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Electronic Student Worksheets to Train Scientific Literacy in Chemical Equilibrium Material

Fitani Wardha Machfiro [1*], Achmad Lutfi [2]

[1,2] *Chemistry Education Study Program, Universitas Negeri Surabaya*

[*] E-mail : achmadlutfi@unesa.ac.id

Abstract: Scientific literacy ability is a skill that is considered a benchmark for high or low thinking ability in a country. This makes researchers develop effective learning media and can train scientific literacy skills**.** The research aims to determine the level of effectiveness of using electronic student worksheets to train students' scientific literacy skills on chemical equilibrium material. The research design used the one-group pretest-posttest method. The sample in this study was class XI IPA, which consisted of 35 students. The research instrument was a pretest-posttest test instrument. The data obtained were analyzed by the N-gain test with the condition that the N-gain reached > 76% and the classical condition with the condition ≥85%. The results of the analysis show that the N-gain is 76.50%, and the classical completeness test is 97.14%. From the analysis, it can be concluded that electronic student worksheets are effective for training scientific literacy skills in chemical equilibrium material.

Keywords: Chemical Equilibrium, Effectiveness, Science Literacy

INTRODUCTION

21st-century education is aligned with the industrial revolution 4.0. Industrial Revolution 4.0 is a change that occurs rapidly with new innovations with the help of human resources to deal with it (Agustina *et al*., 2019). In an environmental situation like this, education has an important role in preparing for the nation's progress and preparing society to compete globally (Fuzi *et al*., 2018). The linkage of the industrial revolution 4.0 with an education that occurs in the 21st century is that students can have 4 competencies, called 4C skills, including critical thinking, creative thinking, collaboration skills, and skills communication (Mukhadis, 2013). The expectations of the 2013 curriculum above are in line with the expectations of the independent curriculum that chemistry can produce innovation in learning, students are expected to be able to explain the application of various scientific concepts, in everyday life and students are expected to have an open mind scientifically (Kemendikbud, 2022). Skills that include one of them are scientific literacy skills. Because scientific literacy is able to realize 21st-century skills(Ait *et al*., 2015; Istiqomah *et al*., 2021).

According to the World Economic Forum (2015), scientific literacy is a skill of the 21st century among 16 other skills (Schwab, 2015). So, scientific literacy is very important that must be trained for every individual, because this is very sustainable in various fields. (Retnowati. dkk, 2022). Scientific literacy is a skill that is considered a benchmark for high or low thinking ability in a country (Gunawan *et al*., 2022). According to Klucevsek (2017) that scientific literacy is a learning process related to the scientific method in collaboration with the experience that has been obtained. Scientific literacy is the skill of thinking and conducting investigations using a scientific approach (Pratiwi *et al*., 2019; Ririn *et al*., 2020). If students have basic skills regarding literacy, then students can obtain information related to new mindsets, and students can communicate this scientific mindset with their friends (Wright *et al*., 2016).

Based on PISA (2015) the scientific literacy of students in Indonesia is still very low, which is proven that Indonesia is in 71st place out of 79 countries (OECD, 2019). From the results of PISA

(2015) regarding scientific literacy, it is necessary to have a chemistry learning process that involves phenomena or problems in everyday life where students are asked to solve them with a logical, critical, and creative mindset. (Yanni *et al*., 2018). Chemical equilibrium is one of the chemical materials that have an abstract concept, so it has a high level of difficulty for high school students who are still difficult to understand chemical equilibrium reactions. The research conducted by Suryadarma & Yahmin (2017) showed that there was a percentage of students with difficulties in understanding the chemical equilibrium sub-material 31% which was classified as low from dynamic equilibrium and equilibrium constant.

