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Enhancing Students' Science Process Skills through the Implementation of POGIL-based General Chemistry Experiment Manual: A Quantitative Study

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Abstract
This study focuses on the development of a POGIL-based experiment manual for general chemistry courses to enhance students' science process skills. The research and development (R&D) method, utilizing the Plomp model, was employed to create a valid and practical manual. Data were collected through a validity and practicality questionnaire, which was then analyzed using the Kappa Cohen's method. The manual's content was found to be highly valid, with an average score of 0.82, while its graphics had an average score of 0.84, also falling within the high category. Practicality was assessed through small group student testing, revealing high practicality scores in terms of user convenience, attractiveness, and benefits, with an average score of 0.77. Overall, the results indicate that the POGIL-based general chemistry experiment manual developed in this study is both valid and practical.

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INTRODUCTION

There is no doubt about the importance of experiment in chemistry education. Chemistry learning will be effective if the theoritical explanation supported by laboratory activity. (Ural, 2016), (D. Branan & M. Morgan, 2010) Activity in laboratory can expect students to connect the phenomena with scientific theory. When finishing scientific problem, students can act like a scientist and do scientific method. Being 'like scientist' activity might be done by scientific approach learning, one of them is Process-oriented guided-inquiry learning (POGIL). (Kuhlthau, 2001) POGIL is a learning method which demand student groups to assemble concepts when discover content. In this method, students discuss with their team when examine data to develop mental construction and it will be applied to problems (Hein, 2012).

POGIL emphasizes personally relevant questions that inspire students to learn more and create unique ways of sharing what have learned. In POGIL, motivation and interest are essential element. Previous studies concluded that POGIL based learning and laboratory activity is effective to develop science skills process. (A. Chase, D. Pakhira, 2013; A. Straumanis, 2010; Farrell et al., 1999; G.Berberoglu, 2014; Gunawan et al., 2019; Moog et al., 2006) This method also encourage students' ability in communication, written expression and problem solving from developing of science process skill (Hein, 2012).

However conventional laboratory activity could not develop all the process skills. Since labor activity only focused on terminology, concept, fact, and detailed procedure regarded to students will be observed. Students already know the theory before doing practicum and confirm it in labor. Eventhough, conventional labor activity has advantage in the class with large number of students and limited time, but disadvantages are more. Students not learn effectively because they only followed the rules than questioning and analysing what they will do. This problem not support the main goals in laboratorium activity.

By changing ‘the way’ in laboratorium into Guided inquiry laboratorium, able to help develop process skills and ‘nature of science’. One of way to simplify lecturer in changing from conventional lab into guided inquiry learning lab is to develop the experiment manual based on guided inquiry in general chemistry subject. When the experiment manual is using by students as a teaching material and they worked and discussed in the group to discover concept, therefore the learning in laboratorium become Process Oriented Guided Inquiry Learning (POGIL).

Process Oriented Guided Inquiry Learning (POGIL) is a students-centered strategy. On POGIL’s class or laboratorium, students work in small group at particular activity which planned to follow the learning cycle. (Hein, 2012)There are three main characteristics that will be used in POGIL learning material, (Ural, 2016) Media is planned to self-managed team whereas the instructor role as a facilitator, (D. Branan & M. Morgan, 2010) Media will guide students by finding a way to develop the understanding, and (Kuhlthau, 2001) Media use discipline content to facilitate process skills development, include high order thinking skills and skills to learn and apply a knowledge in new context.

The goal of this research is producing experiment manual based on POGIL (Process Oriented Guided Inquiry Learning) for general chemistry subject which is valid, practical, and effective in enhancing students process skills.

Every year, new students in chemistry department UNP learn general chemistry and every year lecturer faces the reality that only 20% of students can achieve completeness of course learning outcomes. By using experiment manual based on Guided Inquiry can expected the enhancing number of students who achieve the completeness, because their process skills well sharpened (Farrell et al., 1999). Implementation of Guided Inquiry Learning on General chemistry subject is probably happening because it follows philosophy principle and pedagogic principle on learning cycle and cooperative learning (Moog et al., 2006). The POGIL approach strategy have done effectively in chemistry subject, at school and university. It provided by previous research done by (Rachmawaty et al., 2021), the students who use POGIL in practicum have higher high order thinking skills than verification practicum.

