of POGIL-based LKPD products can support teaching materials in schools, especially in improving critical thinking skills and science process skills of class XI high school students.

## Method

This research is research and development. The basis for the development of this research uses the ADDIE model belonging to Branch (2009). The ADDIE model consists of five stages, namely analysis, design, development, implementation, and evaluation (Branch, 2009). However, this research is limited to the analysis, design, and development stages.

This research consists of two types of data: qualitative and quantitative. Quantitative data was obtained through analysis and design stages. The first stage is analysis, qualitative data obtained by observation and direct interviews, analyzing teacher needs and analyzing student needs. In the second stage of design, qualitative data is obtained by compiling, designing student activities, preparing learning objectives, compiling test instruments, and compiling the initial framework of LKPD. The purpose of qualitative data is to develop specifications for research objectives and to make initial product development designs.

Quantitative data was obtained through the development stage with the validation of experts and practitioners. Development data with expert and practitioner validation is used for the results of product development feasibility tests. The expert validation consists of two validators, namely the media expert validator and the material expert validator. Practitioner validation consists of two validators, namely biology teachers and students as users. The data obtained from the results of the validity and practicality tests were then analysed using the following formula.

$$M = \frac{\sum fx}{N} \times 10i = \text{Scores are provided by expert validators}$$

$\Sigma X = \text{Maximum score}$

The results of the feasibility degree of all the components used in the decision are appropriate or not suitable for use in educational materials in the form of POGIL-based LKPD. The decision categories for the validity test and practicality test are shown in Table 1.

**Table 1.** Eligibility Criteria

Percentage Score (%)	Interpretation
$P > 80$	Very Worth it
$61 < P \leq 80$	Worthy
$41 < P \leq 60$	Pretty decent
$20 < P \leq 40$	Not feasible
$P \leq 20$	Very unworthy

The validators of this study consisted of learning media experts and subject matter experts. Media expert validity test assesses aspects that include illustration and cover design which include: shape, colour, object size and presentation, font size, writing system, image placement, and others. The material expert validity test is about aspects of material quality, language quality, and eligibility support quality which includes the suitability of exercises/tests with competence, and the balance between questions/practice with the material and language used.

The practicality test in this study was conducted on biology teachers and students to respond to the results of developing POGIL-based worksheets. The aspects assessed in the teacher practicality test are feasibility, accuracy, didactic, construction, and technical aspects. While the students include aspects of feasibility, language, presentation, and usefulness.

## Results and Discussion

Based on the initial needs analysis, the teaching materials commonly used by teachers do not support the empowerment of students' critical thinking skills and science process skills. The teacher only uses teaching materials in the form of textbooks and only uses PPT media in delivering learning in class. The results of the analysis of the teaching materials used by the teacher include textbooks and LKPD, showing that both are prepared in general and do not yet contain the steps for implementing the learning model. In addition, the results of the analysis show that both textbooks and LKPD have not been empowered to train students' critical thinking skills.

So far, in Biology learning activities that require practicum activities, the teacher only gives simple assignments such as giving questions to work on individually or in groups and giving assignments through videos that are accessed via YouTube. This results in students not having direct practical experience. Therefore, direct practicum activities are needed so that students have the skills and experience of learning practicum directly, especially in the laboratory.

The LKPD used is still limited to reading and simple work steps. This does not train students to think critically or process science skills in the material being taught. Therefore it is necessary to develop LKPD which is expected to improve students' critical thinking skills and science process skills, especially in biology lessons.

Development is carried out by integrating LKPD with the syntax of the learning model in the form of Process-Oriented Guided-Inquiry Learning (POGIL). In addition, supporting information in the LKPD is added in the form of pictures, videos, articles, and journals which can be accessed in the form of QR. code.

POGIL-based LKPD teaching materials are made in the form of printed LKPD consisting of a cover, list of group names and learning objectives, POGIL syntax consisting of orientation, exploration, concept formation, application, and closing, and at the end there is a glossary to support learning material. The front page contains a list of groups of student learning objectives that will be achieved during learning activities. The front page of the POGIL-based LKPD can be seen in Figure 1.

At meeting 1 there was an orientation activity and continued with exploration activities regarding the organs involved in the respiratory system. The exploration page can be seen in Figure 2.

Pages related to concept formation, at this stage students will get additional concepts regarding the material being taught. The concept formation page can be seen in Figure 3.

