JPPIPA 11(1) (2025)

Jurnal Penelitian Pendidikan IPA

Journal of Research in Science Education

http://jppipa.unram.ac.id/index.php/jppipa/index

Development of Problem-Based Learning Oriented Electronic Worksheets (e-worksheets) to Improve Students' Critical Thinking Skills on Salt Hydrolysis Material

Sania Ayu Puspita[1*], Harun Nasrudin[1]

Chemistry Departement, Universitas Negeri Surabaya, Surabaya, Indonesia.

Received: July 17, 2024
Revised: November 02, 2024
Accepted: January 25, 2025
Published: January 31, 2025

Corresponding Author: Harun Nasrudin
Sania Ayu Puspita
harunnasrudin@unesa.ac.id

DOI: 10.29303/jppipa.v11i1.8554

Abstract: This research aims to obtain problem-based learning-oriented e-worksheets that are feasible to improve students' critical thinking skills on salt hydrolysis material. This research uses Thiagarajan's 4D method, limited to the development stage. The feasibility of e-worksheets is reviewed from three aspects: validity, practicality, and effectiveness. The limited trial was conducted in class XI-12 State High School 1 Sidoarjo with 37 students. The research data showed that The e-worksheets are declared valid, indicated by the mode of content validity and construct validity of 5 with a very valid category. The e-worksheets are declared practical, indicated by the average results of student response questionnaires of 94% with a very practice category supported by the results of student activity observations. The e-worksheets are declared effective, indicated by the average posttest score higher than the pretest score with N-Gain Score of 0.76 in the high category. The paired sample t-test results showed a significance value of 0.000, indicating a significant difference between pretest and posttest scores. The research findings show that e-worksheets focusing on problem-based learning can be used to improve student's critical thinking skills in learning salt hydrolysis material.

Keywords: Chemistry; Critical thinking; Development; e-worksheets; Feasibility; Problem Based Learning; Salt Hydrolysis

Introduction

Indonesian education has implemented the Independent Curriculum. According to the Ministry of Education and Culture No. 56 of 2022, guidelines for implementing the curriculum in the context of learning recovery (Independent Curriculum) are an improvement to the previous curriculum to overcome learning loss due to the impact of the COVID-19 pandemic. The Independent Curriculum gives teachers and students the freedom to carry out the learning process (Faiz & Kurniawaty, 2020). In high school, it is divided into phases E and F. Chemistry is one of those that implements the Independent Curriculum.

Chemistry is a part of science that studies matter's changes, composition, and properties (Ningsih & Hidayah, 2019). Basic chemistry consists of scientific attitudes, processes, and products (Imama & Nasrudin, 2015). Practicum can develop students' scientific attitudes (Ulfa, 2016). According to the learning outcomes, at the end of phase F, students must use acid-base concepts in everyday life, including salt hydrolysis material derived from acid and base reactions (Irawati, 2019). Salt hydrolysis is the reaction of the decomposition of salts by water or the reaction that

How to Cite:
Lestariaji, C., Herawati, E. Y., Arfiati, D., Djaduk, S. L., Ristianadewi, P., Anjasmara, A. S., & Valina, R. (2025). Growth Pattern and Morphometric Characteristics of Keting Mystus gulio (Hamilton, 1822) in Downstream of Gembong and Rejoso River, Pasuruan, Indonesia. *Jurnal Penelitian Pendidikan IPA*, *11*(1), 456–463. https://doi.org/10.29303/jppipa.v11i1.10175

occurs in cations or anions derived from salts with ions from water (Carnawi & Wijayati, 2017). In salt hydrolysis material, students must understand the concept of acid-base, salt formation reaction, salt hydrolysis, and pH of salt solution (Latifah et al., 2014).

Independent curriculum also has general learning outcomes. Students are required to have critical thinking skills. Critical thinking is the ability of students to evaluate information in depth to determine the reliability of the information so that it becomes the basis for making the correct conclusions (Fithriyah et al., 2016). Critical thinking skills are 21st-century skills (Redhana, 2019). These skills are developed through laboratory practicum, problem-solving, and research projects. Critical thinking is the ability to process all problems, information, and observations and then decide the steps to be taken with logic (Pratiwi et al., 2023). Students in salt hydrolysis material do observation practicum to determine the acidic, basic, and neutral properties of various salt solutions and determine the pH of salt solutions. Furthermore, students analyze the data from the observation of the test properties of salt solutions and determine the pH of salt solutions.

Salt hydrolysis material and critical thinking skills are two things that cannot be separated because salt hydrolysis material can be understood through critical thinking (Hassan et al., 2020). However, salt hydrolysis material in chemistry is often considered difficult because of its characteristics and requires more concept understanding (Yotiani et al., 2016). This is supported by pre-research questionnaire data at State High School 1 Sidoarjo, which shows 51.4% of students in class XI-12 have difficulty understanding it. Critical thinking skills helpful in learning salt hydrolysis (Megawati & Sugiarto, 2017).