METHOD

The research was conducted at Universitas Negeri Padang. The participants are Chemistry students in Chemistry Department. Research design used is based on Plomp Development Models. It has 5 stages (Nieveen, 1999). On the research, the researcher did all the stages, from first stage to last stage (Implementation stage). First is Initial Investigation stage, in this stage should be done curriculum analysis. In order to compare empirical evidence in lecture than designed curriculum by Chemistry education study program. Empirical evidence could be gotten by doing Observation. The observation involved 25 chemistry education students in 2019 and 6 general chemistry’s lecturers. Second is Design stage, this stage was conducted prototypes planning of POGIL’s experiment manual by choosing corresponding format to the findings obtained in initial investigation stage. Third is Realisation / Construction Stage, produced hardfile of POGIL’s experiment manual.

Fourth is Test, Evaluation, and Revision stage. This stage aim is to test the validity of the product. The validator involved is some experts in chemistry's lecture, indonesia language's lecture, and education technology's lecturer. If the product is valid, the next step is do the practicality and effectivity in small group. If the error was found in the step, the researcher should do the revision before test to the big group. The last is **Implementation stages**, the valid, effective, and practical POGIL's experiment manual is introduced into General chemistry's lecturer in order to implement the POGIL. This research was focused on producing a valid and practical POGIL based experiment manual in general chemistry course while the effectiveness of the product and its implementation were not carried out. Effectiveness test of the product, POGIL based experiment manual, that have been produced needs to be carried out and then tested in field tests accomplish the quality of the product to improve Students' Science Process Skills.

Data collection used is non test technique by using questionnaire and observation sheets. The questionnaire used to test the validity and practicality. Whereas observation sheets are using for effectivity test. The data analysis technique used in the research is Validity Analysis, Practicality Analysis, and Effectivity Analysis. On validity analysis is using Kappa Cohen with the equation below:(McHugh, 2012)

$$moment\ kappa\ (k) = \frac{P - Pe}{1 - Pe}$$

K = moment kappa indicated product validity

P = actual proportion (counted by the number of values given by the validator divided by the maximum number of values)

Pe = non actual proportion (counted by the maximum number of scores is reduced by the total number of values given by the validator divided by the maximum number of values)

The validity of POGIL's experiment manual can be seen after converted Kappa moments into the categories (Wass, 2009):

Table 1. Decision categories based on Kappa Moments

Interval	Categories
0,81 – 1,00	Higher
0,61 – 0,80	High
0,41 – 0,60	Moderate
0,21 – 0,40	Low
0,01 – 0,20	Lower
< 0,00	Not valid

The practicality analysis also employs Kappa cohen's analysis. While Effectivity Analysis is using qualitative analysis to explain the enhancement of students' process skills. The research flow should be presented in this section with an image caption. The image caption is placed as part of the image *title (figure caption*) instead of part of the image. The methods used in completing the study are written in this section.

RESULTS AND DISCUSSION

Initial Investigation Stage

Need and Context Analysis

Needs and context analysis were obtained based on the results of a study of the curriculum used in general chemistry courses which were analyzed based on the Semester Learning Plan (RPS) and the results of interviews with lecturers and students regarding the implementation of the lecture process, especially laboratory practicum. The interviews were conducted involving 6 general chemistry lecturers and 25 class 2019 students who had completed general chemistry courses.

The results of the RPS study show that the general chemistry course consists of 4 credits with 3 credits for theory and 1 credit for practicum. This indicates an integration between theoretical classes and practicum implementation in general chemistry courses. The learning material in this course consists of nine topics of discussion, of which five involve practicum activities and one is an introduction to chemical laboratory tools and materials. The four main topics practiced are separation of mixtures, stoichiometry (concentration or preparation of reagents), chemical energetics (thermodynamics), and chemical kinetics (factors affecting reaction rates).