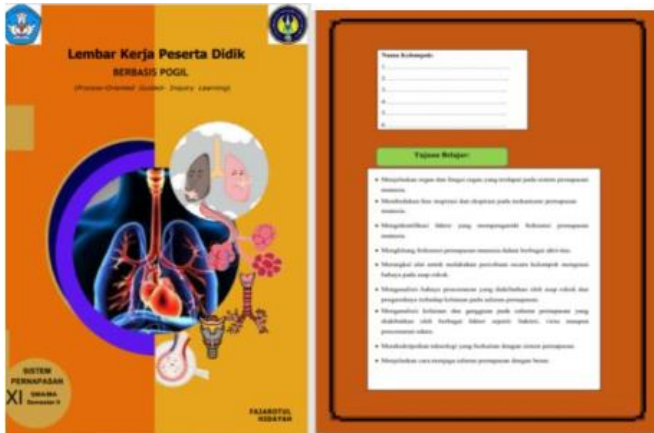


Figure 1. Cover and learning objectives

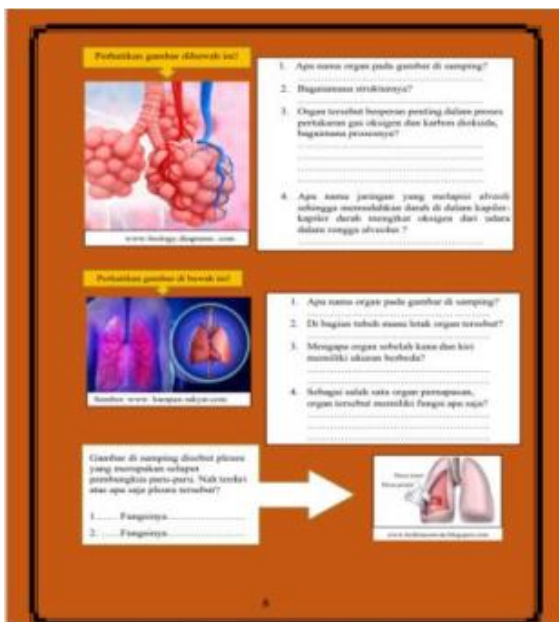


Figure 2. Exploration activities

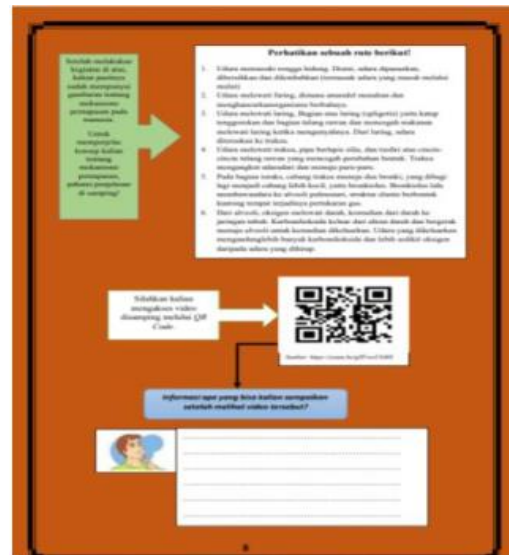


Figure 3. Concept formation activities

Furthermore, orientation activities at the 2nd meeting will study the frequency, respiratory volume, factors that affect respiratory frequency, and the dangers of cigarette smoke to the respiratory tract. Orientation activities can be seen in Figure 4.



Figure 4. Orientation activities

After the orientation activities, the exploration activities continued regarding respiratory frequency, factors that affect the frequency, and testing the content contained in cigarette smoke. The exploration activities can be seen in Figure 5





Figure 5. Exploration activities



Figure 7. Orientation and exploration activities

The exploration activities at the second meeting were carried out directly in the laboratory, where students carried out practical work in groups. It is expected that students' science process skills can be trained optimally and get direct learning experience through experimental and observational activities. After carrying out the experimental activities, students were asked to make a practicum report in groups to communicate in writing the results of the observations obtained, which were then presented directly in-class learning activities at the third meeting.

The closing page contains a glossary that can be used to obtain appropriate additions to the material and continues with a bibliography page. Glossary page and bibliography can be seen in Figure 8.

