HYDROGEN
JURNAL KEPENDIDIKAN KIMIA
https://e-journal.undikma.ac.id/index.php/hydrogen/index

April 2024. 12(2)
e-ISSN: 2656-3061
p-ISSN: 2338-6487
pp. 243-255

Development of Guided Inquiry Oriented with Chemical Representations e-Worksheets to Train Science Process Skills on Chemical Equilibrium

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Article History
Received: 20-03-2024
Revised: 20-04-2024
Published: 30-04-2024

Keywords: guided inquiry; mutiples of chemical representations; science process skills

Abstract
Chemistry learning, namely chemical equilibrium material, is considered less easy to understand for students because they are less able to represent mutiples of chemical representations, and science process skills are low. This problem was found referring to the results of a pre-research questionnaire of students and interviews with high school teachers in Surabaya. Overcoming this, learning media that helps students understand the material according to the characteristics of students is needed. The purpose of this research is to produce a product in the form of Student worksheet electronic that is feasible to develop on chemical equilibrium material. The method used is research and development with the 4D model which consists of defining, designing, developing, and disseminating stages. This research was only conducted up to the development stage. Student worksheet electronic on chemical equilibrium material was tested on students of class XI-5 SMA Negeri 3 Surabaya who had studied chemical equilibrium material was the subject of this study. This research instrument is in the form of a review sheet, validation sheet, student response questionnaire sheet, observation sheet, test sheet. This research produces guided inquiry Student worksheet electronic media oriented to multiple chemical representations on chemical equilibrium material. The results of Student worksheet electronic validation from the aspects of content validity and construct validity, each obtained a mode of 4 so that it is very valid to use. The results of the student response questionnaire reached an average of 88.3% positive response with a very practical category. The results of pretest and posttest data analysis obtained an increase in science process skills as much as 80% of students get a high criteria n-gain score. It is concluded that the guided inquiry Student worksheet electronic oriented to multiple chemical representations on chemical equilibrium material is feasible to use to train students' science process skills.

How to Cite: Putri, R., & Novita, D. (2024). Development of Guided Inquiry Oriented with Chemical Representations e-Worksheets to Train Science Process Skills on Chemical Equilibrium. Hydrogen: Jurnal Kependidikan Kimia, 12(2), 243-255. doi:https://doi.org/10.33394/hjkk.v12i2.11146

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INTRODUCTION

One of the materials taught at school is Natural Sciences (science), which includes chemistry, physics, biology, astronomy and geology. Chemistry is the study of matter and its changes, where the substances involved in chemical changes are elements and compounds (Chang, 2005). In the process of learning chemistry requires an in-depth understanding of concepts taught through a scientific approach in order to have quality, innovative, and superior knowledge and skills, and be able to solve the problems they face (Nainggolan, Hutabarat, & Gultom, 2019). The concept of chemistry learns about phenomena that cannot be observed directly, even learning the process of discovery and mastery of the scientific method. Judging from the reality that occurs in schools proves that many students feel unsuccessful in studying chemistry because the subject is considered difficult for most high school students.

Chemical equilibrium material, especially the sub-matter of factors that affect the shift in the direction of chemical equilibrium is material that is considered difficult to understand by high school students, because chemical equilibrium material is a broad subject matter with concepts and descriptions so that in-depth understanding of concepts is needed (Kurniyaningsih & Yonata, 2019). In addition, this is also because the changes that occur in an equilibrium state in a reaction are at the submicroscopic level so it is difficult to observe with the naked eye (macroscopic). Based on interviews with chemistry teachers that learning chemical equilibrium material so far has only been limited to two levels, namely macroscopic and symbolic, the imbalance of students' understanding of the three levels of chemical representation will result in students having difficulty in relating chemical concepts to everyday life (Safitri, Nursa'adah, & Wijayanti, 2019).