Interviews were conducted as a form of analysis of the actual situation and needs in the field. The results of interviews conducted with lecturers through six open questions indicate that general chemistry lectures are considered to be still not optimally integrated. Even though the RPS has been integrated, the implementation in the field from a time perspective has not been able to achieve integration. Discussions in theory and practicum classes are often different due to learning outcomes that have not been achieved, so lecturers need more time in theory class. In addition, the practicum that has been carried out is still at the stage of confirming concepts or theories that have been studied in theory classes or which are studied independently by students.

Practicum activities in terms of guidance or forms of practicum carried out have not been able to stimulate students to think critically or find their own concepts. In general, students only work on existing procedures without digging deeper or thinking critically about what is being done. This condition has resulted in the inability to see and develop student process skills. The results of the interviews showed that students' processing skills could not be observed or did not develop optimally (only a few, such as observing and conducting experiments, were the most dominant indicators observed). This result was confirmed by most of the students through interviews.

Students tend to only do what is asked according to the procedure without any thinking, observing, critical, and problemsolving processes. Meanwhile, chemistry as one of science class ilmu sains requires process skills to assist in the contextualization of knowledge (Veal et al., 2009). Nevertheless, students still feel great benefits from practicum activities. Most of them considered that practicum activities were able to increase their understanding of the theory because they directly applied the concept through experimentation. The lecturers considered this to be insufficient to have an adequate effect on learning outcomes in general chemistry courses. Practicum activities have not been able to fully support their academic results, but students' understanding in theoretical classes helps students carry out practical activities. This is inseparable from practicum activities which are still limited to confirmation of concepts or theories.

Another benefit felt by students is increasing their laboratory skills such as the use of tools and so on. Some students considered that general chemistry practicum activities were something new. This is because during high school they have never carried out practicum in the laboratory due to limited school facilities. This condition also underlies the opinion of the majority of students that the implementation of independent practicum (without procedures) is less effective in general chemistry courses. This result is in line with the opinion of the lecturer who stated that the input (new students) varied and were not ready to carry out practicum activities without being given work procedures. Other reasons such as general chemistry as one of the basic courses are considered to be understood by students as a whole as a foundation for advanced chemistry and to avoid confusion and a decrease in student interest in chemistry. In addition, the implementation of theory and practicum classes that have not been integrated in terms of implementation time makes students experience the experience of designing their own experiments with conditions that have not yet learned and understood the theory.

Lecturers and students agree with the improvement of practicum activities in general chemistry courses. In terms of implementation, students want a practicum implementation that is in line with the theoretical class. In addition, they hoped that there would be a reduction in the number of trials for each title because the large number of titles resulted in a division of labor for each experiment for each member of the group. This resulted in them not being able to carry out and participate in trying out all the existing experiments so that they felt that their labor skills were not well honed. Furthermore, they want an increase in quality in terms of teaching assistants, namely communication and activeness during practicum. To minimize the number of questions during practicum related to work procedures, students expect clear explanations and no changes to instructions such as trial recipes during practicum activities. Explanations regarding work procedures can be provided through video tutorials that are previously recorded by teaching assistants and given before the practicum schedule. The same thing was supported by one of the lecturers who stated that there was a need to increase the competence of assistants through coaching in order to better understand work procedures and practicum subjects.

Improvements are also considered necessary in terms of experiment manuallines that are used as a solution to create ideal conditions. All students considered it necessary to have questions that guide them in analyzing the results of the observations obtained. Most of the students experienced problems at the practicum results analysis stage which resulted in them making discussions based only on theory and work procedures, without connecting the results with the theory obtained. This analysis question is intended as a form of updating the guide which is felt by lecturers and students as an ideal condition for improving critical thinking skills and other student processing skills. These skills can include asking questions, developing and using models, planning and conducting experiments, analyzing and interpreting data, using mathematical and computer thinking skills, constructing ideas, and communicating information (Reynders et al., 2019).

Questions at the analysis stage will guide students to find important concepts in the experiments carried out. This is in accordance with the POGIL learning stage by involving Critical Thinking Questions in the formation or discovery of concepts. This method can also develop students' process skills so as to help develop students in communicating, writing, and solving problems needed for future career development (Hein, 2012). Based on the needs and context analysis, it is known that there is a need to update the practicum guide with POGIL integration to improve students' processing skills.