The next activity is the discovery of concepts at the second meeting after students have explored. This activity requires students to conclude correctly and add to the questions presented. The concept formation page is shown in Figure 6.

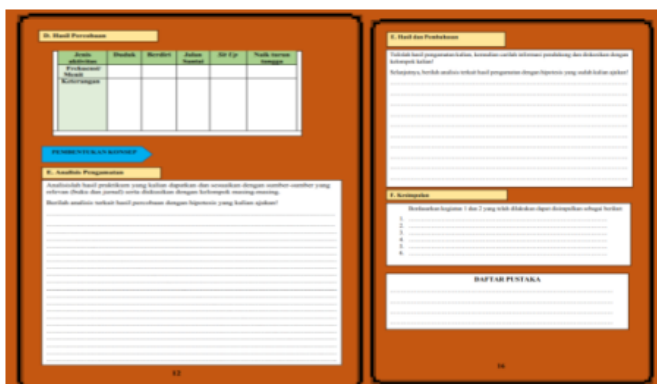


Figure 6. Concept formation activities



Figure 8. Glossary page and bibliography

Next, orientation activities continued with exploration activities at the fourth meeting regarding disorders and technology related to the respiratory system. Orientation activities can be seen in Figure 7.

Activities in the first development stage are validation tests carried out by media experts and material experts. The media expert validity test consists of two aspects in the assessment, namely the design aspect and the illustration aspect of teaching materials or media. The results of the media validity test can be seen in Table 2 as follows.

**Table 2.** POGIL-Based LKPD Assessment by Media Experts

Assessment Aspects	Score (%)	Criteria
Illustration	90	Very Worth it
Design	85	Very Worth it
Average	87.5	Very Worth it

Based on the results of the validity test above, teaching materials in the form of POGIL-based LKPD obtained 90% results on the cover illustration aspect and 85% on the design aspect of the LKPD. The overall average of the aspects measured reached 87.5% with a very decent category. The media validity test can be declared valid after being tested by media experts (Badu, et al., 2020). Media experts are people who have a capacity for media development (Astuti et al., 2022).

Material is one of the most important things in teaching material (Giguere, et al., 2020). The material contained in teaching materials in the form of LKPD is the main part of forming knowledge for students (Julie, 2015). The material contained in the developed POGIL-based LKPD is arranged based on the sequence and learning steps of the POGIL syntax. The POGIL learning sequence has five stages including the Orientation Stage, the exploration stage, the concept formation stage, the application, and the closing stage (Hanson, 2010).

The material expert validity test consists of three aspects including aspects of material quality such as material coherence, material accuracy, and material clarity with KD and indicators, language quality aspects such as adherence to language rules and language suitability for target users, and quality aspects supporting feasibility such as training suitability competence as well as a balance of practice questions with material. The material expert validator was selected based on his capacity as a lecturer who is an expert on the subject of the human respiratory system. The results of the material validity test can be seen in Table 3 as follows.

**Table 3.** Results of Feasibility Assessment by Material Experts

Assessment Aspects	Score (%)	Criteria
Material quality	83	Very worth it
Language quality	75	Worthy
Qualities supporting Eligibility	75	Worthy
Average	78.3	Worthy

Based on Table 3 it can be seen that the material concept of the human respiratory system presented in the POGIL-based LKPD is by Core Competencies, Basic Competencies, and learning indicators. Learning content, both learning materials and learning activities are presented, systematically, and supported by information in the form of videos and articles presented

in QR form. code. The language used in LKPD is communicative easy to understand and in accordance with the development of students.

The average score based on the assessment by material experts is 78.3% with appropriate criteria. This shows that POGIL-based worksheets are appropriate for use in the biology learning process, especially material on the respiratory system in humans. Although there are several suggestions from material experts, namely as follows: material or sources presented in QR form. The code is adjusted to the characteristics of the material being taught and the writing of information in LKPD, several things must be justified, including the content in the concept explanation section.

The POGIL-based LKPD presentation that has been developed meets the criteria. Based on the validity test of media experts and material experts, practitioners will then evaluate them, namely teachers and students.

The practicality test phase was carried out to obtain practical value for the developed POGIL-based LKPD products. Assessment of practicality was carried out using a practicality questionnaire given to practitioners. The practicality assessment by the teacher consists of five aspects, including material feasibility aspects, material accuracy aspects, didactical aspects, construction aspects, and technical aspects. The results of teacher practicality can be seen in Table 4 as follows.