This research uses several indicators to improve critical thinking skills, including interpretation, analysis, evaluation, and inference (Facione, 2015). Students are expected to interpret information about the phenomenon of salt hydrolysis, analyze and solve problems, evaluate answers, and infer conclusions related to it (Megawati & Sugiarto, 2017). Based on the results of pre-research test questions on salt hydrolysis conducted at State High School 1 Sidoarjo, students' critical thinking skills in the indicators of interpretation, analysis, inference, and evaluation are 68%, 46%, 38%, and 39%.

The results of Interviews with chemistry teachers at State High School 1 Sidoarjo revealed that chemistry learning requires a practicum, but a salt hydrolysis practicum has never been done. The dominant teaching method is lecture (teacher-centered). The lack of practicum and variety of learning methods causes students to need more critical thinking skills. The problem-based learning model is recommended for improving critical thinking skills because it is student-centered and allows students to be more active during learning (Estarini, 2023). Problem-based learning includes problem formulation, authentic inquiry, interdisciplinary approach, concrete conclusions, and presentation of results (Chairani & Muchlis, 2019).

Problem-based learning has several phases: Orienting students to the problem, Organizing students to learn, Guiding individual/group experience, Developing and presenting work, Analyzing the evaluation of the problem-solving process (Arends, 2012). These phases can improve students' critical thinking skills. In phases 1 and 2, students practice interpretation by identifying and formulating problems from the phenomenon of salt hydrolysis. In phases 3 and 4, they practice analysis by analyzing the lab results. In phase 5, they practice evaluation and inference by concluding. Problem-based learning effectively trains students' critical thinking skills on salt hydrolysis material, with good to very good feasibility categories (Hambali & Muchlis, 2016).

Based on the results of the pre-research questionnaire, the learning resources used did not improve critical thinking skills; students only used textbooks from the government and MGMP e-worksheets. Therefore, teaching materials that can improve students' critical thinking skills can be developed (Wibowo & Utaminingsih, 2021). Along with the times, the development of teaching materials can utilize technology, such as e-worksheets. E-worksheets are electronic work guides that make it easier for students to understand learning materials (Purnama & Suparman, 2020).

This research developed electronic worksheets using Liveworksheets, a free website that converts printed worksheets into digital ones, allowing access anytime and anywhere (Nurbayani et al., 2021). E-worksheets based on problem-based learning with Liveworksheets are feasible to use in terms of validity and practicality (Hendrayani, 2022). Therefore, e-worksheets can be combined with problem-based learning models to improve students' critical thinking skills on salt hydrolysis material.

Method

The type of research conducted is development research, which is a method used to produce certain products and test their effectiveness (Sugiyono, 2021). The development of this e-worksheet uses Thiagarajan's design, known as the 4-D Model, which is carried out through four stages: define, design, develop, and

disseminate (Thiagarajan, 1974). However, in this study, the dissemination stage was not carried out but only tested on a limited basis. The research design is presented in the following Figure 1.

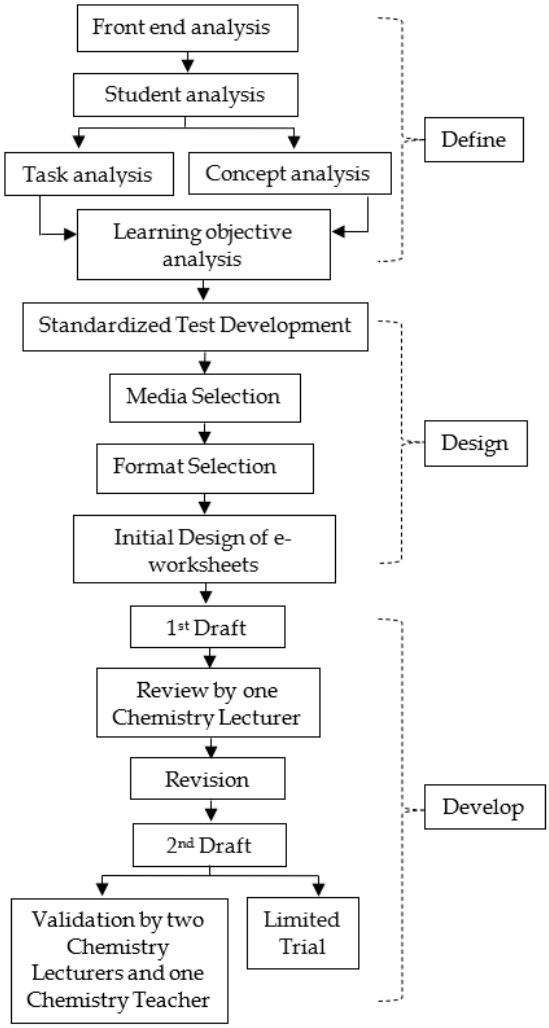

Figure 1. Research Process

The define stage aims to determine the requirements for preparing e-worksheets, including front-end analysis, student analysis, task analysis, concepts, and formulation of learning objectives. The design stage aims to design the e-worksheets, including standardized test development, media selection, format selection, and preliminary design of e-worksheets. The develop stage aims to produce problem-based learning-based e-worksheets that experts have assessed. The steps include reviewing the first draft with one chemistry lecturer to get suggestions for improvement. Then, revisions are made to produce the second draft, which two chemistry lecturers and one teacher validate. After validation, a limited trial of the e-worksheets was conducted.

