

## DEVELOPMENT OF ELECTRONIC WORKSHEETS BASED ON PROJECT-BASED LEARNING ASSISTED BY A VIRTUAL LABORATORY TO TRAIN STUDENTS' CRITICAL THINKING SKILLS

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**Abstract:** This research aims to explain the validity, practicality, and efficacy of electronic worksheets based on Project Based Learning assisted by a virtual laboratory to train students' critical thinking skills on the sub-material of factors that affect the reaction rate. The 4D development model (Define, Design, Develop, Disseminate) is used, limited to the development stage. The results of electronic worksheets validation on content validity and construct validity obtained a score with a mode of 5 for the four electronic worksheets, so the electronic worksheets developed were categorized as very valid. In the electronic worksheets practicality test on student activity observation outcomes, the relevant activity outcomes were 93.89% for meeting 1, 94.44% for meeting 2, 92.22% for meeting 3, and 93.33% for meeting 4. According to the learner response questionnaire results, the share was 91.24%, and the developed electronic worksheets were classified as very practical. The electronic worksheets efficacy test on the pretest and posttest results found that the classical completeness was 0% but increased to 83.33% in the posttest. The Wilcoxon test results showed a significant difference between the pretest and posttest scores, confirming his acquisition of an N-Gain score in the high category, so the developed electronic worksheets met the efficacy criteria.

**Keywords:** *Electronic Worksheets, Project-Based Learning, Virtual Laboratory, Critical Thinking Skills, Reaction Rate*

### INTRODUCTION

Education has a vital role in the nation's life in the face of intensifying international competition. With the advancement of the times, a generation that has high quality, professional, critical, creative, and innovative must be prepared according to plan. One of the things that can be done to form a quality generation is to increase the quality of education. The government has made various efforts to improve the quality of education in Indonesia, from further developing the school curriculum to introducing its independent curriculum. Implementing project-based learning characterizes an independent curriculum, giving schools the independence and freedom to carry out learning projects that are appropriate and close to the school environment. Project learning in the independent curriculum allows learners to be critical, respond quickly to problems, and work well together. It is necessary for learning in the 21st century. There are four abilities that students should acquire in the 21st year century, known as the 4Cs, including critical thinking and problem-solving, creativity, communication skills, and collaboration skills [1].

Based on data from The Trends in International Mathematics and Science Study (TIMSS), Indonesia was found to rank 44th out of 47 countries with a score of 397 in science achievement in 2015 (IEA, 2016). Based on data from the Program for International Students Assessment (PISA), in the science performance category, Indonesia ranked 71st out of 79 countries with a score of 396 (OECD, 2016) [2]. Poor performance of Indonesian students in TIMSS and

PISA survey data shows that Indonesian students' level of critical thinking is generally low because the questions used in TIMSS and PISA require higher-level thinking skills, including critical thinking. Based on these data, the problem of students' low level of critical thinking needs to be minimized because critical thinking ability is one of the skills that can prepare students for future issues, not just when studying in the classroom. Through critical thinking, learners can connect what they learn in school with what they encounter in everyday life [3].

Critical thinking has six indicators: interpretation, analysis, inference, evaluation, explanation, and self-regulation. This research only examines the indicators of interpretation, analysis, inference, and explanation because four already fulfill critical thinking skills, and only strong critical thinkers conduct six indicators [4]. Students' critical thinking skills can be applied to all subjects, including chemistry. To understand systematic concepts in chemistry learning, teachers must emphasize basic skills, especially critical thinking skills because chemistry is related to how to study natural phenomena systematically, so chemistry is not only about mastering a collecting of information in the shape of data, facts, principles or concepts, but also the process of discovery [5].

