DEVELOPMENT OF POGIL-BASED E-WORKSHEET ON COVALENT BOND MATERIALS TO IMPROVE STUDENTS' LEARNING INDEPENDENCE

Arum Dwi Rianjani[*1], Errisya Nur Ainiah[2], Widia Indah Puspita[3], Kusumawati Dwiningsih[4]

[1,2,3,4] Chemistry Education Department, State University of Surabaya, Ketintang, Surabaya, Indonesia

**Corresponding author: kusumawatidwiningsih@unesa.ac.id*

Abstract. *This research aims to create POGIL-based E-Worksheet learning media on Covalent Bond material to increase students' learning independence. This research uses Research and Development (R&D) research to produce and test the effectiveness of media. The subjects of this research were class XI students of SMAN 1 Menganti. The validity results based on assessments from experts were found to be 85.7% for content validity which was included in the very valid criteria and 90.7% for construct validity which was included in the very valid criteria. This E- Worksheet is also considered practical in terms of the student response questionnaire with a score of 77.3% or in the very practical category and the results of observations of student activities obtained a score of 88.9% or in the very practical category. Furthermore, the effectiveness results based on learning independence figures showed that the n-gain of students was in the high category. Based on these results, this E-LKPD can be used as a learning media to increase students' learning independence.*

Keywords: *Covalent Bonds, E- Worksheet, Independence, POGIL, R&D*

INTRODUCTION

Nowadays, chemistry education is one thing that has an important role in life. The field of chemistry studies combines theoretical and mathematical concepts which are generally considered difficult by students. In chemistry lessons, students study natural phenomena regarding composition, structure, properties, energy, and the changes that occur [1].

One of the chemical materials that causes difficulties for students is chemical bonds. When studying chemical bonding material, some students experience difficulty in determining Lewis structures, chemical formulas of compounds, and the types of bonds found in compounds [2]. Chemical bonding is one of the most basic concepts or prerequisite material in learning chemistry and is directly related to. Chemical bonds have abstract characteristics because they are included in the microscopic or unobservable level, such as ionic bonding processes and covalent bond formation [3]. Apart from requiring an understanding of the concept, students must also be able to determine chemical bonds in solving the problem. This requires students to have independent learning so that they can understand chemistry material well.

Learning independence is one of the important aspects that students must have to achieve optimal competence [4]. Students' learning independence can be increased through the use of learning media which is one of the learning facilities for students. Student worksheets are a learning medium that can enable students to independently explore knowledge through activities that include several stages, namely observing, asking, reasoning, trying, and communicating [5].

Worksheet can be designed online or what is called electronic worksheet, which can be developed via flipbook. Flipbook is an interactive electronic learning media that can combine animation, text, video, images, and audio, so that learning can be more interesting [6]. Learning using flipbooks can be a fun learning alternative, not boring, allowing students to understand and remember the material being taught [7].

Dalam meningkatkan kemandirian belajar In increasing students' learning independence, it is necessary to apply a learning model that requires students to be active during the learning process. The learning model that can be used is Process Oriented Guided Inquiry (POGIL). POGIL trains students to carry out

activities like scientists who have collaborative and independent communication skills so that they can improve students' basic skills with meaningful learning.

By combining POGIL-based e-worksheet learning media with covalent bond material containing the implementation of tasks that can guide students to discover concepts, it is hoped that it can create a more active learning atmosphere and can increase students' learning independence. Based on this statement, researchers are interested in examining the influence of "Development of POGIL-based e-worksheet on covalent bond material to improve students' learning independence."

METHOD

This research uses Research and Development (R&D) research to produce and test the effectiveness of the product. The development model in this research is a model developed by Plomp, which consists of three stages, namely initial research, prototype, and assessment.

At the initial research stage, observations were made regarding the problems and needs of the students. Next, at the prototype stage, media design and the instruments needed in this research are carried out. In the final stage, namely assessment, validation is carried out by experts on the prototype that has been created. If the prototype is declared valid then the prototype will be tested in learning.

The method used in this research is the questionnaire and observation method. In the questionnaire method, there are validation questionnaire sheets, student response questionnaires and student learning independence questionnaire sheets. Instrument validity consists of construct and content validity. The validation questionnaire is used to review the initial product, providing input for improvement [8]. In addition, a validation questionnaire was used to obtain validity data for the e-worksheet which was developed based on assessments by validators who were chemistry lecturers, media expert lecturers and chemistry teachers.

Student response questionnaires were used to collect practicality data from the e-worksheet. This questionnaire was filled out by each student honestly. This questionnaire is an assessment of the level of practicality of the e-worksheet when used. Meanwhile, the student learning independence questionnaire was used to collect data related to the effectiveness of interactive e-worksheets. This questionnaire is filled out by each student honestly regarding their learning independence before and after using the developed e-worksheet.