In realizing chemistry learning that is active and easy to understand, a special skill is needed as a form of science process. These skills are commonly called science process skills, which are skills that are needed and must be possessed by students to face competition between humans in this era. Because with the development of science process skills, the basic competencies of students also develop, namely the scientific attitude of students and skills in solving problems (Haryono, 2006). According to Dimyati & Mudjiono (2009), a teacher cannot act as the only person who can transfer facts and theories so that science process skills are needed to be applied in the teaching and learning process.

The importance of developing science process skills is also based on the High School Graduate Competency Standards according to the Regulation of the Minister of Education and Culture Number 5 of 2022 which requires students to have the ability to analyze complex problems and ideas, conclude the results and convey arguments and support their thoughts based on accurate data. This is relevant to science process skills, so it is necessary to improve science process skills in students. In addition, developing science process skills in chemistry lessons is supported by research by Nurkhasanah & Yonata (2017) which states that the science process skills of students are still relatively low because students are less actively involved in the learning process. One of the efforts that can be made in improving students' science process skills is learning by using the guided inquiry model. Learning by applying the guided inquiry learning model is very well implemented to train students' science process skills (Lailahuda & Ismono, 2019).

The guided inquiry learning model is a model developed to actively involve students by conducting a series of investigative activities to solve problems (Hosnan, 2014). In chemical equilibrium material, there are three factors that affect the shift in the direction of equilibrium, namely, concentration factors, pressure and volume factors, and temperature factors, so that it requires in-depth understanding of students to get conclusions from these three factors so that there are no wrong concepts (Kurniyaningsih & Yonata, 2019). The material is closely related to problems that occur in everyday life. Through investigation activities, students will better understand the knowledge they get and the learning will be more meaningful, and can build their own knowledge from the scientific work process so that students will develop process skills and scientific attitudes in themselves for everyday life (Hidayati & Yonata, 2019).

In guided inquiry learning, the teacher's role is as a facilitator for students to solve problems. The syntax of the guided inquiry model is to focus attention and explain the inquiry process, present inquiry problems or phenomena, formulate hypotheses from problems, collect data to test hypotheses, make or formulate conclusions, reflect on the phenomenon/problem and the thinking process used in the investigation (Arends, 2012). The components of science process skills that will be trained in this study are relevant to the syntax of the learning model, so that through the guided inquiry learning model can train students' science process skills on chemical equilibrium material (Berliana & Yonata, 2019).

In order to fulfill the learning process of science process skills, a learning media is needed that can help the process of achieving students' science process skills, especially the Student Worksheet. This is relevant to research Pradipta (2023) which states that electronic student worksheets based on multiple representations on chemical equilibrium material that focuses on science process skills based on valid criteria get positive responses from students and teachers. According to Dermawati, et al (2019), Student Worksheets are one of the learning media in printed form which is usually used by teachers in the learning process containing tasks that must be completed. Tools used to assist the learning process and clarify the meaning in the delivery of learning material are called learning media (Rionanda, et al., 2022). The Student Worksheet serves to add and deepen students' knowledge of the material presented, because in the student worksheet there are components that are made to increase student motivation in the form of problems related to everyday life (Lestari & Muchlis, 2021).

Currently, student worksheets can be further optimized by utilizing technology and presenting them in interesting and interactive electronic media. Electronic student worksheets are learning media in the form of student exercise sheets that are done digitally and carried out systematically and continuously over a certain period of time (Lathifah, dkk., 2021). Electronic student worksheets have the advantage of being able to motivate students to be active in the learning process, can simplify while narrowing space and time so that learning becomes more effective (Suryaningsih & Nurlita, 2020). The research Rahmawati and Agustini (2023) stated that the electronic Student Worksheet was effective in the learning process based on the results of the paired sample t-test pretest and posttest values in the realm of science process skills which showed that the t_{count} was 21.458, t_{table} 1.706 and Sig 0.000, so it was concluded that there was a difference in the pretest and posttest scores and supported by the classical completeness value of the knowledge domain learning outcomes of 92.59%. In order to realize a more effective electronic Student Worksheet, a platform is needed to facilitate it, one of which is liveworksheet. Liveworksheet is a platform that provides a place for teachers to create e-worksheets or interactive worksheets that can be done online. (Nurbayani, et al., 2021). The selection of this platform is very appropriate, because the electronic Student Worksheet to be developed contains multiple chemical representations which require a platform that is able to visualize these representations.

