JPPIPA 10(4) (2024)

Jurnal Penelitian Pendidikan IPA

Journal of Research in Science Education

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

Development of Student Worksheets Problem Solving Oriented to Train Students' Critical Thinking Skills on Acid-Base Material

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Received: January 13, 2024
Revised: March 11, 2024
Accepted: April 25, 2024
Published: April 30, 2024

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DOI: 10.29303/jppipa.v10i4.6937

Abstract: The purpose of this research was to describe the viability of using problem solving worksheets to teach students how to think critically about acid-base material. In assessing the viability of the student worksheets that have been developed, there are three factors that are taken into consideration, namely validity, practicality, and efficacy. In this study, 22 students from class XI MIPA 13 SMAN 1 Sidoarjo participated in a limited trial stage of the Research and Development (R&D) technique from Borg and Gall. The findings of this research indicate that validity, which comprises construct and content validity, each received a mode value of four using appropriate standards. Based on student reaction surveys, practicality reached 92.80% with extremely practical standards, and relevant student activities in the first and second meetings respectively obtained a percentage of 95 55% and 96.12%. The N-gain test yielded medium and high criteria for efficacy. The research's findings indicate that problem solving focused student worksheets are a workable way to support students in strengthening their capacity for critical thought when studying acid-base content.

Keywords: Acid-Base; Critical Thinking; Problem Solving; Student Worksheets.

Introduction

Education is an ongoing process of learning with the goal of gaining attitudes, knowledge, and skills that will be helpful in students' future social interactions (Rosidin et al., 2019). According to studies conducted by Asma et al. (2020), students who graduate from each educational unit must have three competencies which include attitudes (honest, caring, and responsible), knowledge (factual, conceptual, procedural, and metacognitive), and skills (critical, creative, communicative, and independent). Based on this statement, critical thinking abilities are among the crucial proficiencies that students must have in the 21st century (Widyastuti, 2018).

In the field of education, science learning such as chemistry learning is required to develop basic literacy skills, optimize creative and critical thinking skills. Students with critical thinking skills will work hard to provide logical guidance in understanding and creating complex decisions as well as understanding system interactions (Husamah et al., 2018). This statement indicates that developing critical thinking abilities is one of the most crucial things to be trained in learning as a goal of the learning process because it can provide experience to be able to face scientific and social problems in the future (Swart, 2017).

Critical thinking is a mechanism that ends in making reasonable conclusions or decisions about what to believe and what steps to take (Kaliky & Juhaevah, 2018). Critical thinking skills are also defined as abilities that refer to higher-order cognitive functions, like the capacity for evaluate, analyze, and synthesize which can have a positive influence on improving student learning outcomes (Amijaya et al., 2018). According to Facione (2023), there are six primary competencies of critical thinking, namely interpretation, analysis, evaluation, inference, explanation, and self-regulation. Of the six

How to Cite:
Nabila, A., & Azizah, U. (2024). Development of Student Worksheets Problem Solving Oriented to Train Students' Critical Thinking Skills on Acid-Base Material. *Jurnal Penelitian Pendidikan IPA*, *10*(4), 1925–1933. https://doi.org/10.29303/jppipa.v10i4.6937

critical thinking skills, researchers limited only four skills used in this study, namely interpretation, analysis, evaluation, and inference.

One of the attempts that able to instruct the six main skills in critical thinking and measure the level of critical thinking skills of students is through essay tests (Narmaditya et al., 2018). The essay test was given at the time of the pre-research. Pre-research findings have shown that students' critical thinking abilities are still lacking when it comes to learning chemistry. The results of each students' critical thinking skills were obtained, namely interpretation by 28%, analysis by 16%, evaluation by 4%, and inference by 12%. The issue of low critical-thinking abilities among pupils needs to be resolved (Vong & Kaewurai, 2017). The low critical thinking skills experienced by students need to be resolved due to the strategic value of critical thinking skills in life (Saputri et al., 2019).

