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Validity and Practicality of Chemical Equilibrium Electronic Student Worksheets Based on Guided Discovery Learning to Increase the Critical Thinking Ability

Sonya Frisilla[1*], Hardeli[1]

[1] Master of Chemistry Education Study Program, Universitas Negeri Padang, Padang, Indonesia.

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Abstract: Chemical equilibrium is an abstract chemical material that includes concepts and calculations. The purpose of this study was to develop and produce chemical equilibrium electronic student worksheets based on guided discovery learning to improve students' critical thinking skills and fulfill the criteria for validity and practicality. This research and development use the Plomp model which consist of three stages, namely the preliminary research phase, prototyping phase, and the assessment phase. The validity and practicality of the teaching materials developed were obtained through research instruments in the form of validation and practicality questionnaires. Validation was carried out by 6 material expert validators and three media expert validators while practicality was carried out by 40 students of 11th grade high school students and three chemistry teachers. The data analysis technique used is Aiken's V technique for validity and the percentage technique for practicality. The results of the analysis of the material expert validation and media expert validation data based on the average Aiken's V value showed a result of 0.84 and 0.89 with a very valid category. The results of the practicality of the electronic student worksheets were 84.87 and 92.11 with a very high category.

Keywords: Critical thinking; Electronic students' worksheets; Guided discovery learning

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Introduction

The ability to think critically is an important skill for the success of the study, work, and life in the information and technology era of the 21st century because critical thinking allows humans to exploit their potential in seeing problems, solving problems, creating and realizing their abilities. Critical thinking skills are important for students in learning chemistry because in chemistry learning students are required to recognize and solve problems, infer, analyze, conclude, and evaluate (Suryani et al., 2018). Critical thinking is an organized process that allows students to evaluate the evidence, assumptions, logic, and language behind the claims of others. With critical thinking, students will find the truth between the many facts and the information they receive (Ellizar et al., 2019). Based on the core competencies of graduates in the 2013 curriculum in the skills aspect, it requires students to have the ability to think and act effectively and creatively in the abstract and concrete realms. Critical thinking ability is one of the abilities to think in the abstract realm (Kemendikbud, 2013).

The development of critical thinking skills in learning should be optimized by applying appropriate and creative learning strategies for optimal learning. One of the innovative 2013 curriculum learning models by empowering the thinking process through discovery is Guided Discovery Learning (GDL), in this model learning will be designed to find concepts and relationships between concepts (Dahliana & Khaldun, 2018). Learning using discovery learning can improve students' critical thinking skills because students are trained to observe, ask questions, try, reason, and

* Corresponding Author: sonya.frisilla@gmail.com

communicate through the stages of the learning model (Desriyanti et al., 2019). In addition, the discovery learning model also encourages students to be active in the learning process by finding concepts independently from the stimulation provided by the teacher (Lestari et al., 2019). The successful implementation of this guided discovery learning model requires teaching materials that can help the process of achieving students' critical thinking skills, improve students' scientific attitudes, and teaching materials that can encourage students to improve students' conceptual understanding.

Technology, Information, and Communication (ICT) is currently growing rapidly and has shown progress in various aspects, one of which is in the learning process. This is in line with the demands of the 2013 curriculum which expects students to be able to utilize and skillfully use technology, information, and communication needed in the 21st century. In addition, the current state of the COVID-19 pandemic has also affected the education sector. The government decided that the implementation of learning in schools was shifted to online learning so that electronic-based learning media or teaching materials were needed. One alternative that can encourage students to improve their understanding of concepts and improve students' scientific attitudes is the Electronic Student Worksheet (E-WS). E-WS is one of the teaching materials whose presentation is transformed into electronic form in which there are pictures, animations, and videos that are more effective to make learning more interesting for students.

In previous studies, the Student Worksheet used was still conventional. The Student Worksheet contains a set of basic activities that must be carried out by students to maximize understanding to form basic abilities according to indicators of achievement of learning outcomes taken. The Student Worksheet also contains a set of basic activities that must be carried out by students to maximize understanding to form basic abilities according to indicators of achievement of learning outcomes taken (Nizar et al., 2016). The development of Student Worksheet is effective for increasing mastery of concepts (Doyan & Rahman, 2021), the learning process runs actively by training students to develop skills and find concepts (Rizki et al., 2021), to increase learning motivation and student learning outcomes (Ichsan, 2021). The learning process using Student Worksheet showed a significant increase in learning outcomes (Asma, 2020), increased knowledge (Ariani & Meutiawati, 2020), and students' skills in solving given problems (Wahyuni et al., 2020). In previous studies, the Student Worksheet based on guided discovery learning used was still conventional.