One chemical material often found in the surrounding environment and can be applied in everyday life is reaction rate material, which has

sub-material factors that affect the reaction rate—based on pre-research data conducted on January 19, 2023, at 1 Cerme Senior High School in class XI-Match and Science 7, 77 percent of students stated that the reaction rate is a hard material. In addition, 51 percent of students said that the most challenging variation of the problem was problem-solving in everyday life. Judging from the achievements per element in the process skills in phase F, the reaction rate is a material that has the characteristics of requiring proof through experimentation as a justification of the theory that has previously been learned [6]. With the help of experiments, students not only understand the concept of reaction rate but also carry out investigative activities, then analyze, then conclude, and also communicate so that students can build their understanding and thinking skills. Based on the ability to investigate and communicate, students need critical thinking skills.

One of the appropriate learning models to be applied to improve student's critical thinking skills in learning reaction rate material is project-based learning (PJBL). It is in line with research implemented by Salsadella Andini in 2022, where the average percentage of the project-based learning treatment retrieved is 78 percent in the first session in the good category and 88 percent in the second session in the very good category, the percentage of students activity is 88 percent in the good category, the result of critical and creative thinking skills indicated by N-Gain scores of 0.70, 0.73 and 0.73 in the high criteria. Besides that, student learning outcomes are improving. It is shown in the following results from one complete student to 28 complete students, and 95 percent of 31 students received positive responses. From these results, it can be summarized that there is an improvement in students' critical thinking skills through applying the Project Based Learning model [7]. The PJBL model is a learning model whose goal is to keep students focused on complicated issues involved in doing research and understanding learning through research [8]. Project-based learning emphasizes contextual problems that learners can experience directly, encouraging learners to think critically and develop their creativity by developing real-world products [9].

The application of the learning model will be better if it uses tools that support learning activities or utilizes media to make learning more enjoyable. Learning media is used as an instrument or tool that supports the learning process in the classroom and a means of communication that can convey information from the source or teacher to the recipient or learner. Using ICT in learning media can optimize the message delivery process and ensure that messages (topics) are easily understood and accepted by students [10]. One of the media that use ICT is a virtual laboratory. Based on research implemented by Bertha Yonata and Harun Nasrudin in 2018, which concluded that the laboratory activity worksheet could

train students' high-order thinking skills in surface chemistry lectures where the assessment range from the validators is 95.24 percent to 97.92 percent, N-Gain Score ranges from 0.50 in enough category to 1.00 in the high category, and then the responses of the students in very reasonable category [11]. In line with research based on the research conducted by Achmad Lutfi, Harun Nasrudin, et al. in 2022, the results of the application of worksheets prepared by the teacher showed that students were more interested in participating in chemistry learning when using worksheets with the help of virtual laboratories [12]. Various virtual laboratory applications have been developed, including crocodile chemistry 605. Crocodile Chemistry 605 is an imitation shape of a real laboratory used in learning activities or scientific research. Besides being easily accessible and free of charge, it is also easy to operate. So, this media is effectively used to support the learning process.

In applying the learning model and using a medium, teaching materials are needed. It is supported based on research conducted by Efrahim Melinda Br Purba in 2020. The development of Project Based Learning (PJBL) based teaching materials on reaction rate material has been valid with a module validation of 3.85 from all media expert validators, an average module validation of 3.67 from all material expert validators, and an average response to project-based modules of 92.61 percent from 20 students as a sample. So that the teaching materials developed are suitable for use [13]. One of the teaching materials that are often used is worksheets. With the evolution of technology in the world of education, worksheets currently use electronic media that can be accessed via computers, laptops, or smartphones, which changes the name of worksheets to electronic worksheets. Electronic worksheets are needed in the teaching process so that learning activities run following learning objectives. In addition, electronic worksheets can facilitate students in implementing learning activities because it is equipped with a clear workflow [14]. From the description above, researchers are interested in developing electronic worksheets based on Project Based Learning assisted by virtual laboratories on the sub-material of factors that affect the reaction rate as teaching materials are expected to increase students' critical thinking skills. In previous relevant research, there have been many developments in project-based learning worksheets on reaction rate material. Still, the renewal contained in this study is that it emphasizes the use of ICT, where the worksheets students developed are electronic. There is the addition of virtual laboratory assistance as a means of supporting learning to make it more interesting.