In the observation method, observations were made during each POGIL-based e-worksheets development trial on covalent bond material. The observation method is used to determine the practicality of the learning media being developed. The instrument used is the student activity observation sheet.

The data analysis technique used in this research is analysis of the validity of learning media using a four-scale Likert Sort as follows.

Table 1. Four Scale Likert Score

Score	Statement
4	Strongly agree (SA)
3	Agree (A)
2	Don't agree (DA)
1	Strongly Disagree (SD)

The resulting scores from the validation stage are then analyzed using percentages and interpreted according to the following table.

Table 2. Validity Percentage

Precentage (%)	Validation classification
0 - 20	Very invalid
21 - 40	Invalid
41 - 60	Fairly valid
61 - 80	Valid
81 - 100	Very valid

E-worksheets can be declared valid if the validity percentage reaches ≥ 61% [9]. If the e-worksheet does not achieve this score, it is necessary to repair the media and revalidate it by the validator.

Data analysis of student response questionnaire results uses the four Likert scale scores in Table 1. The data obtained is then analyzed using percentages. The percentage for each possible answer is obtained from dividing the frequency by the number of samples, then

multiplying by 100%. The results of the practicality percentage will be interpreted into scores with each criterion, in Table 3.

Table 3. Practicality Percentage

Precentage (%)	Category
0 – 20	Impractical
21 – 40	Less Practical
41 – 60	Quite Practical
61 – 80	Practical
81 – 100	Very Practical

Next, data analysis from the student independence questionnaire was analyzed quantitatively descriptively. Scoring is done based on the Likert scale score as follows.

Table 4. Likert Scale

Critetia	Score	
	Negative Statements	Positive Statements
Never	4	1
Seldom	3	2
Often	2	3
Always	1	4

The data obtained is then analyzed using a formula:

$$\text{Value of Independence} = \frac{\text{score obtained}}{\text{maximum score}} \text{ x } 100\%$$

Furthermore, after being calculated, the percentage obtained is interpreted based on the following criteria.

Table 5. Percentage of Learning Independence

Precentage (%)	Category
0 – 49	Very less independent
50 – 59	Less independent
60 – 69	Quite independent
70 – 89	Independent
90 – 100	Very independent

Increased learning independence of students can be calculated using the analysis method in the form of n-gain with the following formula.

$$< g >= \frac{\text{Tes akhir} - \text{Tes awal}}{S_{max} - \text{Tes awal}}$$

Information:

$<g>$ = Normalized gain score
Final Test = final test score
Pretest = initial test score
S_{max} = score maximum

Then, the N-gain score obtained is interpreted as follows.

Table 6. N-Gain Scoring Table

N-gain Score <g>	Category
$g \geq 0.7$	High
$0.7 > g \geq 0.3$	Currently
$g < 0.3$	Not enough

RESULT AND DISCUSSION

In this research, the product developed is a POGIL-based e-worksheet on Covalent Bond material to increase students' learning independence on chemical bond material. The assessment of the feasibility of student worksheet is reviewed from several aspects including validity, practicality, and effectiveness. The validity aspect is reviewed from the results of the assessment by the validator. The practical aspect is seen from the results of the student response questionnaire after learning using e-worksheets. The effectiveness aspect is seen from the learning independence of students.

Limited trials for this research were carried out in October 2023. This research was tested on 34 class XI students of SMAN 1 Meganti.

E-Worksheet

POGIL-based e-worksheets are designed to adjust the learning objectives that must be achieved at each meeting. E-worksheets can be accessed using a cellphone, computer or laptop connected to the internet network. E-worksheets can be opened by students via a link or barcode that has been sent by the teacher.

Figure 1. E-worksheet display

Figure 2. E-worksheet

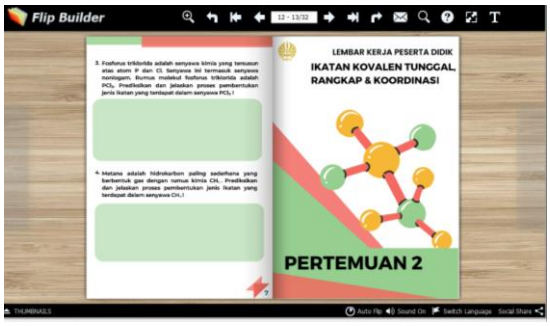

Figure 3. E-worksheet

Figure 4. E-worksheet

Validity of E-Worksheet

The validation sheet in this study includes content and construct validation. The following is the data from the validation results, both in terms of content and construct validation.