The limited trial used in this research was the One Group Pretest-Posttest Design pattern, as follows.

$O_1 \times O_2$

Figure 2. One Group Pretest-Posttest Design

Description:
X = Learning using e-worksheets
O_1 = Pretest Score
O_2 = Posttest Score

E-worksheets were tested on 37 students of class XI-12 State High School 1 Sidoarjo. The research instruments included e-worksheets review sheets, e-worksheets validation sheets, student response questionnaires, student activity observation sheets, and critical thinking skills pretest and posttest sheets. The data collection techniques used were questionnaires, observations, and tests.

Data from the review sheet obtained from chemistry experts, namely one chemistry lecturer at Surabaya State University, in suggestions and input on problem-based learning e-worksheets, will be analyzed descriptively qualitatively for improvement.

Data from the validation sheet regarding the feasibility of problem-based learning e-worksheets developed will be analyzed descriptively and quantitatively by three validators: two Surabaya State University chemistry lecturers State High School 1 Sidoarjo chemistry teacher. Likert scale calculation is used to obtain percentage data (Riduwan, 2009).

Table 1. Likert Scale Categories

Scale	Category
1	Invalid
2	Less Valid
3	Fairly Valid
4	Valid
5	Very Valid

The data collected was analyzed to find the mode value of each content and construct criteria. The mode score indicates the validity of the e-worksheets, which is considered valid if it is ≥ 4 (Lutfi, 2021). If there is no mode, validity is determined by the median (Cao, 2021).

Practicality is a criterion for the quality of e-worksheets in terms of the ease of students in using e-worksheets. The instruments used is a student response questionnaire sheet which is supported by a student activity observation sheet.

The data from the students' response questionnaire regarding responses to e-worksheets include positive and negative questions. On positive questions, the answer "Yes" scored 1 and "No" scored 0. Conversely, on negative questions, the answer "Yes" scored 0 and "No" scored 1.

The following formula calculates the percentage of students' responses and student activity observation to e-worksheets.

$$P = \frac{F}{N} \times 100 \quad (1)$$

Information:
P = Percentage Result
F = Amout gained
N = Maximum amount

Based on this formula, the percentage score obtained is interpreted into practical categories in the following table 2.

Table 2. Practicality Percentage Category

Percentage (%)	Category
0-20	Very Unpractical
21-40	Less Practical
41-60	Practical Enough
61-80	Practical
81-100	Very Practical

If the result is ≥ 61%, the e-worksheet is declared practical or very practical (Riduwan, 2009).

The effectiveness of the developed electronic student worksheets is shown from the critical thinking skills test results. The instruments used are pretest and posttest questions.

Students' critical thinking skills before and after using e-worksheets were analyzed using the N-gain Score and Paired Sample t-test. The difference in the average pretest and posttest scores was calculated to determine the increase in the N-Gain Score.

$$N - Gain\ Score = \frac{Score\ Posttest - Score\ Pretest}{Score\ Maximum - Score\ Pretest} \quad (2)$$

N-Gain Score obtained will be converted to the category range as in the following Table 3 (Hake, 2002).

Table 3. N-Gain Score Category

N-Gain Score	Category
g > 0.7	High
0.3 ≤ g ≤ 0.7	Medium
g < 0.3	Low

E-worksheets effectively improve critical thinking skills on salt hydrolysis material if the gain score is≥ 0.3.

Furthermore, the paired sample t-test was conducted to determine the significance of the difference between pretest and posttest scores. The normality test is a requirement before the paired sample t-test.

The normality test in this research used the Shapiro-Wilk test. This test was conducted with SPSS, and the data was declared normally distributed if the significance value > 0.05. If the data is normally distributed, a paired sample t-test is conducted with Minitab to determine whether students' critical thinking skills significantly increase after using the developed e-worksheets.

Result and Discussion

This research produced data regarding the feasibility of the developed e-worksheets, including validity, practicality, and effectiveness.

Validity of e-worksheets

Validation aims to assess the feasibility of the student worksheets developed before they are tested on students. The validity of the student worksheets was assessed based on content and construct criteria. Data related to content validation is presented in Table 4.

Table 4. Recap of Content Validity

Aspect Validity	Mode of e-worksheets 1	Mode of e-worksheets 2	Category
1	4	4	Valid
2	5	5	Very Valid
3	5	5	Very Valid
4	5	5	Very Valid
Final Mode	5	5	Very Valid

The results of content validation show that the two e-worksheets developed get a mode value of 5, which, according to the Likert scale, is in the very valid category (Riduwan, 2009). The product is declared valid if the mode value is ≥ 4 (Lutfi, 2021).