**RESEARCH METHODS**

The research method used is the Research and Development (R&D) method. According to Sugiyono (2016: 407), Research and Development (R&D) is a research method that produces certain products by testing the efficacy of the products produced [15]. In designing this research, the 4-D model, according to Thiagarajan Semmel (1974), is used, which includes defining, designing, developing, and disseminating [16]. In this research, it was restricted only until the development stage.

This research was implemented in May 2023 at 1 Cerme senior high school in the even semester of the 2022/2023 school year, with the subjects being 30 students in class XI Match and Science.

The data retrieved from this research are quantitative data from validation, practicality, and efficacy results. The research instruments carried out were adjusted to the variables to be studied. The instruments in this research were study sheets, validation sheets, student activity observation sheets, learner response questionnaire sheets, and pretest-posttest sheets for critical thinking skills.

A review of the electronic worksheets was conducted to obtain a related qualitative assessment criticism and suggestions from lecturers of the Department of Chemistry, Faculty of Math and Science, Unesa, as a reference for improving the electronic worksheets. One chemistry teacher from 1 Cerme Senior High School and two lecturers from the Department of Chemistry, Faculty of Math and Science, Unesa, conducted the electronic worksheets validation related to content and construct validity. Electronic worksheets' practicality is seen from student activity observations and learner response questionnaires. The efficacy of electronic worksheets is seen from the pretest and posttest results of critical thinking skills.

The validation data was analyzed from the calculation of the assessment score criteria. This calculation is retrieved based on the Likert Scale according to Table 1 below.

From the evaluation results of the three validators, the mode at each validation point was determined, and data analysis of the validation results was performed.

Table 1. Likert Scale

Score	Assessment
1	Not good
2	Less good
3	Good enough
4	Good
5	Very good

- (1) If the mode  $\geq 3$ , then the point is declared valid
- (2) If mode  $< 3$ , then the point is declared invalid [17].

The practicality of electronic worksheets was retrieved through observing student activities and

learner response questionnaires. Observation of student activity is done in groups by observing the most dominant activity within the group for 3 minutes. The following formula percentages count the retrieved data:

$$\text{Percentage} = \frac{\text{number of activities that appear}}{\text{a total number of activities}} \times 100\%$$

Percentage response questionnaire results were determined from the Guttman scale calculations shown in Table 2 below.

Table 2. Guttman Scale

Answer	Score
Yes	1
No	0

The data acquired is counted as a percentage using the following formula:

$$\text{Percentage} = \frac{\text{number of students who answer yes}}{\text{Total number of students}} \times 100\%$$

Then, the percentage of student activity observations and the results of the learner response questionnaire was interpreted into the criteria contained in Table 3 below.

Table 3. Practicality Score Interpretation

Percentage (%)	Criteria
0-20	Very less
21-40	Less
41-60	Enough
61-80	Practical
81-100	Very practical

electronic worksheets are considered a practical learning medium if it has a success rate of 61% or higher [18].

The efficacy of electronic worksheets is obtained through the pretest-posttest score of critical thinking skills. Students are stated to be complete individually if they score  $\geq 75$ . The pretest-posttest scores are calculated using the formula:

$$\text{Pretest-posttest scores} = \frac{\text{Score obtained}}{\text{Maximum score}} \times 100$$

Then the percentage of classical completeness is calculated based on the number of students' completeness with the following calculation:

$$\text{Classical completeness} = \frac{\text{number of students completed}}{\text{Total number of students}} \times 100 \%$$

Students are said to be classically complete if at least 75% of students reach individual completeness [19].

The obtained pretest and posttest data were analyzed with a normality test using the Shapiro-Wilk test to determine if the data were normally distributed and hypothesis testing using the Wilcoxon test to determine whether there were differences in pretest and posttest scores with the help of SPSS software. Then the increase in students' critical thinking skills before and after being given the developed electronic worksheets is determined through the N-gain score. Electronic worksheets are declared effective if classical completeness  $\geq 75\%$  is obtained. The Wilcoxon test shows results that there is a significant difference between the pretest and posttest scores, and if the students' critical thinking skills receive an N-gain score of  $0.7 > g \geq 0.3$  with moderate criteria or  $g \geq 0.7$  with high criteria [20].