Table 7. Content Validity Results

No.	Criteria	Precentage (%) and Category
1.	Suitability of learning outcomes in media developed with the independent curriculum	91.67 Very valid
2.	Suitability of phenomena in the media developed with the learning objectives to be achieved	83.33 Very valid
3.	Suitability of questions in the media developed with the learning objectives to be achieved	75.00 Valid
4.	Learning objectives have been formulated clearly and are in accordance with learning outcomes	91.67 Very Valid
5.	The animations and images presented support the material	83.33 Very Valid
6.	Questions in the media are presented systematically	83.33 Very Valid
7.	Includes student activities can increase learning independence	91.67 Very Valid

Table 8. Construct Validity Test Results

No.	Criteria	Precentage (%) and Category
1.	The media is presented with clear and relevant facts, concepts and theories	75.00 Valid
2.	The media is equipped with interactive features that can increase students learning independence	91.67 Very Valid
3.	There are media usage instructions that help understand how to use the media	100 Very Valid

No.	Criteria	Precentage (%) and Category
4.	The language used is in accordance with correct rules	91.67 Very Valid
5.	The language used is communicative	91.67 Very Valid
6.	Media presentation attracts students to learn	83.33 Very Valid
7.	The choice of colors in the media is appropriate	91.67 Very Valid
8.	Typography (type and arrangement of letters) is appropriate	100 Very Valid
9.	The layout in the media is appropriate	91.67 Very Valid

Based on Table 7 and Table 8, the e-worksheet is included in the valid category because the validity percentage reaches ≥ 61% [9]. Validity results based on assessments from experts were found to be 85.7% in content validity which was in the very valid category and 90.7% in construct validity which was in the very valid criteria.

In terms of content validity, it gets a very valid category. This shows that the covalent bond material contained in the e-worksheet is in accordance with the learning outcomes in the independent curriculum. The content of the covalent bond material contained in the e-worksheet is the process and formation and properties of covalent bonds, types of covalent bonds, and the polarity of covalent bonds which are adapted from [10] and [11].

In terms of construct validity, the category is very valid. This shows that the arrangement, presentation, use of language, and appearance of the e-worksheet are appropriate. Apart from that, the features and learning models in e-worksheets can increase students' learning independence.

Practicality of E-Worksheet

The practicality of e-worksheet is obtained from student response questionnaire instruments supported by observation sheets of student activities during learning using e-worksheet. The results of the student response questionnaire are shown in Table 9.

Table 9. Student Response Questionnaire Results

No	Aspect	Precentage (%) and Category
1.	The phenomena presented are in accordance with the learning objectives	79.45 Practical
2.	The learning steps in e-worksheet are difficult to follow	67,80 Practical
3.	The questions in the E-LKPD are suitable for building concepts in the material	80,14 Practical
4.	Availability of supporting images according to the material	79,45 Practical
5.	Availability of learning resources in accordance with the material in learning	78,08 Practical
6.	The writing in the e-worksheet can be read clearly	81,50 Very Practical
7.	The user guide information and instructions for using e-worksheet are quite complicated	71,92 Practical
8.	The questions are presented using sentences that are easy to understand	80,14 Practical
9.	The sentences used give rise to multiple interpretations	69,18 Practical
10.	The language used is communicative	76,02 Practical
11.	POGIL based e-worksheet is easy to operate	76,02 Practical
12.	I was challenged to work on the questions provided	71,23 Practical
13.	I complete the questions in the e-worksheet in the appropriate time	72,60 Practical
14.	This e-worksheet is able to make me lazy in studying	80,14 Practical
15.	The font size used is correct and easy to read	80,82 Practical

No	Aspect	Precentage (%) and Category
16.	The type of font used is easy to read	80,82 Practical
17.	The available image is blurry	78,08 Practical
18.	the layout and components of learning media are correct	80,82 Practical
19.	The e-worksheet design presented is attractive	84,24 Very Practical
Average		77,29 Practical

Based on student response data, the results were 77.29% or included in the practical category. Statements in the response questionnaire related to the contents of the e-worksheet are found in points 1, 2, 3, 4, 5 and 7, while statements related to constructs are found in points 6, 8, 9, 10, 11, 15, 16, 17, 18 and 19. Apart from that, there are statements related to students' learning independence at points 12, 13, and 15.

Based on the results of the response questionnaire, on average students agreed with the statement that the questions in the e-worksheet were suitable for building concepts in the material. This shows that the POGIL learning model can help students build concepts well.

In the student response questionnaire, both statements related to content, constructs and student learning independence received the very practical category. This is in line with data from observations of student activities during learning using e-worksheet.