Based on observations and the results of interviews with chemistry subject teachers as well as giving questionnaires to 11th grade high school students, information was obtained that there were problems encountered when learning chemical equilibrium. The first problem is in the learning process teachers still often use textbooks as the main reference material in teaching. In general, students get knowledge only from teacher explanations who are still guided by textbooks and the learning process still tends to be teacher center, therefore students become passive and lack the motivation to develop more critical thinking.

The second problem is, as many as 79% of students who were given a questionnaire stated that the chemical equilibrium material is a material that is still considered difficult by students because the material is computational so that students have difficulty in determining the formula to be used in solving chemical equilibrium learning problems. The third problem is that there is not enough time in the learning process. Based on the problems encountered, to support guided discovery learning-based learning, especially on chemical equilibrium material by utilizing technological advances and the need for E-WS that can improve students' critical thinking skills. This study aims to develop a chemical equilibrium E-WS based on GDL to improve students' critical thinking skills, as well as to determine the validity and practicality of the product.

Method

This type of research is educational design research. The development model used is the Plomp development model as developed by Tjeerd Plomp. This model consists of 3 stages, namely preliminary research, development or prototyping phase, and assessment phase (Plomp & Nieveen, 2007). To produce quality development, an assessment is needed. The quality of the product developed is determined by the criteria of validity, practicality, and effectiveness (Nieveen, 1999). In this study, the expected product is E-WS based on GDL to improve students' critical thinking skills of chemical equilibrium material. The destination of making this E-WS is to meet valid and practical criteria. This research on E-WS teaching materials was carried out at FMIPA UNP and SMAN 14 Padang. The validation was carried out by chemistry education experts, engineering lecturers, and educational technology lecturers. The practicality of the E-WS used is seen from the results of observing the implementation of learning, filling out practical questionnaires by chemistry teachers and students.

The data collection instrument in this study was a questionnaire validation and practicality of the product. Validation questionnaires are useful for assessing the level of validation of the developed teaching materials, validation is carried out by several experts or experienced experts to assess the weaknesses and strengths of the resulting product (Sugiyono, 2009). In

this study, the validation was carried out by 9 validators consisting of 6 material expert validators and 3 media expert validators. Material validation was carried out by 3 chemistry lectures and 3 chemistry teachers.

In this study, the validation value given by the validator was analyzed using a data analysis technique in the form of categorical judgments based on Aiken's V scale. The data obtained from the questionnaire was then analyzed using the Aikens' V formula.

$$v = \frac{\Sigma s}{n(c-1)} \quad (1)$$

Information:
s : r – lo
r : the number given by validator
lo : the lowest validity rating score
c : the highest number of validity assessments
n : number of validators

Table 1. Decision Category Based on Aiken's V

Criterion V	Interpretation
V ≤ 0.40	Low
0.40 < V ≤ 0.80	Medium
0.80 < V	High

(Retnawati, 2016).

In this research, the data analysis technique of practicality assessment uses the formula:

$$\%\ Practicality = \frac{Total\ score}{Maximum\ score}\ x\ 100\ \% \quad (2)$$

The values obtained are interpreted according to the categories shown in Table 2.

Table 2. Categories of practicality assessment

Achievement Rate	Category
81 – 100	Very Practical
61 – 80	Practical
41 – 60	Quite Practical
21 – 40	Less Practical
0 – 20	Not Practical

(Yanto, 2019)

Result and Discussion

Preliminary research.

At the preliminary research stage, it aims to identify problems that occur in equilibrium learning so that an overview of the product specifications needed in the development of E-WS is obtained. At the preliminary research stage, it is necessary to analyze the needs of teachers and students by performing interviews, curriculum analysis, and conceptual analysis.

The needs analysis aims to know the basic problems that students and teachers face in learning chemistry to develop teaching materials. The analysis was carried out by interviewing chemistry teachers and giving questionnaires to students at SMAN 3 Padang, SMAN 7 Padang, and SMAN 14 Padang. Based on the interviews that have been conducted, it is known that the teaching materials used in learning are still in the form of printed books, learning still uses the lecture method and is teacher-centered, and the questions on the teaching materials used are still very few to test the cognitive level of students at the C4 - C6. The results of the student questionnaire data showed that 79% of students stated that chemical equilibrium material is one of the difficult chemical materials in determining formulas, students want teaching materials that have a complete material with easy-to-understand language, there are exercises and practicums, and the time given to learn in class is not enough.