## RESULTS AND DISCUSSION

This research aimed to describe the validity, practicality, and efficacy of electronic worksheets in training critical thinking. Electronic worksheets are student worksheets that can be processed digitally, systematically, and continuously within a period [21]. Electronic worksheets developed is a student worksheet that is done with the help of a simulation of reaction rate practicum in the Crocodile Chemistry 605 application.

### Define Stage

In the preparation stage, problems were identified by distributing questionnaires to students and interviewing chemistry teachers from 1 Cerme senior high school. Based on pre-research data that was conducted on January 19, 2023, in class XI Math and Science 7, information was obtained from students that the learning resources used in the reaction rate material were textbooks and the learning media that teachers often used as blackboards. 57% of students stated that by reading the textbook, they still needed help understanding the subject matter available in the book. And from the results of interviews with chemistry teachers, information was obtained that ICT still needed to improve learning.

### Design Stage

At the design stage, the researcher made an initial design of the electronic worksheets, which consisted of 4 factors according to Petrucci, namely electronic worksheet one on the concentration factor, electronic worksheet two on the surface area factor, electronic worksheet three on the temperature factor, and electronic worksheet four on catalyst factor [22]. A live worksheet was selected for making electronic worksheets because it is easily accessible and free.

The live worksheet application can be accessed via the <https://www.liveworksheets.com/> link, where teachers and students can access it online. Before using the application, the teacher registers using the commonly used Google email. After creating an account, the teacher can create electronic worksheets with the live worksheet application by uploading a PDF file. Later, if the electronic worksheets are ready, we can share the electronic worksheets link with students [23].

Making an electronic worksheets design using Microsoft Word which can later be changed to a PDF format. The first thing to do is to create an electronic worksheet cover.

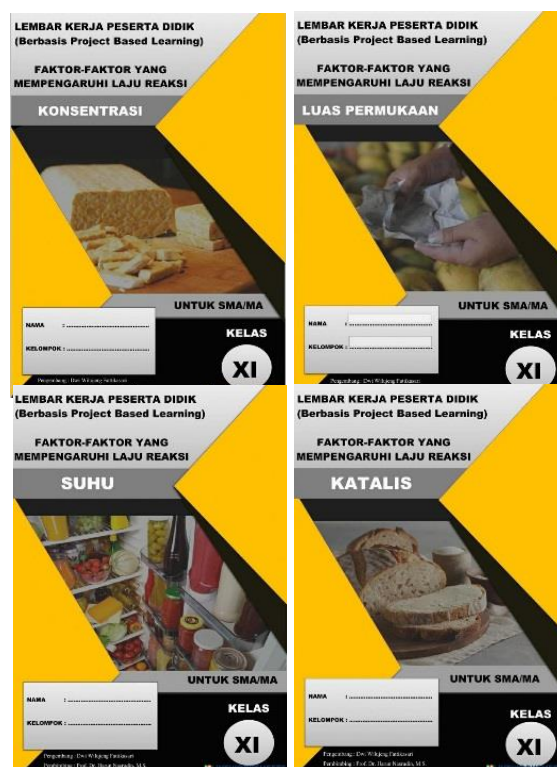


Figure 1. Cover of electronic worksheets

In Figure 1, there is a cover page that loads the title of the electronic worksheets, a picture that matches the project being carried out, the names of the authors and supervisors, the identity of the owner of the electronic worksheets (name, group), and class. The cover is made based on the electronic worksheets development guidelines in Depdiknas (2008), where the writing on the worksheets cover must be harmonious between images and letters; the photos must support the content of the material and increase the attractiveness of students to read worksheets [24].

In Figure 2, there are activities in phase 1 (determination of fundamental questions) and phase 2 (developing project plans) in the Project Based Learning model [25]. In Phase 1, everyday phenomena are presented through YouTube videos, followed by analytical questions about the

explained phenomena. In phase 2, a new phenomenon is presented that has something to do with the phenomenon at the beginning. This phenomenon is used as a reference when creating a project plan in the form of a project design for students, including project titles, project objectives, problem formulation, hypotheses, experimental variables, tools and materials, and experimental procedures.