Study of Literature

The choice of POGIL is inseparable from the reasons for the suitability of this learning activity to develop students' process skills in terms of communication, writing, and problem solving (Hein, 2012). The process skills that will be developed through the guide include cognitive skills (information processing, critical thinking, and problem solving) and group dynamic skills (interpersonal communication, teamwork, and management) in activities that apply the scientific method including asking questions, conducting experiments, analyzing and interpreting data, constructing ideas, and so on (Reynders et al., 2019). Whereas, a guidance is developed such a modification to laboratory guidance by Williamson and Peck (Veal et al., 2009) consist of several sub-part on each step of experiment, like title, introduction, goal, procedure work, pre-lab exercise, observation result, analysis, and post-lab question. In line with the previous statements, the more students do scientific process in POGIL will made students use more science process skills to think critically, analytical, and systematic to solve the problem as concept formation process. Instead, there is a scientific process which is only less done in expository learning activities and is not used as a step in the concept formation process leads to science process skills students become less developed (Mu'minin et al., 2020).

Development of Conceptual framework

The conceptual framework that has been produced refers to needs and context analysis as well as literature studies. POGIL practicum learning is one of the solutions to improve students' process skills such as asking questions, conducting experiments, analyzing and interpreting data, constructing ideas, and so on. The POGIL learning cycle which consists of exploration, concept formation, and application accompanied by critical questions or analysis supports the creation of practicum learning that can improve students' processing skills. For maximum results, POGIL practicum activities must be supplemented with teaching materials in the form of POGIL practicum guides.

Design and Realisation Product Stage

According to General chemistry's RPS, there are four practicum titles that will be integrated so that in the general chemistry practicum guide designed there are four practicum titles namely mixture separation, solution preparation, thermochemistry and reaction rates. Each practicum is created using the POGIL cycle. The sections contained in each title are title, introduction, objectives, procedures, prelab exercises, observations, analysis, and postlab questions. The important part that distinguishes this manual from the usual practicum guide is the introduction and analysis section and this is the hallmark of POGIL. In the introductory part students are given questions whose answers they will conclude through experiments. With this question students begin to think about what they will do. The analysis section (in POGIL is at the exploratory stage of concept formation) is the section for analyzing experimental results by providing questions that make students think critically. By answering this question, students are expected to be able to find concepts based on the answers they put forward. Consolidation of the concept (in POGIL is at the application stage) is given in postlab activities. The questions in the postlab can be answered by students when students have found the concept at the analysis stage.

The guide cover is made more attractive with the predominant blue color. The blue color was chosen because the blue color can provide a calming and pleasant feeling to students and can improve student performance.

Test, Evaluation, and Revision Stage

The 1st Prototype or initial draft of product is in the form of POGIL's experiment manual which has been realized. It goes through product quality testing, namely product validation. The validation was carried out by expert lecturers in UNP. Product validation consist of content validation and graphics. The result of content validation can be seen in the table 2.

Table 1. The average Kappa moment of Content Validation's guide

No	Eligibility Component	Kappa Moment's Result	Categories
1	Content	0,83	Higher
2	Presentation	0,81	Higher
3	Language	0,81	Higher
4	Feasibility of overall content of guide	0,81	Higher

Based on Table 2, content validation of produced guide includes in higher categories with the kappa moment is 0,81. This result shows dontent validity component of POGIL's experiment manual contain appropriate content from social dimension, knowledge dimension (completeness if the material, the depth of the material, etc), and skills dimention. It is proven according to Figure 1.