Based on this, we need teaching material that can make students more active in learning. The results of the study (Windari, 2018) states that guided discovery learning-based worksheets are effective in improving learning outcomes, (Nurahman & Saulon, 2018) and students are easier to understand the material provided.

Curriculum analysis aims to study the scope of the material and learning objectives to develop teaching materials. This analysis includes an analysis of the abilities that students must master in studying chemical equilibrium material in accordance with the 2013 revised 2020 curriculum. Based on the syllabus analysis in the 2013 revised 2020 curriculum that has been carried out, an analysis of Basic Competence is obtained which is translated into Competency Achievement Indicators.

Concept analysis aims to determine the concepts developed in learning. Concept analysis in this study was carried out by identifying the main concepts in the chemical equilibrium material. Based on the concept analysis, it is found that the main concepts that must be mastered by students include: chemical equilibrium, dynamic equilibrium, homogeneous equilibrium, heterogeneous equilibrium, shifting equilibrium, Le Chatelier's principle, equilibrium constant, and equilibrium in industry.

In the preliminary study, a literature study was also carried out, this analysis was used by searching for some literature in the form of relevant journals related to research, namely GDL and the use of E-WS, then calculated how big the influence was. The effect on the GDL obtained an average effect size value of 4.13 which shows a high influence on learning outcomes and for the use of student worksheets the effect size value is 4.51 with a high category in improving learning outcomes, so the use of GDL models and Student Worksheet are good to use in research because they affect learning outcomes.

Development or prototype phase

At this stage, four prototypes were produced before creating the final prototype where each prototype was

followed by a Tessmer formative evaluation stage. The prototype results at each stage are described as follows:

Prototype I

Based on the results of the analysis at the preliminary research stage, the product is designed in the form of an E-WS based on GDL, designing a model that is in accordance with the learning objectives of chemical equilibrium material, and making evaluation questions. The prototype I is a prototype generated from the design and the preliminary research. The prototype I produced in the form of E-WS has several components, namely:

1. Cover

The cover of the developed contains the title of the E-WS, the material discussed, the class, the name of the researcher. The cover is designed in such a way and describes the contents of the student worksheet.

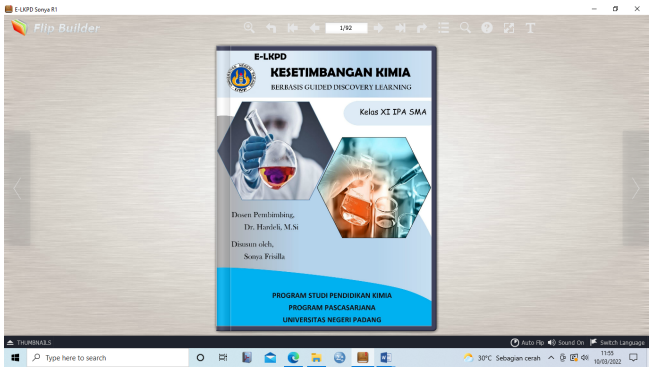

Figure 1. E-WS cover

2. Instructions for using E-WS

There are instructions for using the E-WS for teachers and students that contain instructions on how to use the E-WS based on guided discovery learning.

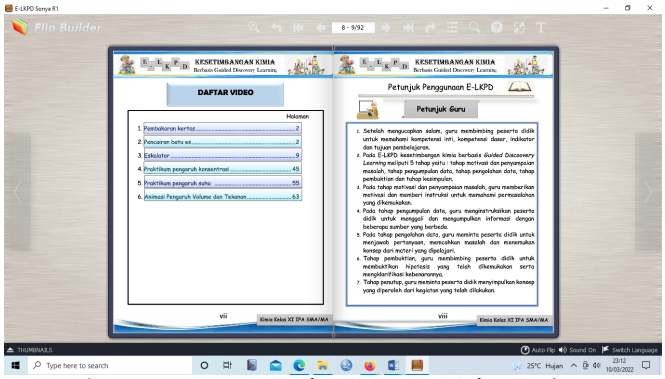

Figure 2. Instructions for using E-WS for teachers

3. Basic competencies

Basic competence contains aspects of abilities that must be mastered by students and as a reference for compiling competency indicators in a lesson.