Supported by pre-research results using 3 test questions regarding scientific literacy skills which include 3 scientific literacy competencies. There is a percentage of scientific literacy ability in 35 students, obtaining a percentage of 38% which means that the scientific literacy ability of students in chemical equilibrium material is low.How to overcome problems understanding the material and fulfill scientific literacy skills in the 2013 curriculum, can be done by utilizing technology and communication in the learning process and this can assist teachers in creating effective and efficient learning for students, especially in the 2013 curriculum. The selection of learning media or teaching materials in the form of electronics is supported by the influence of technological science to welcome the era of the industrial revolution 4.0 in the world of education based on 21st-century skills (Kemendikbud, 2018). The use of technology to support learning has a positive impact, namely, it can make teachers produce effective teaching and learning processes for students (Fujiati *et al*., 2020; Yuningsih *et al*., 2020).

The teaching materials or media being developed are electronic student worksheets to train students' scientific literacy skills on chemical equilibrium material. This media is in the form of electronic media with the help of a web platform in the form of a liveworksheet. Liveworksheets Web is a web platform that can be accessed free of charge for any use and this application can be searched via Google Chrome, Microsoft EDGE, Browser, and others (Fuada & Fajriati, 2021). The electronic student worksheets have been tested from the aspect of validity and practicality. From the two tests, valid and practical results were obtained. From the results of validity and practicality, it means that the learning media can be used to train students' scientific literacy skills in chemical equilibrium material. However, the learning media has not been reviewed for effectiveness measurement. So research is more focused on examining the effectiveness of electronic student worksheets.

Learning media can be said to be effective if the media has criteria such as in terms of the availability of supporting facilities, the ability to be changed, the complexity of the media, and the use of the media (Sari & Iswendi, 2023). Testing the effectiveness of learning media was developed in the form of electronic student worksheets with the help of liveworksheets to train scientific literacy in chemical equilibrium material. Student worksheets as electronic learning media. The following is a part of the electronic student worksheet.

Figure 1. Student Worksheet Cover

The picture above is the cover of an electronic student worksheet with an illustration of a person doing a practicum, there is a worksheet title, a place to write biographical data, and a class description. Because in developing learning media or a learning media, a cover is needed that is in accordance with the subject matter used.

Figure 2. Fill in Student Worksheets

Figure 2 is the contents of the electronic student worksheet. The contents include domains of scientific literacy, buttons to go to material summary pages, buttons to access virtual laboratories, questions, and page numbers. This component aims to facilitate students during their use.

Based on these research problems, researchers are interested in researching the effectiveness of an electronic student worksheet. There is previous research on Cholifia & Novita's research (2022) with the same theme and research urgency, namely the development of electronic student worksheets to train scientific literacy skills in the matter of reaction rates, but in this study uses effectiveness data analysis with the N-gain test and the t-test. Meanwhile, in this study, there is research renewal in terms of data analysis using the N-gain test and classical completeness as well as on electronic student worksheets, there is a virtual lab to support students in practicing scientific literacy skills.

METHOD

Research in measuring effectiveness was carried out from 8-16 May 2023, before the research took place a preliminary study was carried out by analyzing the learning problems that existed in the school. This study used a one-group pretest-posttest trial design. In this study, it was carried out with an initial test (O_1), given treatment (X) namely by using electronic student worksheets, and given a final test (O_2) (Sugiyono, 2016). The instrument used to support this research uses 10 multiple-choice questions that have been tested for their validity aspects. In the instrument, 10 multiple choice questions were arranged according to the characteristics of the questions from PISA, and included the scientific literacy domain, namely 1) context domain, 2) knowledge domain, 3) skills domain, and 4) attitude domain (OECD, 2016). However, in this study, only 3 domains were used, namely the context domain, knowledge domain, and skills domain.

Effectiveness data from pretest and posttest scores were analyzed quantitatively by calculating the N-gain score using SPSS 25. The equation for the N-gain score formula is calculated by calculating the posttest score minus the pretest score divided by the maximum score and subtracted by the pretest score. This statement is made to find the N-gain score, then to find the N-gain percent can be in the form of the N-gain score multiplied by 100%. If using the effective criterion reference > 76%, then the results of these calculations can be interpreted based on the N-gain percent level criteria presented in the table below.