Table 10. Results of Observation Student Activities

No	Aspect	Precentage (%) and Category
1.	Students can participate in learning activities using POGIL-based e-worksheet well	92.46 Very Practical
2.	Students can take part in every stage of the activities in the POGIL-based e-worksheet	89.72 Very Practical
3.	Students can use POGIL-based e-worksheet well	84.93 Very Practical
4.	Students take part in learning using POGIL-based e-worksheet on time	82.87 Very Practical
5.	Students ask questions about material they do not understand	89.72 Very Practical
6.	Students discuss the material with friends	91.09 Very Practical
7.	Students work on practice questions on the POGIL-based e-worksheet	88.35 Very Practical
8.	Students can freely express their opinions and explore in finding a concept	86.30 Very Practical
9.	Students conclude the material they have studied with the teacher	92.46 Very Practical
10.	Students complete the questions on time according to the given duration	91.78 Very Practical
Average		88.97 Very Practical

Based on Table 10, it is known that each aspect gets a very practical category. This shows that students can use the e-worksheet well and can follow the POGIL learning model in the e-worksheet.

Student activities related to independent learning in points number 4, 5, 6, 7 and 9 received the very practical category. This shows that the use of e-worksheets with the POGIL model is able to facilitate students to increase learning independence because in this model students are required to be able to solve problems independently, responsibly and confidently [12].

Effectiveness of E-Worksheet

Data on the effectiveness of e-worksheets on covalent bond material to increase students' learning independence was obtained from the students' learning independence questionnaire. Questions related to the condition of students' learning independence are contained in the learning independence questionnaire sheet.

In the learning independence questionnaire there are 25 statements with details of 16 positive statements and 9 negative statements. There are four answer choices that students can choose, including, Always (A), Often (O), Rarely (R), and Never (N).

The results of n-gain student learning independence are shown in Figure 5.

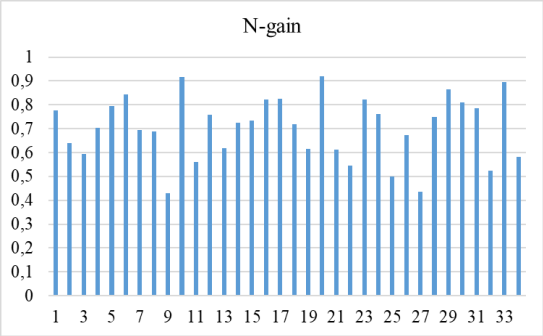

Figure 5. N-gain results

Based on Figure 1, it is known that the n-gain results of students' learning independence are on average in the high category. This shows that students' learning independence has increased significantly. These results show that the interactive e-worksheet developed is effectively used to increase students' learning independence.

In the e-worksheet, the questions are arranged systematically based on POGIL inquiry syntax. When answering these questions, students need to work on the e-worksheet from start to finish so they can conclude the material being studied well. According to [13], efforts to increase independence are by making students' agendas more effective through giving assignments regularly.

The e-worksheet developed contains interactive features that make it easier for students to learn. Based on connectivist learning theory, the use of digital technology in learning can be done to make it easier for students to learn independently, creatively, build relationships and share material that is not well understood. This is in accordance with research by [13], which states that learning by utilizing digital technology is able to provide a concrete picture of the material presented, save time, and train students' independent attitudes. Students' learning independence after learning using interactive e-worksheets is shown in Figure 2.

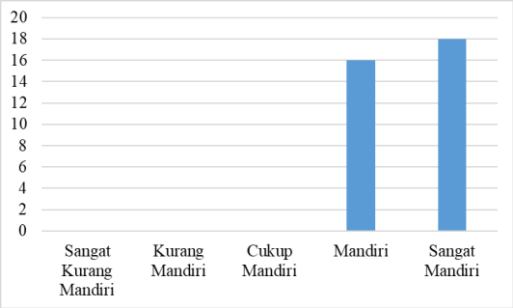

Figure 6. Learning Independence

Based on Figure 6, it is known that students' learning independence falls into two categories, namely independent and very independent. This shows that after learning using e-worksheets students are independent.

From the validity, practicality and effectiveness results obtained, the POGIL-based e-worksheet on Covalent Bond material to increase students' learning independence is considered to meet the appropriateness standards of a learning media.

CONCLUSION

Based on the results of the research that has been carried out and the data that has been obtained, it can be concluded that the POGIL-based e-worksheet on Covalent Bonds material to increase students' learning independence can be used as a learning medium to support chemistry learning, especially on covalent bond material.

SUGGESTION

This research was only carried out at SMAN 1 Menganti, so it would be better if it was also applied to other high schools to get more accurate results. Then, because there are time limitations (number of meetings), more meetings can be carried out so that the use of the module is more optimal.

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