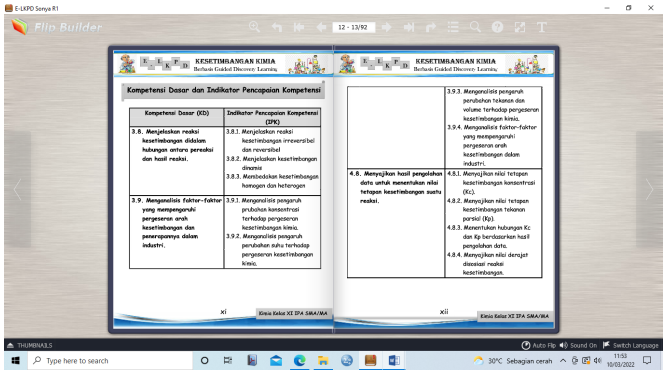

Figure 3. Basic competencies

4. Student activity sheet

Each student activity sheet contains learning objectives and a summary of the material adapted to the guided discovery learning stage.

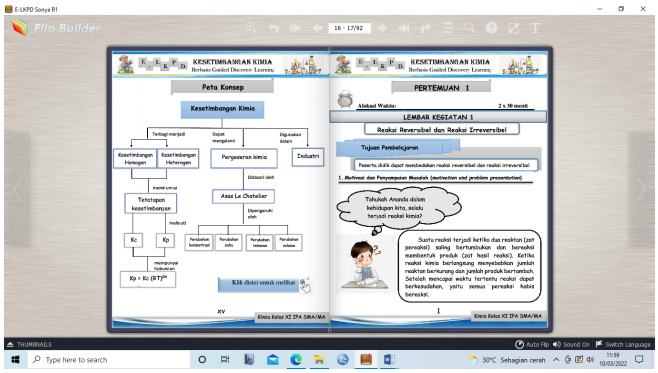

Figure 4. Student activity sheet

5. Practical demonstration video

Students can see and observe the practicum process virtually and are equipped with questions that guide students to think critically.

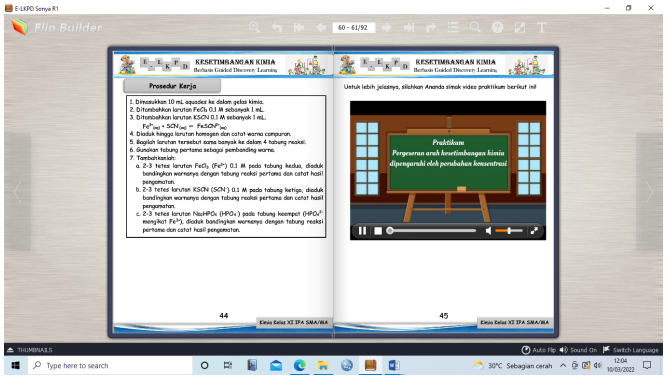

Figure 5. Practical demonstration video

6. Evaluation

This evaluation is used to see the extent to which students' abilities after studying chemical equilibrium material using E-WS based on GDL.

7. Bibliography

The bibliography aims to make students aware of the sources used in compiling the E-WS so that students can look for other sources to increase students' insight into the material being studied.

The learning activities of a prototype I produced using guided discovery learning stages include (1) motivation and problem presentation, (2) data collection, (3) data processing, (4) verification, and (5) closure. The design of prototype I in the form of a chemical equilibrium E-WS based on guided discovery learning was produced using the flip pdf pro application. The type of writing used varies with the size that is adjusted. The choice of color variations for prototype I was adjusted to the needs to make it look attractive, which was dominated by gray, green, and blue colors.

The design of this E-WS includes aspects of content, construct, language, and graphic components. The product that has been designed and developed is called prototype I.

Prototype II

At this stage, a formative evaluation of the Tessmer is carried out in the form of self-evaluation of the prototype I that has been produced. In general, many improvements were made to typos, image size/layout, consistency in writing, and requiring revision of several E-WS components.

Prototype III

At this stage, Tessmer's formative evaluation was carried out in the form of an expert review and one-to-one evaluation of prototype II with the following results:

1. Expert Review

Then validation by expert review on prototype II. The instrument used in this E-WS validation stage is a validation questionnaire sheet. The validator will assess the E-WS and provide suggestions for improvements to the products that have been developed. The validator's suggestions will be a reference in product improvement. There are four components assessed by the validator, namely the content, the construct, the language, and the graphic component (Depdiknas, 2008).

The results of the validation of product by validator were analyzed using Aiken's, the results of the analysis can be seen in table 3.