Table 1. Criteria Level N-gain Score Percent (Hake, 1999)

Persentase	Kriteria
< 40	Tidak Efektif
40 – 55	Kurang Efektif
56 – 75	Cukup Efektif
> 76	Efektif

Electronic student worksheets to train scientific literacy skills on chemical equilibrium material developed can be said to be effective if the percentage of N-gain obtained is > 76%. In addition to the N-gain test, effectiveness data analysis was also carried out using the classical completeness test. In the classical mastery test, a class is said to be complete, if the percentage of classical mastery obtained is ≥85% (Afrita, 2021) of the total number of students who have achieved an individual completeness score of at least 75 (Yusuf Hidayat *et al.,* 2020).

RESULTS AND DISCUSSION

Based on a preliminary study in the form of problem analysis, it was found that 53% of students were taught chemical equilibrium material by utilizing scientific literacy skills and 78% stated that there was no supporting learning media to train scientific literacy skills. These results are consistent with the results of teacher interviews which state that so far the chemistry learning process has not trained scientific literacy skills. This is because there are no effective learning media for training scientific literacy in chemical equilibrium material. These problems make researchers interested in developing a learning media in the form of electronic student worksheets to train scientific literacy skills in chemical equilibrium material, with reference to the guided inquiry learning model. The guided inquiry learning model was chosen as a support for scientific literacy-oriented electronic student worksheets because the inquiry model is a learning model with syntax that leads to scientific steps and is related to science as an alternative to solving a problem (Daniah, 2020).

The development of electronic student worksheets to train scientific literacy in chemical equilibrium material has been tested for validity and practicality. Based on the results of the validity of electronic student worksheets, it was found that electronic student worksheets for training scientific literacy in chemical equilibrium material had obtained valid criteria in accordance with the validity criteria stated by (Plomp & Nieveen, 2013). As for the practicality of electronic student worksheets, it can be stated that electronic student worksheets for training scientific literacy skills on chemical equilibrium material have obtained practical criteria according to the practicality percentage of ≥61%. (Riduwan, 2015). The data used for the analysis of effectiveness data is the pretest and posttest scores from the scientific literacy ability test on chemical equilibrium material. The pretest and posttest were analyzed using the N-gain test and the classical completeness test which are described as follows.

N-gain Test

Based on the results of the pretest and posttest were analyzed to get the average score of N-gain. The calculated data can be seen in Table 2 below.

Table 2. Hasil Skor N-gain

Descriptive Statistics					
	N	Minimum	Maximum	Mean	Std. Deviation
Ngain_scora	35	.50	1.00	.7650	.13282
Ngain_persen	35	50.00	100.00	76.4966	13.28229
Valid N (listwise)	35				

N-gain is the calculation of the initial score obtained and the final score of students by calculating N-gain by subtracting the posttest score and pretest score, then dividing it by the ideal score and subtracting the pretest score (Utomo *et al*., 2020). From the table above, the N-gain data is obtained with a total of 35 students as respondents. Then the table above also states the average result of the pretest-posttest at Ngain percent of 76.50%. These results can be interpreted as the average pretest and posttest N-gain scores getting effective results because they get a percentage of >76% (Hake, 1999). Then based on research from (Cholifah & Novita, 2022) concerned with the development of electronic student worksheets to train scientific literacy skills in the matter of reaction rate, this gets an N-Gain score of (0.050-0.414) this score gets a score with high criteria (Hake, 1998).

It can be said that the E-LKPD is effective for training scientific literacy skills in the matter of reaction rates. From previous research statements and associated with N-gain score acquisition data. Obtaining an N-gain score of 76.50% with effective criteria and supported by obtaining an N-gain score (0.77) with high criteria, then the electronic student worksheet is effective for practicing scientific literacy skills in chemical equilibrium material.

Classical Mastery

Effectiveness data is also supported by data analysis from classical completeness. The results of students' classical mastery can be seen in Table 3 below.

Table 3. Results of Classical Mastery

Number of Students who complete	= 34
The number of students who did not complete	= 1
Individual completeness	minimum 75
Completeness Percentage	97,14%

Based on the classical completeness results in Table 3, there were 34 students who completed the chemical equilibrium material, because the posttest score obtained was above the individual completeness score of at least 75. Out of the 35 students, there was only 1 student who did not complete the equilibrium material, because the posttest score obtained is less than the individual completeness of at least 75.