**Penentuan Pertanyaan Mendasar**

Pada tahap ini, guru mengambil topik yang sesuai dengan realitas dunia nyata

**Kebakaran Hutan**

Tontonlah video berikut ini!

Angin Kencang, Kobaran Api di Gunung Rante dan Gunung Rante Se...

**FOKUS** **KEBAKARAN HUTAN KAWASAN GUNUNG IJEN**

Kebakaran hutan yang melanda gunung Ijen dan gunung Rante terus meluas. Ada sekitar 10 hektare lebih lahan yang terbakar. Kencangnya embusan angin menjadi salah satu penyebab cepatnya api menjalar. Pada kasus kebakaran hutan, jika pada saat terjadi kebakaran hutan ada angin yang berhembus, atau jika angin berhembus kencang, maka kebakaran akan menjadi semakin besar dan lahan tersebut semakin cepat terbakar. Seperti halnya pada video tersebut, kencangnya angin membuat api semakin sulit dipadamkan. **Mengapa hal tersebut bisa terjadi?** Hal ini berkaitan dengan konsentrasi oksigen di udara. Dimana oksigen merupakan salah satu unsur dalam segitiga api yang dapat menyebabkan kebakaran jika bereaksi dengan 2 unsur lainnya yaitu sumber panas dan bahan bakar.

(Sumber : ArahJatim.com)

**Menyusun Perencanaan Proyek**

Konsep dasar mengenai pengaruh konsentrasi terhadap laju reaksi dapat diterapkan dalam kehidupan sehari-hari. Misalnya dalam pembuatan tape dan tempe. Kedua makanan tersebut dibuat melalui proses fermentasi dengan menggunakan ragi. Serupa dengan fenomena di awal, apakah jika konsentrasi besar (menggunakan ragi yang banyak) dapat membuat laju reaksi (proses fermentasi) semakin besar? Maka untuk membuktikan kebenaran dari konsep yang telah didapatkan, mari kita lakukan sebuah proyek. **Rancanglah proyek tersebut bersama kelompok!**

Figure 2. Activities in phases 1 and 2

In Figure 3, there are activities in Phase 3 (compile a project schedule), phase 4 (monitoring project activities), phase 5 (testing results or products), and Phase 6 (evaluating experience), according to Widiarso, E (2016). Before entering phase 3, there is a revision/suggestion table from the teacher and improvements made by students to the project design that has been designed. Then in phase 3, there is a place for students to fill in the timeline and deadline for completing the project that the teacher has agreed on. In phase 4, there is a table of observations to fill in the results of Windows shopping activities (displaying project results).

In phase 5, there is a video of the movement of particles within matter, after which students are asked about the effects of concentration (on electronic worksheets 1), surface area (on electronic worksheets 2), temperature (on electronic worksheets 3), catalysts (in electronic worksheets 4) on the reaction rate with

the collision theory according to the results of the projects that have been carried out. Then there is a place to fill in the conclusion of the results of the presentation that has been done. In addition, there is also an explanation of the components that must be met in the project report as a follow-up assignment.

**Menyusun Jadwal Proyek**

Pada tahap ini, guru dan peserta didik secara kolaboratif membuat timeline dan deadline dalam penyelesaian proyek

**Memonitor Kegiatan Proyek**

Pada tahap ini, guru bertanggung jawab untuk melakukan monitor terhadap aktivitas peserta didik selama menyelesaikan proyek

Dalam tahap ini, akan dilakukan kegiatan windows shopping, dimana kalian akan memajang hasil proyek yang telah dilakukan. Sebagian peserta didik menjaga toko (stan) dan sebagian lainnya bertugas sebagai visitor (orang yang berkeliling). Setelah itu, isikan hasil pengamatan kalian pada tabel di bawah ini, dan presentasikan di depan kelas!