In the first aspect, the suitability of salt hydrolysis material with learning outcomes and objectives, e-worksheets 1 and e-worksheets 2 get a mode score of 4, categorized as valid. The suitability of material in e-worksheets with learning outcomes and learning objectives was carried out to analyze whether the salt hydrolysis material was by the learning outcomes in the curriculum (Aisyah & Yonata, 2019). The learning outcome that must be achieved is that students can use acid-base concepts in everyday life. Hydrolysis material relates to this concept because salt is formed from the reaction of acids and bases (Irawati, 2019). Salt hydrolysis material in problem-based learning-oriented e-worksheets is presented through concept maps and problem phenomena, which encourage students to analyze so that they can think critically. Problem-based learning model is a learning model that presents problematic situations that are authentic and meaningful to students (Arends, 2012).

In the second aspect, the suitability of e-worksheets with the phases of the problem-based learning model, e-worksheets 1 and e-worksheets 2 get a mode score of 5, categorized as very valid. Salt hydrolysis material on

problem-based learning e-worksheets is presented through concept maps and problem phenomena, which encourage students to analyze so that they can think critically. Problem-based learning model is a learning model that presents problematic situations that are authentic and meaningful to students (Arends, 2012). Furthermore, students can answer questions in problem identification, problem formulation, and hypotheses in the phase of organizing students to learn. Make observations in the phase of assisting independent and group research. Learners answer analysis questions in the phase of developing and presenting work and displaying it. Then, students can make conclusions and answer evaluation questions in the phase of analyzing and evaluating the problem-solving process. Based on the meta-analysis shows that the problem-based learning (PBL) model improves students' critical thinking skills by 83.45% (Miterianifa et al., 2019).

In the third aspect, the suitability of e-worksheets to improve critical thinking skills in e-worksheets 1 and e-worksheets 2 get a mode score of 5, categorized as very valid. Based on the Decree of the Ministry of Education and Culture Number 008 of 2022, chemistry learning aims to foster students' critical thinking skills. Based on Facione's indicators, critical thinking skills include interpretation, analysis, inference, and evaluation (Facione, 2015). Interpretation indicators are outlined in the problem identification questions, problem formulation, observation variables, and writing of the observations' data, analysis in post-observation analysis questions, inference in hypothesis and conclusion questions, and evaluation in evaluation questions after analysis and conclusions.

In the fourth aspect, the correctness of the substance of the e-worksheets which contains the accuracy of the concepts and definitions of salt hydrolysis, as well as the accuracy of the material images presented obtained a mode score of 5, categorized as very valid. The content on e-worksheets should include prerequisite material, which serves to reinforce accurate basic concepts before discussing the core material (Purnama & Suparman, 2020). Overall, based on the content validity of e-worksheets get a mode value of 5, which is very valid. According to Lutfi (2021), the product is declared valid if the mode value is ≥ 4. Thus, the developed problem-based learning-oriented e-worksheets can be used in the learning process.

Data related to construct validation is presented in Table 5. The results of construct validation show that the two e-worksheets developed get a mode value of 5, which on the Likert scale is categorized as very valid (Riduwan, 2009). According to Lutfi (2021), the product is declared valid if the mode value is ≥ 4. Construct validity on e-worksheets includes aspects of graphics, presentation, and linguistics.

Table 5. Recap of Construct Validity

Aspect Validity	Mode of e-worksheets 1	Mode of e-worksheets 2	Category
Graphics	5	5	Valid
Presentation	5	5	Very Valid
Linguistic	5	5	Very Valid
Final Mode	5	5	Very Valid

In the first aspect, the graphical aspect in e-worksheets 1 and e-worksheets 2 get a mode score 5, categorized as very valid. The color harmony of text, background, images, and tables supports the achievement of learning objectives. According to research by Arsyisyah & Haryati (2023) the existence of graphic aspects can encourage students to study the e-worksheets developed actively.

In the second aspect, the presentation gets a mode score of 5, categorized as very valid. This aspect includes the cover presents the content of the e-worksheets, there is a place to write answers as needed, and the order of presentation. Based on Zein & Musyarofah (2024) research shows that the presentation aspect can encourage students to be active in learning.

In the third aspect, the linguistic gets a mode score of 5 with a very valid category. This aspect includes the clarity of the information presented and the appropriateness of the use of terms, symbols, and icons. The results are supported by Zein & Musyarofah (2024) that produces an average percentage score of 93.750% with the criteria of valid on the linguistic aspect so that there is clarity in language and readability level. Overall, based on the construct validity of e-worksheets developed, get a mode value of 5, which is very valid. According to Lutfi (2021), a product is considered valid if it obtains a mode ≥ 4. Based on this criteria, problem-based learning-oriented e-worksheets to improve critical thinking skills on salt hydrolysis material developed can be used in the learning process.

Practicality of e-worksheets

The practicality of the developed e-worksheets is known through the results of the student response questionnaire after the e-worksheets trial is tested, which are then supported by the students' activities when the e-worksheets is tested.

Student response questionnaires to determine responses to e-worksheets consisting of aspects of critical thinking skills, problem-based learning models, material, presentation, linguistics, and appearance. Data related to the student response questionnaire is presented in the following Table 6.