Based on the description above, the most effective solution that can be done by researchers to overcome the problems that occur is to develop learning media with the title "Development of Guided Inquiry Electronic Student Worksheets Oriented to Multiple Chemical Representations to Train Students' Science Process Skills on Chemical Equilibrium Matter. It is hoped that this learning media can train students' science process skills in this material. This is because the media produced is in accordance with the characteristics of students, namely the fulfillment of the three levels of chemical representation in learning and the components of science process skills through investigation activities so that it can help students understand chemical equilibrium material, especially the submaterial of factors that affect the shift in the direction of chemical equilibrium. This study aims to determine the feasibility of Guided Inquiry electronic Student Worksheets based on valid, practical, and effective criteria for training students' science process skills.

METHOD

This type of research is research and development (R&D) by applying the 4D model which consists of defining, designing, developing, and disseminating stages (Thiagarajan et al., 1974). This research was only carried out until the development stage so that it only focused on the level of feasibility in terms of validity, practicality, and effectiveness results.

The first stage is defining, namely defining the problems of students during the learning process and the learning needs of students. Defining is done with the steps of beginning-end analysis, student analysis, final task analysis, and final concept analysis through interviews with chemistry teachers and distributing questionnaires to high school students so that facts are obtained in the field regarding the problems and needs of students, which are then continued with the step of determining instructional objectives.

The second stage, namely design, is making a design. At this stage the researcher makes an initial design of the product to be developed, namely the guided inquiry electronic Student Worksheet oriented to multiple chemical representations on chemical equilibrium material. The activity steps in the design stage are the preparation of test standards, selection of learning media, website selection, virtual lab selection, and format selection tailored to multiple chemical representations and guided inquiry learning models. The result of this stage is a draft of the electronic Student Worksheet to be developed.

The third stage, namely development, is that researchers realize the designs that have been made and conduct reviews and validations as a form of evaluation of the learning media developed, involving validation assessments by three validators (two chemistry lecturers and one chemistry teacher), then revisions are made according to the validator's suggestions and comments. After validating the electronic Student Worksheet, then a limited trial was carried out, namely a pretest-posttest before and after using the electronic Student Worksheet, Then a response questionnaire was distributed to students after using the developed electronic Student Worksheet to determine the practicality of using electronic Student Worksheet based on the students' response questionnaire, and observations were made of students' activities carried out by fellow students during the learning process, observations were made for each individual student to find out each student's activity to support practicality data.

The product developed is learning media in the form of Guided Inquiry electronic Worksheets Oriented to Multiple Chemical Representations to Train Science Process Skills on Chemical Equilibrium Material. This research uses the One Group Pretest-Posttest Design method. The research design is presented in table 1.

Table 1. One-group pretest-posttest research design

Group	Pretest	Treatment	Posttest
Experimental group	O_1	X	O_2

Description:

O_1 : pretest score (before treatment)

O_2 : posttest score (after given treatment)

X : treatment using Guided Inquiry e-Worksheet

The subject of this research is the Guided Inquiry Electronic Worksheet Oriented to Multiple Chemical Representations on Chemical Equilibrium Material which was tested on students in class XI-5 SMA Negeri 3 Surabaya who had received the material.

The data collection method in this study, namely the questionnaire method, includes a review questionnaire assessed by one chemistry lecturer to get suggestions and comments, a validation questionnaire assessed by three validators to determine the suitability of electronic Student Worksheets with content and construct validation aspects, The student response questionnaire given to students at the end of learning to determine the practicality of electronic student worksheets based on student responses, the observation method carried out by observers, namely fellow students to observe student activities during the learning process to support practicality criteria, and the test method is divided into two, namely pretest and posttest to determine the initial ability of students before using electronic student worksheets and the final

ability of students after using electronic student worksheets based on the results of the science process skills test.