**Menguji Hasil atau Produk**

Pada tahap ini, penilaian dilakukan untuk membantu guru dalam mengukur keterampilan standar, memberi umpan balik tentang tingkat pemahaman yang sudah dicapai peserta didik

**ANALISIS** Berdasarkan ilustrasi di samping, hubungkan pengaruh konsentrasi terhadap laju reaksi dengan teori tumbukan sesuai dengan hasil proyek yang sudah dilakukan!

**INFERENSI** Berdasarkan hasil presentasi, buatlah kesimpulan singkat!

**Evaluasi Pengalaman**

Pada tahap ini, guru dan peserta didik mengembangkan diskusi dalam rangka memperbaiki kinerja selama proses pembelajaran, sehingga pada akhirnya ditemukan suatu temuan baru untuk menjawab permasalahan yang diajukan pada tahap pertama pembelajaran

Setelah melakukan kegiatan proyek, kalian akan melakukan refleksi dengan membuktikan kebenaran konsep yang telah kalian dapatkan melalui kegiatan praktikum virtual menggunakan aplikasi *Crocodile Chemistry 605*.

**Petunjuk Kegiatan Virtual Lab**

1. Setelah berhasil memasang aplikasi *Crocodile Chemistry 605*, buka aplikasi tersebut
2. Pilih *reaction rates*, kemudian *concentration and rate*
3. Terdapat 3 tabung reaksi berisi kalsium karbonat yang direaksikan dengan asam hidroklorik dengan konsentrasi yang berbeda seperti pada gambar berikut :

Figure 3. Activities in phases 3, 4, 5 and 6

In Phase 6, there are virtual lab steps for applying Crocodile Chemistry 605 that students must perform, followed by some lab questions. In the last section, there are indicators of critical thinking of explanation. Namely, students associate concentration factors (on electronic worksheets 1), surface area (on electronic

worksheets 2), temperature (on electronic worksheets 3), and catalysts (on electronic worksheets 4) with the phenomenon that existed at the outset. When finished, students can immediately submit the results of their electronic worksheets work by clicking the finish button. The students' electronic worksheet's work results will go directly to the teacher's email.

### Develop Stage

The first product was the electronic worksheets Draft I, which was then developed to create electronic worksheets based on project-based learning, with the support of a virtual lab in a suitable manner. Therefore, the electronic worksheets have been validated and tested to achieve these requirements—the feasibility of what was discussed in the development stage.

### Validity of electronic worksheets

During the first stage of development, a validation process consisting of the validity of content and structure was performed. Two chemistry lecturers from the Unesa Faculty of Mathematics and Natural Sciences and one teacher from 1 Cerme senior high school conducted this process. Content validity aims to determine the suitability of electronic worksheets related to content eligibility criteria. In contrast, construct validity includes linguistic, presentation, and graphical criteria. The validation process uses validation instruments, and the validation results are obtained as follows:

Table 4. Results of Validity

	Component	V1	V2	V3	Mode	Criteria
electronic worksheets 1	Content	5	4	5	5	Very valid
	Linguistic	5	4	5	5	Very valid
	Presentation	4	4	5	4	Valid
	Graphical	5	4	5	5	Very valid
electronic worksheets 2	Content	5	4	5	5	Very valid
	Linguistic	5	4	5	5	Very valid
	Presentation	4	4	5	4	Valid
	Graphical	5	4	5	5	Very valid
electronic worksheets 3	Content	5	4	5	5	Very valid
	Linguistic	5	4	5	5	Very valid
	Presentation	4	4	5	4	Valid
	Graphical	5	4	5	5	Very valid
electronic worksheets 4	Content	5	4	5	5	Very valid
	Linguistic	5	4	5	5	Very valid
	Presentation	4	4	5	4	Valid
	Graphical	5	4	5	5	Very valid

The validation results data summary showed that the content component received mode 5 with very valid criteria for four electronic worksheets. It shows that the scope of eligibility of the contents contained in the electronic worksheets is appropriate, which includes the suitability of learning activities on the electronic worksheets with project learning syntax, the usefulness of learning activities on the electronic worksheets with indicators of critical thinking skills, suitability with the material theory of the factors that are affecting rate of reaction, and electronic worksheets can guide students in collecting and processing data through project activities.