Table 6. Recap Student Response Questionnare

Aspects	Percentage (%)	Category
1	98	Very Practical
2	97	Very Practical
3	84	Very Practical
4	91	Very Practical
5	97	Very Practical
6	97	Very Practical
Average	94	Very Practical

The results of students' responses to the e-worksheets trial obtained an average score of 94%, including in the very practical category (Riduwan, 2009). Arisandi & Suryani (2023) research supports these results, showing that problem-based learning-oriented Worksheets on salt hydrolysis material has practicality with an average of 92%, including a very practical category. Using problem-based learning-oriented e-worksheets can improve critical thinking skills with a practicality result of 98.44%, which is included in the very practical category (Hidayah et al., 2024).

Practicality is also supported by observing student activity every 3 minutes. Data related to the observing student activity is presented in the following Table 7.

Table 7. Recap Student Activity

Types of e-worksheets	Percentage of Relevant Activity (%)	Category
e-worksheets 1	95	Very Practical
e-worksheets 2	97	Very Practical

The results of observations of relevant student activities at the first and second meetings obtained a percentage of 95% and 97%.

Problem-based learning-oriented e-worksheets are practical if most of the relevant activities are carried out compared to irrelevant activities (Bierera & Muchlis, 2021). Asnaini & Mahidin (2017) also mentioned that using e-worksheets during learning can increase student activity. Therefore, overall student activity goes well when learning using e-worksheets, which supports the practicality of the e-worksheets developed.

Effectiveness of student worksheets

The effectiveness of the developed e-worksheets is known through the pretest and posttest scores of critical thinking skills, which contain ten essays containing two questions of interpretation indicators, four questions of analysis indicators, two questions of inference indicators, and two questions of evaluation indicators. The pretest and posttest values were analyzed using the N-gain Score and Paired Sample T-test.

N-Gain Score to analyze the improvement of students' critical thinking skills. The data obtained from the N-Gain pretest-posttest test of critical thinking skills are presented in the following Table 8.

Table 8. N-Gain Test Results

Name	Pretest Score	Pretest Score	N-Gain Score	Category
ARM	26.67	73.33	0.64	Medium
ADP	23.33	90.00	0.87	High
AWDL	20.00	76.67	0.71	High
ANDH	33.33	83.33	0.75	High
AKN	46.67	83.33	0.69	Medium
BRR	30.00	66.67	0.52	Medium
BKS	23.33	90.00	0.87	High
CPDN	33.33	86.67	0.80	High
DNA	46.67	86.67	0.75	High
DF	20.00	90.00	0.88	High
EFS	36.67	83.33	0.74	High
FBAA	36.67	86.67	0.79	High
GDL	36.67	96.67	0.95	High
HA	6.67	86.67	0.86	High
IAG	43.33	90.00	0.82	High
IL	30.00	93.33	0.90	High
MHA	23.33	70.00	0.61	Medium
MLHF	20.00	73.33	0.67	Medium
MAA	30.00	83.33	0.76	High
MAM	23.33	76.67	0.70	Medium
NR	46.67	80.00	0.62	Medium
NMR	36.67	86.67	0.79	High
NDPP	36.67	90.00	0.84	High
NKS	30.00	93.33	0.90	High
PRM	26.67	83.33	0.77	High
PARUT	30.00	76.67	0.67	Medium
PQCA	30.00	86.67	0.81	High
PTTK	36.67	73.33	0.58	Medium
RACA	30.00	80.00	0.71	High
RAM	36.67	86.67	0.79	High
RDK	46.67	93.33	0.87	High
RAAG	20.00	76.67	0.71	High
RPR	40.00	80.00	0.67	Medium
SMA	20.00	90.00	0.88	High
SAZ	40.00	90.00	0.83	High
SNR	43.33	90.00	0.82	High
SMK	26.67	76.67	0.68	Medium
Average	31.53	83.78	0.76	High

The mean pretest and posttest scores of students' critical thinking skills were 31.53 and 83.78. The results obtained align with the research of Hidayah et al. (2024), which revealed that Problem Based Learning-oriented e-worksheets can improve students' critical thinking skills.

N-Gain Score analysis also found increased pretest and posttest scores on each critical thinking skill indicator. The following are the results of the N-Gain Score test on each critical thinking skill indicator in Table 9.

Table 9. N-Gain Test Results of Critical Thinking Skills Indicators

Indicator	Pretest Score	Pretest Score	N-Gain Score	Category
Interpretation	55.95	89.19	0.75	High
Analysis	26.35	81.31	0.75	High
Inference	22.97	87.39	0.84	High
Evaluation	27.03	80.00	0.73	High

Based on the results of the N-Gain test, the indicators of interpretation, analysis, inference, and evaluation have an increase in pretest and posttest scores with an N-Gain Score of 0.75, 0.75, 0.84, and 0.73, which is included in the high category.

After that, a normality test was carried out before the paired sample t-test. A normality test is conducted to determine that the sample data taken from the population is normally distributed (Diomara et al., 2022). The following results of the normality test of the pretest and posttest scores of students' critical thinking skills are presented in Table 10.