Data Analysis Technique Validation of Guided Inquiry e-Worksheets Oriented to Chemical Representations on Chemical Equilibrium

The evaluation process of the validity level of the assessment results is carried out using the mode, then the mode obtained is interpreted in table 2.

Table 2. Criteria for the validity of the Guided Inquiry e-Worksheets

Scores	Criteria
1	Invalid
2	Less Valid
3	Valid
4	Very Valid

(Adaptation Riduwan, 2015)

The data obtained in validation is in the form of ordinal data which has the nature that mathematical operations cannot be performed (added, subtracted, multiplied, and divided), so the determination is made by mode. This means that the decision is made on the largest number. It is declared valid if the minimum score is 3 (Lutfi, 2021).

Analysis Technique for Students' Response to Guided Inquiry e-Worksheet Oriented to Chemical Representations on Chemical Equilibrium

In order to find out the response of students to the electronic worksheet developed, a questionnaire was given to students. This assessment refers to the measuring aspect of the Guttman scale. The Guttman scale is an assessment based on positive and negative statements. For the value of positive and negative statements on the Guttman scale, it can be seen from table 3.

Table 3. Guttman scale score

Response	Answer	Score
Negative	Yes	0
	No	1
Positive	Yes	1
	No	0

(Adaptation Riduwan, 2015)

The calculation of the percentage of respondents' answers to the statements in the questionnaire is then calculated using the following formula.

$$\%\ response\ of\ students = \frac{\sum score\ obtained}{\sum maximum\ score} \times 100\%$$

The percentage results obtained from the previous calculation are then interpreted in the criteria of table 4. It is said to be practical if it gets a percentage of ≥ 61% (Riduwan, 2015).

Table 4. Percentage of practicality criteria

Percentage (%)	Criteria
0 - 20	Not Practical
21 – 40	Less Practical
41 – 60	Practical Enough
61 – 80	Practical
81 – 100	Very Practical

(Adaptation Riduwan, 2015)

Students Activity Observation Analysis Technique for Guided Inquiry e-Worksheets Oriented to Chemical Representations on Chemical Equilibrium

In addition to the student's response questionnaire, the practicality of the electronic Student Worksheet media is supported by observations of student activity. This assessment also refers

to the measuring aspects of the Guttman scale can be seen in table 3. Then the calculation of the percentage of student activity on the statement in the observation sheet is calculated using the following formula.

$$\%\ Activity = \frac{\sum score\ obtained}{\sum score\ maximum} \times 100\%$$

The percentage results obtained are then interpreted in the criteria of table 4. It is said to be practical if it gets a percentage of ≥ 61% (Riduwan, 2015).

Science Process Skills Test Analysis Technique

The results of the pretest and posttest scores of students were then analyzed using the n-gain test, with the following formula.

$$N - Gain = \frac{Posttest\ Score - Pretest\ Score}{\text{Maximum } Score - Pretest\ Score}$$

The results of the n-gain value are averaged and then interpreted into the gain index category in table 4. It is said to be effective if students experience an increase in process skills tests, namely a minimum N-gain score ≥ 0.30.

Table 4. Gain index criteria

Score N-gain	Criteria
N-gain ≥ 0,70	High
0,30 ≤ N-gain < 0,70	Medium
N-gain < 0,30	Low

(Lestari & Yudhanegara, 2017)

RESULTS AND DISCUSSION

The development of guided inquiry electronic Student Worksheet media oriented to multiple chemical representations on chemical equilibrium material to train students' science process skills using the 4D model development consisting of define, design, develop, and disseminate, which only reaches 3 stages, namely define, design, and develop.