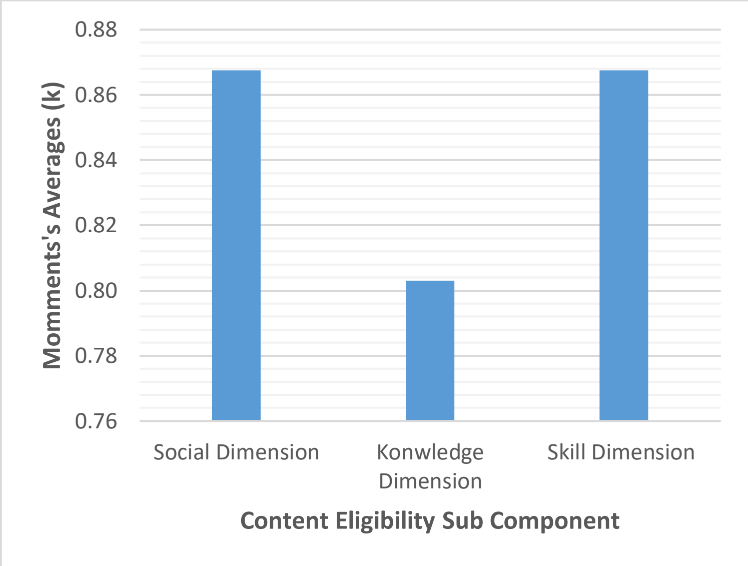

Figure 1. The average of Kappa Moment from Feasibility of Guidance Content Components

The resulting POGIL chemistry guide contains content that can increase the dimensions of social attitudes, knowledge, and student skills. In terms of the skills dimension, the product has a very high level of validity (average kappa moment 0.87), so it can be said that the product is capable of having a good impact on student skills. Basically, an experiment or experiment is a way of presenting learning by experimenting, experiencing and proving directly to improve their skills and understanding regarding a subject being experimented on Arindawati and Huda (Arindawati, A., & Huda, 2004). Experimental activities can make students have a scientific mindset and deep understanding of the scientific concepts being studied (Eggen, P., & Kauchak, 2012). Apart from the dimensions of skills and knowledge, the developed POGIL guide is also considered to have very high validity (average kappa moment 0.87) in terms of the dimensions of social attitudes. This proves that the product forms and builds student social attitudes, in this case student process skills, so that it can help develop students in communicating, writing, and solving problems needed for future career development (Hein, 2012). The content of the product is believed to make students happy learning to use this product which will increase students' courage in various social attitude skills. Salirawati stated that fun learning is learning that makes students not afraid of being wrong, laughed at, belittled, depressed, but instead students dare to do and try, ask questions, express opinions/ideas, and question other people's ideas (Salirawati, 2008). All of these aspects are in accordance with the indicators of student process skills proposed by Reynders et al (Reynders et al., 2019) that the process skills that will be developed through guidance include cognitive skills (information processing, critical thinking, and problem solving) and group dynamic skills (interpersonal communication, teamwork, and management) in activities that apply the scientific method including asking questions, conducting experiments, analyzing and interpreting data, constructing ideas, and so on.

Apart from the eligibility of the content, the feasibility component of presenting content to the guide is also considered appropriate in terms of presentation techniques, supporting material presentation, presentation of learning to the guide, and completeness of presentation. This is evidenced by the average kappa moment obtained for each component, according to the following figure

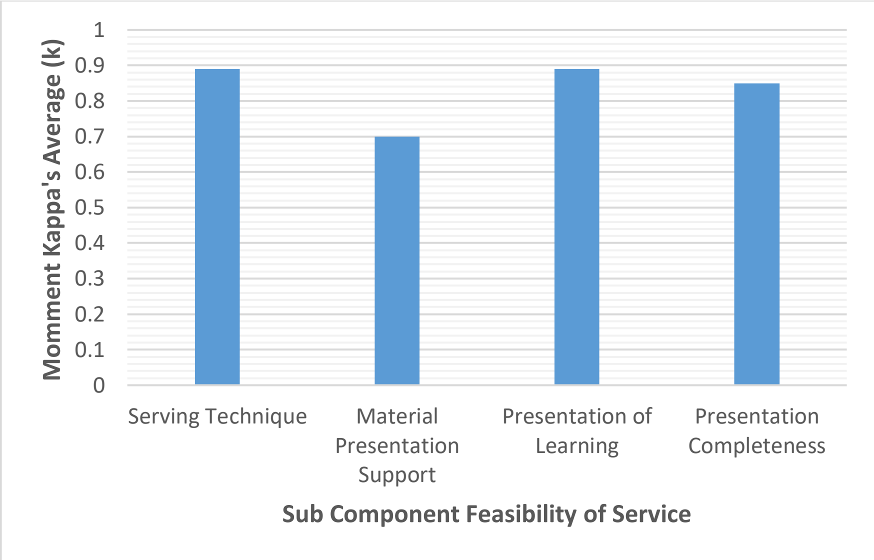

Figure 2. Momen Kappa Average from Feasibility of Guidance Presentation Component