Table 3. Assessment of Material Expert Validation Results

Aspect	V	Validity category
Content Component	0.84	Very Valid
Construct Component	0.88	Very Valid
Language Component	0.78	Valid
Graphical Component	0.84	Very Valid
Average	0.84	Very Valid

E-WS using the 2013 curriculum, the validity of learning steps using a guided discovery learning model, and accuracy of the content of chemical equilibrium materials in line with indicators to be achieved and learning goals. Based on research results, E-WS for guided discovery learning-based chemical balance to strengthen students' critical thinking skills has very valid criteria. This shows that the materials presented at E-WS are consistent with the curriculum revised in 2013 in terms of basic abilities, indicators and learning outcomes to be achieved. In addition, the issues raised as motivations in the steps of the GDL model are consistent with the subject being taught. The questions contained in E-WS guide students to discover their own concepts. The E-WS content components have been validated so that the developed product can be used in the learning process to support teachers and students in achieving the abilities they need in equilibrium chemistry. This is by following per under the theory that validity indicates a product developed according to the curriculum and based on a strong rational theory (Rochmad, 2012).

The construct component for verifying the suitability of E-WS developed in the learning model used is the guided discovery learning model. E-WS development uses the format of E-WS presentations based on the systematic structure, including cover sheets, referrals, tables of contents, instructions on how to use E-WS for teachers and learners, and basic abilities. Will be displayed. Core competencies, learning goals, activity student sheets, rating questions, answers, answer keys, and references tailored to the guided discovery learning phase. For construct components, E-WS scores were achieved in a very valid category. This shows that E-WS activities are organized systematically by clearly presenting learning goals and indicators achieved by teachers and students. In addition, E-WS activities were ordered based on the steps of a guided discovery learning model: motivation and problem presentation, data collection, data processing, validation, and completion (Yerimadesi et al., 2017). By using these steps, students are guided and guided to explore their knowledge.

The language component is easy to understand and adheres to Indonesian grammar to note the language used. The score received from the validator is valid in a valid category. This shows that E-WS activities are organized systematically by clearly presenting learning goals and indicators achieved by teachers and students. The language used is compatible with the level of understanding and helps students develop their critical thinking skills. This is by following per under the statement of (Depdiknas, 2008) that the indicators assessed as validators in terms of linguistics include readability, clarity of information, suitability of writing

correct Indonesian language rules, and use of language effectively and efficiently.

A graphic component to verify the suitability of cover designs, images, text, and color usage to give E-WS a pleasing look. Based on the evaluation, the E-WS developed has a very useful category. This shows that the cover design you choose is attractive, the image is easy to recognize, and the text and font size used is proportional, making it easier for the user to read. The content layout and E-WS layout are neat, and the color combinations used in E-WS are attractive and can arouse students' interest in learning. In addition to assessments from material experts, the products developed were also assessed by 3 media experts consisting of 2 engineering lecturers and 1 educational technology lecturer.

Media validation was carried out by three media expert lecturers. There are three aspects assessed by the validator, namely the display aspect, programming aspect, and utilization aspect (Sukardi, 2012). In media validation, three aspects are assessed by the validator, namely aspects of the display, programming, and utilization. The results of the analysis can be seen in table 4.

Table 4. Assessment of Media Expert Validation Results

Aspect	V	Validity category
Display	0.83	Very Valid
Programming	0.93	Very Valid
Utilization	0.92	Valid
Average	0.89	Very Valid

Aspects of appearance, to see the selection of the right letters, display images or videos that are good to see, as well as backgrounds that do not interfere with the legibility of the writing contained in the E-WS teaching materials. The assessment obtained from the validator is in the very valid category. This shows that the letters, pictures, videos, and backgrounds used are very clear and precise in this teaching material. The existence of this display aspect makes students more focused on learning (Ellizar et al., 2018).

The programming aspect is to see the efficiency of the media presented based on the balance of the composition of text, images, and videos, the ease of using the E-WS, the use of symbols/icons in the E-WS that can be understood. The assessment obtained from the validator is in the valid category. this shows that the efficiency of the media presented is correct.

Aspects of utilization, to observe the ease of interacting with E-WS teaching materials, the availability of examples and illustrations that clarify understanding of the material, contextual materials, and can attract students to learn to use E-WS teaching materials. The assessment obtained from the validator is in the very valid category. This shows that users are very easy to interact with E-WS teaching materials, have illustrations that clarify understanding of the material, contextual materials, and can increase the attractiveness of students in learning by using these teaching materials. Therefore, E-WS provides flexibility for students to learn independently in finding concepts (Ellizar et al., 2018).