Table 10. Tests of Normality

Test	Kolmogorov-Smirnov[a]			Shapiro-Wilk		
	Statistic	df	Sig.	Statistic	df	Sig.
PRE_KBK	0.113	37	0.200*	0.956	37	0.153
POST_KBK	0.167	37	0.010	0.951	37	0.102

*. This is a lower bound of the true significance.
a. Lilliefors Significance Correction

Based on the figure, it can be seen that the sig or p-value of the pretest and posttest is sig > 0.100, it means the data are normally distributed because they have a sig or p-value > 0.05. Therefore, it can be concluded that H0 is accepted or the pretest and posttest values are normally distributed (Razali & Wah, 2011).

The paired sample t-test was conducted after ensuring that the pretest and posttest data were normally distributed. Its purpose is to compare the means of the pretest and posttest taken from paired groups. This test uses Minitab. The following paired sample t-test results on pretest and posttest scores.

The paired sample t-test results showed a P-Value of 0.000 (P-Value <0.05), so that H0 was rejected and H1 was accepted, showing a significant difference in the critical thinking skills of students on salt hydrolysis material after using problem-based learning-oriented e-worksheets, so that the e-worksheets is effective for learning.

These results are in line with Nurkhalida & Nasrudin (2023), which in the development of e-worksheets can train critical thinking skills by obtaining a significance value in the paired sample t-test of 0.000 which shows a significant average difference in the pretest posttest value so that the e-worksheets developed can improve critical thinking skills.

Conclusion

Based on the research results and discussion, it is concluded that problem-based learning-oriented e-worksheets to improve students' critical thinking skills on salt hydrolysis material are feasible to use in terms of several aspects: The e-worksheets are declared valid, indicated by the mode of content validity and construct validity of 5 with a very valid category. The e-worksheets are declared practical, indicated by the average results of student response questionnaires of 94% with a very practice category supported by the results of student activity observations. The e-worksheets are declared effective, indicated by the average posttest score higher than the pretest score with N-Gain Score of 0.76 in the high category. The paired sample t-test results provide a significance value of 0.000, indicating a significant difference between the pretest and posttest scores.

Acknowledgments
The author would like to thank all students of class XI-12 State High School 1 Sidoarjo who have participated in the development of this student e-worksheets.

Author Contributions
Conceptualization, S. A. P. and H. N.; methodology, S. A. P. and H. N.; data curation, S. A. P.; writing—original draft preparation, S. A. P.; editing, S. A. P.; formal analysis, H. N.; validation, H. N.; and writing—review, H. N. Each author has reviewed and approved the published version of the manuscript.

Funding
This research received no external funding.

Conflicts of Interest
The authors declare no conflict of interest.

References

Aisyah, D., & Yonata, B. (2019). The Development of Student worksheet to Train Critical Thinking Skill in Acid Base Matter For Senior High School in 11th Grade. *UNESA Journal of Chemical Education*, *8*(3), 340–349. https://doi.org/10.26740/ujced.v8n3.p

Arends, R. I. (2012). *Learning to Teach (6th)*. The McGraw-Hill. https://doi.org/10.18907/p1079-016-07776-3

Arisandi, H., & Suryani, O. (2023). Pengembangan LKPD Berbasis Problem Based Learning Pada Materi Hidrolisis Garam Untuk Sekolah Penggerak Fase F. *Jurnal Pendidikan Tambusai*, *7*(3), 21730–21738. Retrieved from

https://jptam.org/index.php/jptam/article/download/9950/8068

Arsyisyah, R., & Haryati, S. (2023). Pengembangan E-Lkpd Termokimia Berbasis Self Regulated Learning (Srl) Menggunakan Wizer.Me Pada Kelas XI SMA/MA Sederajat. *Journal of Research and Education Chemistry*, *5*(2), 74. https://doi.org/10.25299/jrec.2023.vol5(2).14947

Asnaini, A., & Mahidin. (2017). Pengembangan LKPD Berbasis Pendekatan Scientific untuk Meningkatkan Hasil Belajar dan Aktivitas Peserta Didik pada Materi Larutan Penyangga. *Lantanida Journal*, *4*(1), 60. https://doi.org/10.22373/lj.v4i1.1868

Bierera, E., & Muchlis. (2021). Pengembangan LKPD Berbasis PBL untuk Melatihkan Keterampilan Berpikir Analitis pada Materi Elektrolit dan Nonelektrolit. *UNESA Journal of Chemical Education*, *10*(2), 149–158. https://doi.org/10.26740/ujced.v10n2.p149-158

Cao, W. (2021). Discussion about the Mean, Median, Mode and their Validity, and the Representative Number. *Journal of Contemporary Educational Research*, *5*(3), 71–74. https://doi.org/10.26689/jcer.v5i3.1949

Carnawi, S., & Wijayati, N. (2017). Application of Project Based Learning (PBL) Model for Materials of Salt Hydrolysis to Encourage Students' Entrepreneurship Behaviour. *International Journal of Active Learning*, *2*(1), 50–58. Retrieved from https://www.learntechlib.org/p/208705/