In terms of presentation feasibility, the guide has good presentation completeness such as being equipped with instructions for using the guide, rules and laboratory safety. Aspects of work safety in the laboratory must be contained in guidelines or practicum guidelines such as warnings or hazard symbols on the materials used (M.U Maharani, 2013). In addition to providing an understanding regarding the implementation of experiments, practicum instructions are intended to increase students' competence and confidence in conducting chemical experiments, where chemical experiments can be used as a scientific basis for chemistry, so that students can understand, appreciate, and apply the chemical concepts they have acquired (American Chemical Society, 2015). In addition, the learning stages presented are also in accordance with the POGIL practicum learning activities referring to The College Board which states that the guided inquiry learning cycle includes three main activities, namely exploration, concept formation, and application.

In terms of quality, the validity of the guide content is valid, which means that the content is in accordance with the subject matter and purpose of the product. In order to improve the guide, revisions were made to several things that became the validator's notes including the following:

1. Improved the Question of The Day in title I. The validator considered that the questions raised were impossible to solve in the experimental sub-discussion because the mixture of alcohol-containing waste and ammonium chloride made it impossible to separate it with just one method.
2. Improved the introduction in title I so that it can be explained more fully with the depth of the material according to the topic.
3. Improve the procedures and analysis questions in title I. The step of observing the temperature at the first drop in the distillate flask is less relevant for the experimental step of separating mixtures. This step is appropriate when conducting a boiling point experiment.
4. Fixed writing tables in the II title to make it easier for users to use the guide later.
5. Fixed the image illustration in title II. The schematic drawing of the dilution of the solution is corrected with illustrations using real tools such as a glass beaker or volumetric flask, so that it can increase student understanding in understanding the introduction given.

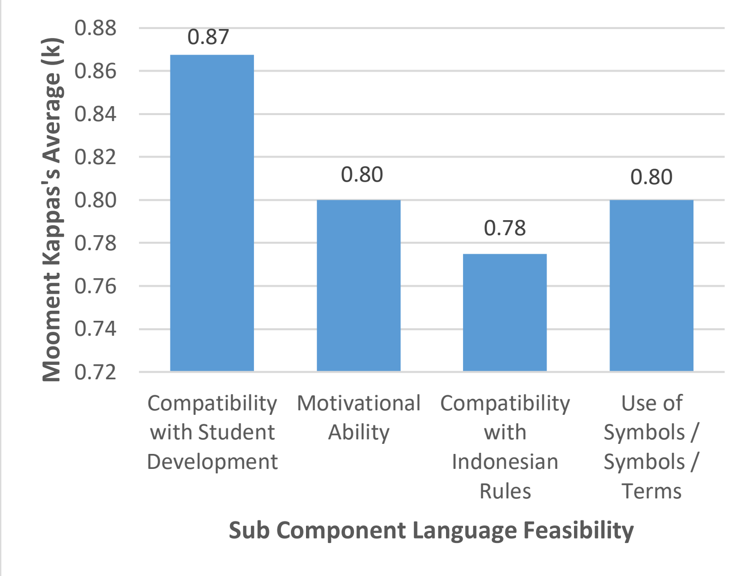

Figure 3. Moment Kappa Average from Feasibility of Guidance Languages Components

Product validation does not only cover content validity. The product is also validated by experts in terms of graphical validity to assess the product in terms of appearance, both in terms of design, layout, font type and size selection, and other aspects. The validation results show that the valid POGIL practicum guide is in the very high category with an average kappa moment of 0.84.