Stage Define

According to Trianto (2010), this stage is carried out to define the needs in the chemistry learning process and collect various information related to the media that will be developed to train students' process skills with the stages of (1) Initial-Late Analysis, namely collecting information about the problems faced in learning chemistry through interviews with chemistry teachers and high school students so that facts are obtained in the field. (2) Student Analysis, namely students find it difficult to distinguish the factors that affect the shift in the direction of chemical equilibrium, because the reaction changes that occur in an equilibrium state are at the submicroscopic level, while the results of interviews with chemistry teachers state that learning chemical equilibrium material so far has only been limited to two levels of representation (microscopic and symbolic). In line with the research of Sinaga, et al. (2023) that the majority of students are happy when the learning process is given stimulation through eye stimuli in the form of images, illustrations, and the involvement of limbs.

Stages (3) Final Task Analysis, namely the content of the electronic Student Worksheet is adjusted to the learning outcomes of the independent curriculum which is in phase F. (4) Final Concept Analysis, which produces a concept map of chemical equilibrium material that refers to the factors that affect the shift of chemical equilibrium, namely. (5) Specification of Learning Objectives produces learning objectives, namely students can analyze, students can determine, students can conclude, and students can communicate factors that affect the shift in the direction of chemical equilibrium (Thiagarajan, Semmel, & Semmel, 1974).

Stage Design

At this stage the researcher makes a design regarding the product to be developed, namely the Guided Inquiry Electronic Worksheet Oriented to Multiple Chemical Representations to Train Science Process Skills on Chemical Equilibrium Material. The steps are (1) Media Selection, namely the media used electronic Student Worksheets, (2) Format Selection, which is adjusted to the guided inquiry learning model with investigation activities through virtual labs (Thiagarajan, Semmel, & Semmel, 1974). Based on the opinion of Hamruni (2009) that the principle of learning with inquiry is the process of asking and finding out the answers to scientific questions, the questions asked can lead to investigative activities. Electronic student worksheet is also adapted to multiple chemical representations (macroscopic, submicroscopic, and symbolic).

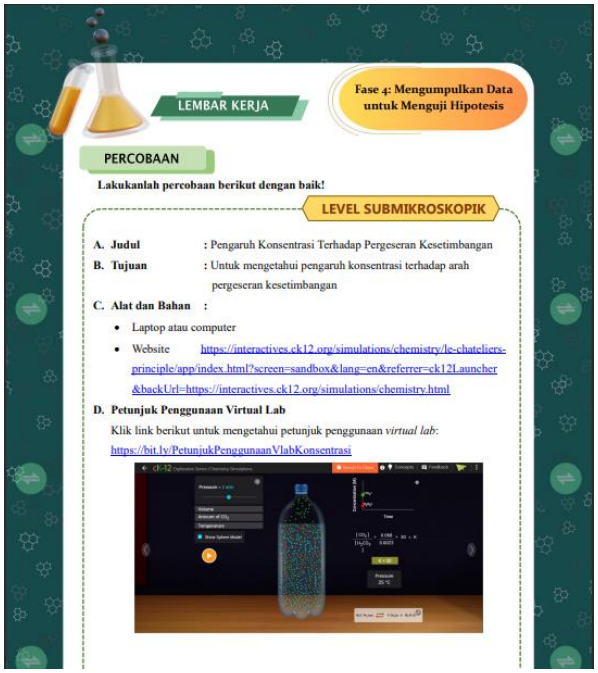

Figure 1. Inquiry Activities through Virtual Lab on Electronic Student Worksheets

Stage Develop

The development stage is carried out so that the development product, namely the Guided Inquiry Electronic Worksheet Oriented to Multiple Chemical Representations to Train Science Process Skills on Chemical Equilibrium Material. At this stage, validation by expert validators and limited trials were carried out.

Validation

According to Nieveen & Plomp (2007), the validity criteria is the feasibility of the product seen based on two things, namely content validity and construct validity. The assessment of the validation process refers to the Likert scale value Riduwan (2015) with invalid to very valid categories, a scale of one to four. Content validity includes the suitability of content with learning outcomes, guided inquiry syntax, science process skills components, and multiple representations. While construct validity consists of aspects of presentation, language, and design. Validation involved three experts, namely two chemistry education lecturers and one chemistry teacher, who aimed to test the feasibility and quality of electronic worksheet products. If the aspects assessed by the validator obtain a mode with a score ≥ 3, it is declared valid and can be used. Based on table 5, it shows that the guided inquiry electronic Student Worksheet product has a mode of 4 in the content and construct aspects, so it is in the very valid category.