**Table 4.** Results of Assessment by Biology Teachers

Assessment Aspects	Score (%)	Criteria
Appropriateness	90	Very worth it
Accuracy	83	Very worth it
Didactic	80	Very worth it
Construction	87,5	Very worth it
Technical	81,25	Very worth it
Average	84,35	Very worth it

Based on the results of the teacher practicality test above, the biology teacher's response to POGIL-based LKPD was 90% in terms of material feasibility, 83% in terms of material accuracy, and 80% in didactic terms. 87.5% on the construction side and 81.5% on the technical side. The average rating by biology teachers is 84.35% with a very decent category.

Based on the teacher's assessment, it can be explained that the POGIL-based LKPD is interesting to study, and the material presented about the human respiratory system is in accordance with core competencies and core competencies. The contents of the LKPD are compiled and systematic, contain learning objectives, and are equipped with relevant sources. It is hoped that this POGIL-based LKPD can help teachers create student-centered learning through the activities presented.

The results of the evaluation of POGIL-based LKPD products by students consist of four aspects: feasibility, language, presentation, and usefulness. The results of product assessment by students are shown in Table 5 as follows.

**Table 5.** Student Assessment Results of LKPD Products

Assessment Aspects	Score (%)	Criteria
Appropriateness	86	Very worth it
Language	84	Very worth it
Presentation	87	Very worth it
Benefits	82	Very worth it
Average	85	Very worth it

Based on the results of the POGIL-based LKPD product assessment by the students above, the results obtained were 86% on the feasibility aspect, 84% on the linguistic aspect, 87% on the presentation aspect, 82% on the usability aspect, and an average overall aspect of 85% with the criteria very worth it.

According to (Arsy & Octarya, 2022) the steps of the POGIL model consist of 5 phases, including orientation, exploration, concept formation, application, and finally closure (closing phase). The POGIL model allows students to acquire better critical thinking skills and science process skills because the POGIL model syntax supports students to be more active in obtaining information and opportunities to utilize and develop teamwork skills, communication and critical thinking, where teachers in class this acts as a learning facilitator (Maknuniyah et al., 2019). Based on this, students with previous learning disabilities, together with study groups that have been formed, can use previous knowledge to build on their existing knowledge. Thus, the POGIL learning model allows it to be used in biology learning.

In the activities contained in the LKPD, interesting response results were obtained, especially in practicum activities. This is expected to improve students' scientific process skills. Science process skills are important skills in carrying out scientific activities that are usually used in science subjects including biology (Elfeky et al., 2020). Inayah et al. (2020) states that science process skills play a very important role in helping students develop ways of thinking, being active, practicing responsibility in the process of acquiring knowledge or developing it.

The results of another study conducted by Erna et al. (2018) obtained the result that the use of the POGIL model in the learning process has been proven to be able to improve student learning outcomes from the cognitive domain. This is because the POGIL model is designed to increase student activity so that students become learning centers and can develop thinking processes in determining the outcome of a problem. This is in line with research conducted by Elfina (2020) that

the use of LKPD can improve students' critical thinking skills as evidenced by the results of the effectiveness test, there is an increase between students before and after using LKPD. In addition, research conducted by the Ikhwan (2022) states that the POGIL model is a good alternative learning model to be applied in science learning, both at the elementary, middle and high school levels, especially for training students' cognitive abilities such as thinking skills critical.

The results of the practical test show that students can use POGIL-based worksheet smoothly and without problems. Students realize that POGIL-based LKPD material is presented creatively and do not get bored using it in learning. The presentation of the material is complemented by pictures and videos, as well as interesting articles that can be read in QR. Code format to broaden students' insight into learning material about the human respiratory system.

The validity and practicality tests carried out obtained an average of very good categories. So that it can be declared valid and practical for further research.

## Conclusion

The validity test conducted on media experts in the form of POGIL-based LKPD obtained an average of 87.5% and material experts of 78.3%. Practicality tests conducted by Biology teachers get an average of 84.35% and students 85%. Based on the validity and practicality tests that have been carried out by the researchers, the teaching material product in the form of POGIL-based LKPD to empower students' critical thinking skills and science process skills is declared feasible and can be used for further research.

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## Contributing Author

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