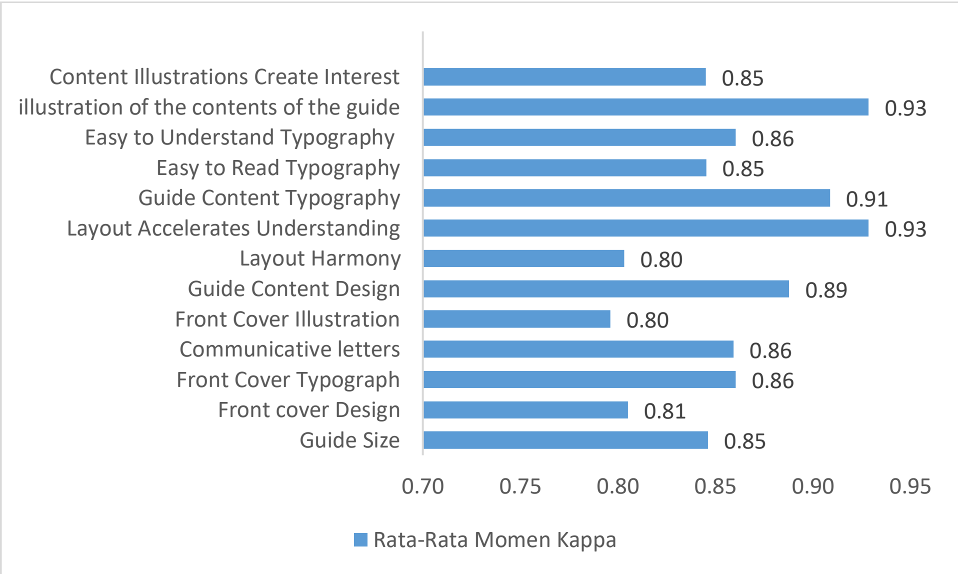

Figure 4. Moment Kapa Average from Feasibility of Guidance Graphic

In terms of quality, the validity of the guiding graphic is valid, which means that in appearance it is considered attractive and in accordance with the provisions. To improve the guide, revisions were made to several things that became the validator's notes, as follows:

1. Fixed the size of the image captions on the guide to make it easier for users to read the information provided.
2. Adding the back cover design of the guide which contains the author's biography so as to give a thorough and complete impression of the guide and make it easier for the reader to communicate with the author.
3. Improve the composition of the front cover by changing the position of the UNP logo to the top and increasing its size so that the identity of the product is more visible from the

agency. Then, adding the word "Author" before the author's name so that it helps make it easier for readers to know the names listed are the authors of existing products. In addition, there is an improvement in terms of the proportionality of the objects displayed, namely the size of the test tube must be smaller than other objects because in reality this is the case and a support is needed at the bottom of the round flask because this flask cannot stand upright without a foothold.
4. Fixed the font size on page numbering which was judged to be less proportional.
5. Added the source of several images loaded in the guide to increase the level of confidence in the visualization that is displayed.

At this stage a formative evaluation was also carried out in the form of a one-to-one evaluation of the product draft involving three students majoring in Chemistry at UNP class of 2019. The evaluation was carried out by distributing questionnaires related to product legibility and practicality in terms of ease of use, efficiency time and benefits. The results of the one-to-one trial showed that the product was considered practical with a very high category (average kappa moment 0.92). Furthermore, it is known that based on these results, an illustration is obtained that the product draft (prototype II) that has been produced in terms of appearance in the form of a cover and color selection in the module is considered good and able to attract students' interest to read it. The choice of font type and size in the module is clear and the language used is easy for students to read and understand. Prototype II in the form of a POGIL guide is considered to have clear and easy-to-understand learning stages because it is supported by detailed steps that must be carried out by practitioners in carrying out experiments/experiments. In addition, the existence of analytical questions in the guide can help students to observe and analyze the data that has been obtained from observations. Then, the pre-lab questions that were presented before conducting the experiment were considered useful for students to help them understand the material to be experimented with.

After revisions were made based on suggestions and input on one-to-one evaluations and expert validation, prototype III of the product was produced. Then, a formative evaluation was carried out in the form of a small group evaluation on prototype III to determine the practicality of the product. According to Mudjijo (Mudjijo, 1995), practicality shows the level of ease of use and implementation of the product which includes costs and time in implementation, as well as the management and interpretation of the results.