Based on the results of the pretest and posttest it is known that most of the students answered the scientific literacy ability test questions correctly in the context domain, and the skills domain, especially in explaining scientific phenomena, as well as the domain of evaluating and designing

scientific investigations. Here is one picture showing the domain where the majority of students answered correctly.

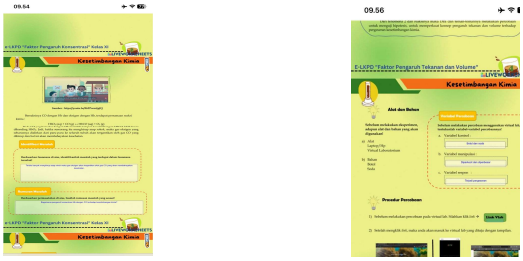

Figure. 4 Correct Answers on the Electronic Worksheet

Then there is the domain of scientific literacy where the minority answered wrong in the domain of competence to interpret data and facts scientifically.

Figure 5. Incorrect answers on the Electronic Learner Worksheet

In the pretest-posttest for the context domain, phenomena are presented in support of the information from the questions given (OECD, 2016). This phenomenon is developed into a question that is also adapted to the domain of competence in explaining scientific phenomena. In the domain of explaining scientific phenomena, students are asked to identify problems according to the phenomena presented. Then the skills domain for evaluating and designing scientific investigations, given an overview of practicum activities and given questions such as "Based on the experimental data above, what happens when you add a few drops of $FeCl_3$ and KSCN solution which turns reddish brown?" From these questions, students were asked to determine the color change when given $FeCl_3$ and KSCN drops, according to the experimental illustration presented in the problem, and according to PISA (2015) to use the dimensions of content, procedural, and epistemic knowledge in evaluating and designing a scientific investigation. , and interpreting data in various life problems requires an intermediate level of cognitive understanding.

Based on the posttest results of the scientific literacy ability test, it is known that only a small proportion of students answered incorrectly in the domain of skills to interpret data and facts scientifically. In this domain there are examples of problems such as “Based on the chemical equation N_2 (g) + $3H_2$ (g) ↔ $2NH_3$ (g) ΔH = -92.4 kJ. Relate the problem/phenomenon to the sub-material on the factors that affect shifts in chemical equilibrium!”. From these questions, students were asked to relate the phenomenon of NH_3 formation with factors that affect shifts in chemical equilibrium. Many students make mistakes in answering these types of questions. Because in the question for the domain

of interpreting data and facts scientifically there are questions about analyzing and requiring concentration for higher-order thinking (OECD, 2016).

Based on the results and discussion above, it was obtained that the percentage of classical completeness was ≥85%, namely 97.14% of students had completed practicing scientific literacy skills in chemical equilibrium material (Afrita, 2021). During the research process, of course, there were obstacles faced by researchers and students namely when using electronic student worksheets there were some students who had difficulty accessing electronic student worksheets. However, researchers can direct students to join a group of friends while continuing to refresh the device used in order to display electronic student worksheets. In this research, there are previous studies that are used to support the latest research (Sari & Iswendi, 2023).

Based on previous research conducted by Chofifah and Dian (2020), namely using electronic student worksheets to train scientific literacy skills in the material of reaction rates. This study found that the developed electronic student worksheets could train scientific literacy skills in the matter of reaction rate, which was shown based on the analysis of pretest and posttest data. Learning by training scientific literacy in students, can make students understand more about the material being taught, as well as in learning activities students also get meaningful lessons because in training scientific literacy they are also involved in problems that exist in everyday life (Fuzi *et al*., 2018).

CONCLUSION

Based on the results and discussion above, it is found that electronic student worksheets for training scientific literacy skills in chemical equilibrium material meet the effective criteria according to the results of analysis of N-gain test data and classical mastery so that electronic student worksheets can be used to train literacy skills science students on chemical equilibrium material.

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