Chairani, R. P., & Muchlis. (2019). Penerapan Model Pembelajaran Berbasis Masalah Untuk Melatihkan Kemampuan Berpikir Kritis Peserta Didik Pada Materi Larutan Penyangga Kelas XI di SMAN 1 Sidoarjo. *Unesa Journal of Chemical Education*, *8*(1), 16–21. https://doi.org/10.26740/ujced.v8n1

Diomara, N., Handayani, D., & Elvia, R. (2022). Pengembangan Bahan Ajar Berbasis Android pada Materi Sistem Koloid Melalui Pendekatan Problem Based Learning. *ALOTROP*, *6*(2), 131–141. https://doi.org/10.33369/alo.v6i2.24968

Estarini, N. K. D. (2023). Penerapan Model Pembelajaran Problem Based Learning (PBL) Dalam Meningkatkan Aktivitas dan Hasil Belajar Peserta Didik Kelas XI AK 3 di SMK Negeri 4 Negara. *Progresif*, *2*(2), 201–206. https://doi.org/10.59562/progresif.v2i2.30143

Facione, P. A. (2015). Critical Thinking : What It Is and Why It Counts. *Insight Assessment*, 1–30. Retrieved from https://www.insightassessment.com/CT-Resources/Teaching-For-and-About-Critical-Thinking/Critical-Thinking-What-It-Is-and-Why-It-Counts/Critical-Thinking-What-It-Is-and-Why-It-Counts-PDF

Faiz, A., & Kurniawaty, I. (2020). Konsep Merdeka Belajar Pendidikan Indonesia dalam Perspektif Filsafat Progresivisme. *Konstruktivisme : Jurnal Pendidikan Dan Pembelajaran*, *12*(2), 155–164. https://doi.org/10.35457/konstruk.v12i2.973

Fithriyah, I., Sa'dijah, C., & Sisworo. (2016). Analisis Kemampuan Berpikir Kritis Siswa Kelas IX-D SMPN 17 Malang. *Prosiding Konferensi Nasional Penelitian Matematika Dan Pembelajarannya*, 580–590. Retrieved from https://proceedings.ums.ac.id/index.php/knpmp/article/view/2545

Hambali, A. I., & Muchlis. (2016). Implementation of Problem Based Learning Model on Salt Hydrolysis Matter to Train Students Critical Thinking Skill Grade XI-D SMAN 1 Pamekasan. *Unesa Journal of Chemical Education*, *5*(3), 750–755. Retrieved from https://shorturl.asia/rkO2X

Hassan, P., Laliyo, L. A. R., Botutihe, D. N., & Abdullah, R. (2020). Identifikasi Kemampuan Berpikir Kritis Siswa dengan Menggunakan Five-Tier Multiple Choice pada Materi Hidrolisis Garam. *Hydrogen: Jurnal Kependidikan Kimia*, *8*(2), 74. https://doi.org/10.33394/hjkk.v8i2.2961

Hendrayani, A. (2022). *Pengembangan LKPD Berbasis Problem Based Learning Berbantuan Liveworksheet Pada Materi Alat Optik [Skripsi*. Doctoral Dissertation: UIN Sultan Syarif Kasim Riau. Retrieved from https://repository.uin-suska.ac.id/60923/

Hidayah, S. N., Nasrudin, H., & Azizah, U. (2024). Development of Problem-Based-Learning (PBL)-Oriented Electronic Student Worksheets (e-Worksheet) to Improve Critical Thinking Skills of Class XI Senior High School Students on Factors that Influence Rate of Chemical Reactions Material. *International Journal of Current Science Research and Review*, *07*(06). https://doi.org/10.47191/ijcsrr/V7-i6-80

Imama, N., & Nasrudin, H. (2015). Penerapan Model Pembelajaran Inkuiri Untuk Melatihkan Keterampilan Berpikir Kritis Siswa Pada Materi Laju Reaksi di Kelas XI SMAN 1 Sreseh Sampang. *UNESA Journal of Chemical Education*, *4*(2), 212–217. https://doi.org/10.26740/ujced.v4n2.p

Irawati, R. K. (2019). Pengaruh Pemahaman Konsep Asam Basa terhadap Konsep Hidrolisis Garam Mata Pelajaran Kimia SMA Kelas XI. *THABIEA : JOURNAL OF NATURAL SCIENCE TEACHING*, *2*(1), 1–6. https://doi.org/10.21043/thabiea.v2i1.4090

Latifah, S., Sugiharto, & Sugiharto. (2014). Studi Komparasi Penggunaan Praktikum dan

Demonstrasi Pada Metode Problem Solving Terhadap Prestasi Belajar Siswa Materi Hidrolisis Garam Kelas XI Ilmu Alam SMA Al Islam 1 Surakarta Tahun Pelajaran 2010/2011. *Jurnal Pendidikan Kimia Universitas Sebelas Maret, 3*(3). Retrieved from https://shorturl.asia/QJf04

Lutfi, A. (2021). *Research and Development (R&D): Implikasi dalam Pendidikan Kimia*. Universitas Negeri Surabaya.