The linguistic component obtained mode 5 with valid criteria for the four electronic worksheets. It shows that the aspects in this component have been fulfilled according to the guidelines for preparing teaching materials in the Ministry of National Education (2008), which includes writing electronic worksheets using easy-to-understand terms, using short and clear language, using good and correct Indonesian according to EYD, and using effective and efficient language.

The presentation component was obtained in mode 4 with valid criteria for the four electronic worksheets. It shows that the aspects in this component have been fulfilled, which include presenting learning objectives so that the discussion is focused, including how to use the crocodile chemistry 605 laboratories to support virtual experiment work. There are clear activity titles in each electronic worksheet's position, the video presentation is appropriate and can help students understand concepts, and the audio is presented with good intonation.

The graphical component obtained mode 5 with valid criteria for the four electronic worksheets. It shows that the aspects of this component have been fulfilled, according to the guidelines for preparing teaching materials in the Ministry of National Education (2008), which includes the cover design describing the contents of the electronic worksheets, the use of font types and text sizes used to make it easier for readers to use the electronic worksheets and suitability

layout of text and images on electronic worksheets.

The content and construct validity results obtained a score of more than three on each aspect. Then the developed electronic worksheets meet the validity criteria because if the mode  $\geq 3$ , the point is declared valid.

The next step was an electronic worksheets experiment to examine the practicality and efficacy of electronic worksheets, conducted by 30 students from Class XI Math and Science in 1 Cerme senior high school. The design used for the experiment was a one-group pretest-posttest design, in which the experimental pattern was followed by an initial test (pretest), then a learning-style treatment with the

developed electronic worksheets, and then a final examination (posttest). Then a participant response questionnaire was provided.

### The practicality of electronic worksheets

The practicality of electronic worksheets was evaluated using student activity observation sheets and learner response questionnaires. Observation sheets are helpful for overviewing student activity. During learning, three observers observe and record student activity that is appropriate and inappropriate for the learning activity.

Table 5. Result of Student Activity Observation

Student Activities	Activity Percentage			
	Meeting 1	Meeting 2	Meeting 3	Meeting 4
Relevant activities	93.89%	94.44%	92.22%	93.33%
Irrelevant activities	6.11%	5.56%	7.78%	6.67%
Total	100%	100%	100%	100%

From the data in Table 5, the percentage of relevant activities carried out by students during learning at meeting 1 was 93.89%, at meeting 2 was 94.44%, at meeting 3 was 92.22%, and at meeting 4 was 93.33%. The percentage of related activities is over 81%, so that the developed electronic worksheets can be categorized as very practical.

Then the learner response questionnaire aims to find out students' opinions or responses regarding the electronic worksheets developed. This response questionnaire relates to aspects of (1) knowing the clarity of the material and its relation to increasing students' understanding (content), (2) knowing the clarity of the language used in the electronic worksheets (language), (3) knowing students' interest in electronic worksheets (presentation), (4) identify the level of ease in using electronic worksheets (graphics).

From the data in Table 6, a practicality percentage of 91.24 percent is obtained, with each aspect having a percentage of 96.66 percent for content, 88.33 percent for language, 89.99 percent for presentation, and 89.99 percent for graphics. The achievement rate is over 81 percent, so the developed electronic worksheets are categorized as very practical.

Table 6. Result of Student Responses Questionnaire

Assessed aspect	Practicality percentage	Category
Content	96.66%	Very practical
Linguistic	88.33%	Very practical
Presentation	89.99%	Very practical
Graphical	89.99%	Very practical
Total	91.24%	Very practical

### Efficacy of electronic worksheets

The efficacy test of the electronic worksheets was developed using pretest and posttest sheet instruments to determine students' learning results before and after using electronic worksheets. The pretest and posttest sheets consist of a critical thinking skills test totaling eight description questions, including two interpretation questions, two inference questions, two analysis questions, and two explanation questions. The pretest results showed that no students were complete, while the posttest results of 30 students who were the subjects of the field trial showed that 83.33 percent or 25 students were finished, while the other five students needed to be completed. The resulting pretest and posttest data are analyzed by normality and hypothesis tests using the t-test if the data are normally distributed and the Wilcoxon test if the data are not normally distributed. The normality test determines whether the pretest and posttest scores are normally distributed.