Table 5. Guided inquiry electronic worksheet validation score

Validity	Aspects of validation	Mode	Criteria
Content	Conformity with CP	4	Very valid
	Conformity with guided inquiry syntax	4	Very valid
	Conformance to the components of science process skills	4	Very valid
	Conformance with multiple chemical representations	4	Very valid
Construct	Presentation	4	Very valid
	Language	4	Very valid
	Design	4	Very valid

Relevant to the research Februanti, et.,al, (2023) which states that a student worksheet developed must be in accordance with the concepts and theories based on the basic competencies in the applicable curriculum so that it is clear the learning objectives that students want to achieve.

Limited Trial

After validating and revising the product, the next step is to conduct a trial. This stage aims to assess the practicality and effectiveness of the developed product. The limited trial aims to assess the feasibility of using the guided inquiry electronic Student Worksheet oriented to multiple chemical representations to train students' science process skills on chemical equilibrium material (Thiagarajan, Semmel, & Semmel, 1974). This stage was conducted to students of class XI-5 SMA Negeri 3 Surabaya who were randomly selected and heterogeneous with the condition that they had studied chemical equilibrium material. After product testing, students filled out a response questionnaire to measure their responses to the developed electronic worksheets. The criteria for practicality according to Nieveen (2010), electronic student worksheets must be clearly useful for students and easy to use in the learning process (Rizki, Wijaya , & Frentika, 2020). The overall average score received a percentage of 88.3% positive response in the very practical category. The analysis of the students' response questionnaire shows the practicality aspects of using the guided inquiry model, the practicality aspects in practicing science process skills, the practicality aspects with multiple chemical representations, and the ease of use presented in table 6.

Table 6. Student response score

Assessment Aspects	Score	Criteria
Guided inquiry model	100%	Very practical
Components of science process skills	97,5%	Very practical
Multiple chemical representations	90%	Very practical
Ease of use	68,3%	Practical

Apart from being seen from the responses of students, the practicality of the electronic worksheet is supported by observations of student activities conducted by fellow students. The results obtained during learning activities using guided inquiry electronic worksheets, active students in the learning process seen from student participation showed a score of 82.3% including the very practical category, student activities practicing their science process skills supported by electronic worksheets showed a score of 97.8% including the very practical category. The ease of students in understanding the material through multiple chemical representations showed a score of 99% including a very practical category, and the ease of students in using the features in the electronic worksheet showed a score of 100% including a very practical category.

Table 7. Student activity score

Assessment Aspect	Score	Criteria
Student participation	82,3%	Very practical
Activity of practicing science process skills	97,8%	Very practical
Ease with multiple chemical representations	99%	Very practical
Ease of use	100%	Very practical

The effectiveness of the electronic worksheet is reviewed from the pretest and posttest results of students' science process skills which are then analyzed using the n-gain formula, so that the criteria for students' n-gain scores are known. It is said to be effective if the N-gain score of students reaches ≥ 0.30.

Table 8. Student N-gain score

Student Code	N-gain	Criteria
A1	0.9	High
A2	0.8	High
A3	0.8	High
A4	0.9	High
A5	1.0	High
A6	0.7	High
A7	0.6	Medium
A8	0.9	High
A9	0.8	High
A10	0.6	Medium
A11	0.8	High
A12	1.0	High
A13	0.7	High
A14	0.6	Medium
A15	0.8	High
A16	1.0	High
A17	0.8	High
A18	0.8	High
A19	0.9	High
A20	0.6	Medium

After completing their worksheets, the students' answers were analyzed using N-gain and the summary is presented in table 8 to determine the effectiveness of the students' worksheets. The analysis showed that students with codes A1, A2, A3, A4, A5, A6, A8, A9, A11, A12, A13, A15, A16, A17, A18, A19 obtained n-gain scores of 0.7 to 1.0 in the high category. Codes A7, A10, A14, and A20 were in the medium category with an n-gain score of 0.6.