Small group trials were carried out involving 16 students majoring in chemistry at UNP class of 2019. Students were divided into four groups and carried out one of the experimental/experimental titles in the module, namely the reagent making experiment. After conducting an experiment according to the POGIL steps in the guide, students were asked to provide an assessment in the form of a questionnaire consisting of several aspects of the guide, namely ease of use, time efficiency, and benefits for assessing the practicality of the POGIL guide used. This is in accordance with what was stated by Sukardi (Sukardi, 2011) that practicality can be seen from the aspects of ease of use, time efficiency, and usefulness of a product.

Table 2. Moment Kappa Average of Guidance Practicality

No	Practicality Components	Momen Kappa's Value	Categories
1.	Simplicity	0,80	Higher
2.	Time Efficiency	0,69	High
3.	Benefit	0,81	Higher
	Final Practicality	0,77	High

According to the table, the results showed that the product was considered easy to use as evidenced by the average kappa moment of 0.77 in the high category. This means that the instructions for using the guide, the materials, the language used in the product, the use of guided inquiry learning stages (POGIL), and the questions presented in the product are classified as easy for students to use. Apart from that, in terms of time efficiency, the product is also considered to be able to help practitioners in making practicum time efficient.

In terms of benefits, students consider that the guided inquiry learning stage (POGIL) which consists of several stages (orientation, exploration and concept formation, application, and closing) can assist them in finding concepts according to the practicum/experiments being carried out. The orientation stage assists students in connecting material with practicum concepts that will be found through introductory material, pre-lab questions and Question of the Day (QoTD) questions to stimulate students' curiosity and interest in conducting experiments. Then, the exploration and concept formation stages were considered to be able to guide them in conducting experiments through clear procedures and assist in analyzing the results of observations obtained through analytical questions. Furthermore, the application stage is considered capable of providing new experiences and deepening the concepts found in the form of practice questions. The last stage, the closing stage in the guide is considered capable of assisting students in drawing conclusions and concepts obtained as well as answering the QoTD questions given before starting the experiment.

Then, the guide as a whole is considered capable of increasing student activity in carrying out practicums. This is in accordance with what was stated by Şen et al., (Şen et al., 2015) states that learning using guided inquiry can increase the independence of students compared to conventional learning activities so that students are more active in learning.

Based on the suggestions of students in the small group trial, a revision was made to prototype III such as correcting writing errors such as work procedures so that it confused practitioners and other writing errors. In addition, most argue that the guide is very interesting and easy to use and helps students understand the experimental activities carried out with analytical questions. This analysis question is one of the keys to the success of guided inquiry activities to guide students to explore models (in this case the experimental results that have been observed) (Moog et al., 2006). It is these analytical questions and exploratory activities that determine students' success in discovering concepts.

However, the large number of pre-lab and post-lab questions resulted in students needing more time to answer questions so that time efficiency was reduced. This is a note and we consider that in terms of the quantity and quality of the questions it is appropriate, but students need to get used to using this product. Usually practicum/experimental activities are carried out using existing guides that focus more on students/practitioners conducting experiments during lecture hours without involving the whole learning process, starting from the initial activities until students are able to obtain concept from what is practiced.

CONCLUSION

In conclusion, the study has successfully developed a POGIL-based experiment manual consisting of four main topics that have been assessed to be valid and practical. The validity of the manual in terms of its content and graphics has been found to be high with an average kappa moment of 0.82 and 0.84, respectively. The practicality of the manual has also been found to be very high (average kappa moment 0.92) based on one-on-one trials and high (average kappa moment 0.77) based on small-scale tests. The resulting product has shown promise and is now ready to be tested for its effectiveness in improving students' process skills. Further studies are needed to evaluate the impact of this manual on students' learning outcomes and to explore its potential to enhance chemistry education.

RECOMMENDATIONS

Based on the findings of this study, it is recommended that further research be conducted to test the effectiveness of the POGIL's experiment manual in improving students' Science Process Skills. To this end, field tests or product implementation may be necessary. The results of such studies could provide valuable insights into the manual's effectiveness and inform potential modifications that could enhance its ability to improve students' process skills. It is also recommended that future studies consider the potential for the manual to be adapted for use in different educational settings or with different student populations.

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