Table 7. Result of the Normality Test

	Tests of Normality					
	Kolmogorov-Smirnov <sup>a</sup>			Shapiro-Wilk		
	Statistic	Df	Sig.	Statistic	Df	Sig.
Pretest	.139	30	.143	.926	30	.039
Posttest	.184	30	.011	.923	30	.032

a. Lilliefors Significance Correction

The normality test was carried out using IBM SPSS Statistic 26 application software. Based

on Table 7, pretest and posttest scores are not normally distributed, as seen from the Shapiro-Wilk test results, with a big value.  $< 0,05$ . Sig. for the pretest is 0.039, and Sig. for the posttest is 0.032. A nonparametric Wilcoxon test was performed because the data were not normally distributed. The Wilcoxon test aims to determine whether there is a significant difference between the pretest and posttest [26].

Table 8. Result of Wilcoxon Signed Rank Test

Test Statistics	
Posttest – Pretest	
Z	-4.787 <sup>b</sup>
Asymp. Sig. (2-tailed)	.000

a. Wilcoxon Signed Ranks Test

b. Based on negative ranks.

The Wilcoxon test obtained is the significance value on the pretest-posttest of 0.000, meaning Sig.  $< 0,05$ . It shows a significant difference between the pretest and posttest scores. The conclusion is that  $H_a$  is accepted and  $H_o$  is rejected because  $H_o$  states no significant pretest-posttest related change/difference. In contrast,  $H_a$  says there are significant changes/differences related to the pretest-posttest. Furthermore, the pretest and posttest data were calculated using the N-gain score to determine the increase in students' critical thinking skills test results.

Table 9. Result of N-gain Score

Pretest	Posttest	N-gain	Criteria
27.60	80.10	0.72	High

From the data in Table 9, the N-gain score is 0.72, meaning that the N-gain score is  $\geq 0.7$  with high criteria. From the efficacy test, it can be concluded that the classical completeness increased during the pretest by 0 percent to 83.33 percent during the posttest, from the Wilcoxon test showed the results that there was a significant difference among the pretest and posttest scores and the acquisition of the N-gain score in the high category so that the developed electronic worksheets meet the criteria of efficacy.

Based on the research results of Riska Wulandari (2018), the validity of worksheets seen from the percentage of content validity obtained was 89.86%, and the percentage of construct validity was 89.26%. The practicality of worksheets is seen from the average percentage of each aspect in students' responses of 96.5% and the average percentage of each aspect of the observation of activities of 98%. The efficacy of worksheets is seen from the increase in critical thinking skills, where as many as 86.66% of students have n-gain with high criteria, 13.33% have n-gain with moderate criteria, and the overall project results show good criteria. So the student worksheet-

oriented project-based learning developed effectively trains students' critical thinking skills [27].

## CONCLUSION

From the results of this research, electronic worksheets based on Project Based Learning assisted by virtual laboratories are feasible to use and can train students' critical thinking skills. It indicates the validity of electronic worksheets obtained a mode of 5 in the very valid category, the practicality of electronic worksheets in terms of student activity observations with relevant activities at meeting 1 of 93.89%, at meeting 2 of 94.44%, at meeting 3 of 92.2%, and at meeting 4 of 93.33% so that electronic worksheets is categorized as very practical and in terms of learner response questionnaires obtained a percentage of the practicality of 91%, 24 percent with a very practical category, and the efficacy of electronic worksheets in terms of the pretest-posttest results of students' critical thinking skills obtained classical completeness at pretest of 0 percent increased to 83.33% at posttest, from the Wilcoxon test showed the results that there was a significant difference among pretest and posttest scores, and the acquisition of N-gain score in the high category so that the electronic worksheets developed met the efficacy criteria.

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