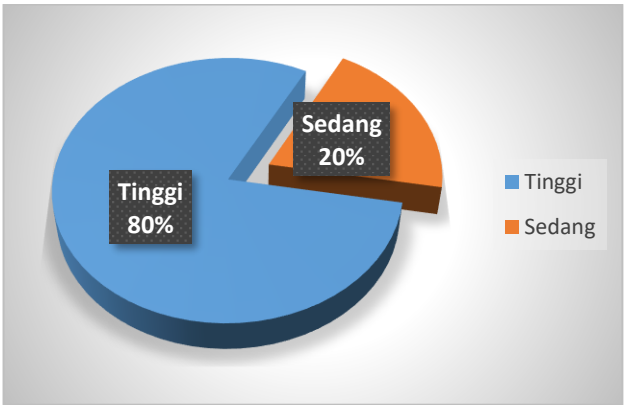

Figure 2. Diagram of Gain Score of Students' Science Process Skills

Overall, based on Figure 2, after learning using the guided inquiry electronic worksheet oriented to multiple chemical representations, students' science process skills increased from

the pretest results by 80% in the high category and 20% in the medium category, so that the electronic Student Worksheet was developed. declared effective for training students' science process skills. This is supported by learning through investigation activities and the fulfillment of the three levels of chemical representation in the electronic Student Worksheet which was developed so that it can help students practice their process skills. Research conducted by Masruhah, et al. (2022) stated that guided inquiry electronic Student Worksheets are effective for improving students' science process skills. The process skills approach can be interpreted as an insight or practice in developing intellectual, social and physical skills that originate from fundamental abilities which, in principle, are within students. (Tawil & Liliasari, 2014). In addition, based on research Astutik (2021) states that through the guided inquiry learning process and practicing scientific thinking skills, it can improve student learning outcomes.

Electronic worksheets function as teaching materials designed to reduce the role of the teacher and increase active participation of students in the learning process. This is important because active mental involvement of students is very important for effective absorption of lesson material (Purba, et al., 2021). Electronic worksheet guided inquiry oriented multiple chemical representations provide benefits to students' science process skills in chemical equilibrium material, namely contributing to facilitating students' understanding of chemical equilibrium material, so that students can easily understand existing concepts. The guided inquiry electronic student worksheet media is oriented towards multiple chemical representations to train students' science process skills on chemical equilibrium material which has gone through the refinement stage of validation by experts.

CONCLUSION

The development of e-worksheets with a guided inquiry model oriented to multiple chemical representations facilitated by the liveworksheet platform to train students' science process skills on chemical equilibrium material has been carried out well and successfully. Electronic worksheet obtained mode 4 in the aspects of content and construct validity, so it was categorized as very valid. Student responses to electronic worksheets have shown high practicality in the learning process. This is proven by the student response questionnaire which produced an overall average score of 88.3% positive responses. The developed electronic worksheet has proven effective in supporting the learning of chemical equilibrium in high school with high criteria for 80% of students.

RECOMMENDATIONS

Based on the results of this research, it is recommended that the electronic worksheet media Guided Inquiry Oriented to Multiple Chemical Representations to Practice Students' Science Process Skills on Chemical Equilibrium Material be developed and innovated on other learning materials by modifying the media according to the conditions and needs of students based on the curriculum applied taking into account the cultural diversity of students. If further research is facilitated by a live worksheet platform, it is best for students to use a PC/tablet/laptop during the learning process using electronic worksheet media.

ACKNOWLEDGEMENTS

The author is grateful to the supervisor who has provided direction in this research, and thanks to the validator who has validated the electronic worksheet validation assessment sheet, response questionnaire sheet, observation sheet, test sheet. Apart from that, the researcher also

thanks the school, both teachers and students, as well as all parties who participated in this research.

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