Megawati, E. N., & Sugiarto, B. (2017). Keterampilan Berpikir Kritis Pada Materi Hidrolisis Garam Siswa SMA Negeri 1 Driyorejo Gresik Melalui Penerapan Model Pembelajaran Problem Posing. *Universitas Negeri Surabaya*, *6*(2), 208–211. https://doi.org/10.26740/ujced.v6n2.p

Miterianifa, T., Y., K., A., & Ayu, H. D. (2019). Meta-analysis: The effect of Problem-Based Learning on Students' Critical Thinking Skills. *AIP Conference Proceedings. The 2nd International Conference On Science*. https://doi.org/10.1063/1.5139796

Ningsih, R. K., & Hidayah, R. (2019). The Effectiviness od Chemical Practicum KIT to Train Science Process Skill in 10th Grade. *JCER (Journal of Chemistry Education Research*, *3*(1), 1. https://doi.org/10.26740/jcer.v3n1.p1-8

Nurbayani, A., Rahmawati, E., Nurfaujiah, I. I., Putriyanti, N. D., Fitria, N., Safira, Y., & Ruswan, A. (2021). Sosialisasi Penggunaan Aplikasi Liveworksheets sebagai LKPD Interaktif Bagi Guru-guru SD Negeri 1 Tegalmunjul Purwakarta. *Indonesian Journal of Community Services in Engineering & Education*, *1*(2), 126–133. https://doi.org/10.17509/ijocsee.v1i2.33479

Nurkhalida, S., & Nasrudin, H. (2023). Development of Student Worksheets Oriented Guided Inquiry to Improve Student's Critical Thinking Skills on Acid Base Material. *PENDIPA Journal of Science Education*, *7*(3), 423–430. https://doi.org/10.33369/pendipa.7.3.423-430

Pratiwi, A. M., Putra, C. A., Wardana, K. A. K., Fitriana, L., Muttaqien, M. S. A., & Dayu, D. P. K. (2023). Implementasi Pembelajaran Blended Learning Untuk Meningkatkan Berpikir Kritis Siswa Pada Kurikulum Merdeka. *Prosiding Seminar Nasional Bahasa, Sastra, Seni, Dan Pendidikan Dasar (SENSASEDA)*, *2*, 148–156. Retrieved from http://jurnal.stkipbjm.ac.id/index.php/sensasedа/article/download/2058/1004

Purnama, A., & Suparman. (2020). Studi Pendahuluan: E-LKPD Berbasis PBL untuk Meningkatkan Kemampuan Literasi Matematis Peserta Didik. *Jurnal Kajian Pendidikan Matematika*, *6*(1), 131–140. https://doi.org/10.30998/jkpm.v6i1.8169

Razali, N. M., & Wah, Y. B. (2011). Power Comparisons of Shapiro-Wilk, Kolmogorov-Smirnov, Lilliefors and Anderson-Darling Tests. *Journal of Statistical Modeling and Analytics*, *2*(1), 21–33. Retrieved from https://www.nbi.dk/~petersen/Teaching/Stat2017/Power_Comparisons_of_Shapiro-Wilk_Kolmogorov-Smirn.pdf

Redhana, I. W. (2019). Mengembangkan keterampilan abad ke-21 dalam pembelajaran kimia. *Jurnal Inovasi Pendidikan Kimia*, *13*(1). https://doi.org/10.15294/jipk.v13i1.17824

Riduwan. (2009). *Dasar-Dasar Statistika*. Bandung: Alfabeta.

Sugiyono. (2021). *Metode penelitian kuantitatif, kualitatif, dan R&D*. Bandung: Alfabeta.

Thiagarajan, S. (1974). *Instructional Development For Training Teachers Of Exceptional Children: A Source Book*. University Of Minnesota. Retrieved from https://eric.ed.gov/?id=ED090725

Ulfa, S. W. (2016). Pembelajaran Berbasis Praktikum: Upaya Mengembangkan Sikap Ilmiah Siswa Pada Pembelajaran Biologi. *Jurnal Pendidikan Islam Dan Teknologi Islam*. https://doi.org/10.30821/niz.v6i1.29

Wibowo, S. A., & Utaminingsih, S. (2021). Efektifitas Pengembangan Buku Ajar Berbasis Nilai-Nilai Karakter Multikultural Terhadap Keterampilan Berpikir Kritis Siswa. *Jurnal Pendidikan Dan Kebudayaan*, *11*(1), 54–62. https://doi.org/10.24246/j.js.2021.v11.i1.p54-62

Yotiani, S., I., K., & Nuswowati, M. (2016). Pengembangan Bahan Ajar Hidrolisis Garam Bermuatan Karakter Berbasis Inkuiri Terbimbing Untuk Meningkatkan Kemampuan Berpikir Kritis Siswa. *Jurnal Inovasi Pendidikan Kimia*, *10*(2), 1731–1742. https://doi.org/10.15294/jipk.v10i2.9526

Zein, F. A., & Musyarofah, M. (2024). Pengembangan Elektronik Lembar Kerja Peserta Didik (E-LKPD) Interaktif Menggunakan Wizer.me Pada Pembelajaran IPS. *Prima Magistra: Jurnal Ilmiah Kependidikan*, *5*(1), 57–68. https://doi.org/10.37478/jpm.v5i1.3573