2. One-to-one evaluation

At the one-to-one stage, the evaluation was carried out through interviews with three students with different abilities, namely low, medium and high abilities. The aspects evaluated were clarity, attractiveness, and apparent error. After the product was revised based on the assessment of the two formative evaluations, prototype III was produced.

Prototype IV

Assessment of the practicality of an E-WS can be seen from the aspect of ease of use, efficient learning time, and the benefits of teaching materials on the interests of students (Sukardi, 2012). A small group trial was conducted on prototype III, the E-WS teaching materials were tested in a small group evaluation of 6 students with heterogeneous abilities (high, medium, and low), the instrument used was a questionnaire. This questionnaire is intended to determine the utility of E-WS before proceeding to the field-testing phase. This small group evaluates the ease of use, the efficiency of learning time, and product benefits. The analysis of the practicality questionnaire for small group students can be seen in table 5.

Table 5. Practical Results in Small Group Trials

Aspect	% Practicality	Category
Ease of Use	93.33	Very Practical
Learning Time Efficiency	93.00	Very Practical
Benefits	90.00	Very Practical
Average	92.11	Very Practical

The average result of the practicality assessment of the E-WS that has been developed in small groups is 92.11 with a very practical category, and several parts must be improved in the E-WS. After evaluating the small group, the revised E-WS is called prototype IV and it can be concluded that the chemical equilibrium E-WS teaching materials based on GDL can be continued with field tests at school.

This shows that the E-WS teaching materials are easy to use (Sukardi, 2012), increase understanding, and make students active in learning. Students can also study teaching materials wherever and whenever they are (Daryanto, 2010). In addition, teaching materials are also supported by systematic learning steps to guide students in finding concepts (Ellizar et al., 2018).

Assessment Phase

The assessment stage aims to see the practicality of the chemical equilibrium E-WS based on GDL which has been developed on a larger scale, which is piloted in schools. The practicality of E-WS is seen from the aspects of ease of use, the efficiency of learning time, and benefits. Practical data were obtained from teacher response questionnaires and student response questionnaires after carrying out learning using E-WS.

Table 6. Practical Results by Teachers

Aspect	% Practicality	Category
Ease of Use	89.00	Very Practical
Learning Time Efficiency	80.00	Practical
Benefits	85.71	Very Practical
Average	84.87	Very Practical

The teacher's response questionnaire contains 18 aspects of the statement filled out by 3 chemistry teachers. The results of the teacher's practicality questionnaire are shown in table 6. Based on table 6, it can be seen that the developed E-WS teaching materials have a very high level of practicality in the category, meaning that these E-WS teaching materials are practically used by teachers in the learning process.

Table 7. Practicality Results by Students at the Field Test Stage

Aspect	% Practicality	Category
Ease of Use	83.39	Very Practical
Learning Time Efficiency	76.00	Practical
Benefits	79.25	Practical
Average	79.55	Practical

Student practicality questionnaires were given to 40 students in 11th grade high school students after learning using E-WS teaching materials was carried out. The results of the practicality of students at the field test stage can be seen in table 7. Based on the table above, it can be concluded that the level of practicality obtained is practical, this shows that the developed E-WS is interesting, easy to understand because the instructions for using the E-WS, and GDL models help students understand learning materials and help students find concepts independently.

This is by following per under the statement (Lestari et al., 2019) that the discovery learning-based teaching materials can help study time more efficiently and the presence of animation makes students happy to learn independently. The results of the data analysis showed that E-WS chemical balance based on guided discovery learning is practical to use to improve critical thinking skills in grade 11.

Conclusion

Based on the development and experiments conducted on the chemical equilibrium E-WS teaching materials based on guided discovery learning to improve students' critical thinking skills that are valid and practical. So, it was found that the E-WS teaching materials produced in this development study had a very valid level of validity, both from the results of material expert validation and media expert validation with an average V value of 0.84 and 0.89. At the level of practicality of E-WS teaching materials, very practical results were obtained in small group trials and teacher practicality with practicality percentages of 92.11 and 84.87. Based on the questionnaire at the field test stage, the percentage of practicality was 79.55 with the practical category. This shows that the chemical equilibrium E-WS teaching materials based on guided discovery learning to improve students' critical thinking skills are categorized as valid and practical in their use.

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