A method that can be used to help students develop their critical thinking abilities is to vary learning through the selection of models, approaches, or learning methods that focus on students so that students' ability to think deeply and understand concepts can be trained (Fara et al., 2019). The learning model in question is the problem solving learning model. Students' critical thinking abilities will also improve if they can correctly solve the issues in the problem solving learning model (Rosidin et al., 2019). This aligns with the results of previous research which shows that the problem solving learning model is able to train students' critical thinking skills (Alberida et al., 2022; Triyanto et al., 2014).

The problem solving learning model is a learning model in which there are critical thinking skills activities that begin with confrontation and end with problem solving according to problem conditions (Hanum et al., 2019). Problem solving learning requires students to understand the concept of the material being studied more specifically through a critical thinking process (Sani et al., 2020). In line with research by Rahmawati & Nasrudin (2016) which suggests that in learning problem solving students actively search, think critically, and act independently. One can describe the problem solving learning model as a collection of learning activities that emphasize the scientific problem solving process (Azizah & Nasrudin, 2022). There are four components in problem solving learning which include understanding the problem, making a solution plan, executing the solution plan, and re-examining the solution that has been done (Polya, 1973).

The problem solving learning model must be supported by appropriate teaching materials in order for the learning process to be effective and successful. Teaching materials are needed to help students understand the concepts of the subject matter they are studying (Ismathulhuda et al., 2022). The teaching material in question is the use of student worksheets. Research by Hidayati & Masril (2019) states that the non-optimal use of student worksheets results in constrained achievement of student competencies over the classroom's instructional and learning process. Student worksheets are printed teaching resources in the kind of paper sheets that contain information and questions related to a material that must be answered by students (Noprinda & Soleh, 2019). The importance of using student worksheets is that they can foster student activeness in learning activities, help students understand a concept or material, and can be used as a guide in learning activities (Rizki et al., 2021). The worksheets can be completed by students individually or in groups, and they can be utilized for observations both inside and outside of the classroom (Wazni & Fatmawati, 2022). Based on this description, the existence of problem solving oriented student worksheets is expected to train students' critical thinking skills.

Chemistry is one of the fields of study where requires the application of a problem-solving learning model to train students' critical thinking skills (Darwis et al., 2020). The chemistry topic in question is acid-base material. The concept of acid-base is chemical material related to everyday life and is one of the basic principles in chemistry lessons, which means that to learn other chemical materials, an understanding of the acid-base concept is needed first (Saputri & Laksono, 2023). Based on pre-research, 72% of students revealed that chemistry lessons are difficult to understand, especially in acid-base material. This is similar to the findings of the study conducted by Wulandari et al. (2018) which indicates that one of the challenging topics in chemistry courses is acid-base material because of its abstract concept, resulting in students having difficulty in understanding the material. In addition, Ekawisudawati et al. (2021) in their research also stated that acid-base is considered difficult material because it contains complex, interconnected material, requires calculations, and also requires a gradual and in-depth understanding of concepts. Critical thinking skills are thought to be essential to be implemented while studying acid-base material. Previous research states that in acid-base material can train critical thinking skills using teaching materials in the form of student worksheets (Yessi et al., 2019). In order to accomplish this goal, it is necessary to develop student worksheets with problem solving oriented to train students' critical thinking skills on acid-base material.

Method

The Research and Development (R&D) approach was used in this research which relates to (Sugiyono, 2017). The student worksheet developed was tried out to a limited trial to 22 students of class XI MIPA 13 SMAN 1 Sidoarjo. The instruments used in this research include the review sheet of the student worksheet, the validation sheet of the student worksheet, the students' response questionnaire, the students' activity observation sheet, and the pretest and posttest sheets of students' critical thinking skills. Further, the techniques employed in this study to gather data are questionnaire, observation, and test method. Meanwhile, the data sources in this research are comments and suggestions from chemistry lecturers and chemistry teachers as well as the results of pretest and posttest of students of class XI MIPA 13 SMAN 1 Sidoarjo as seen in Figure 1.

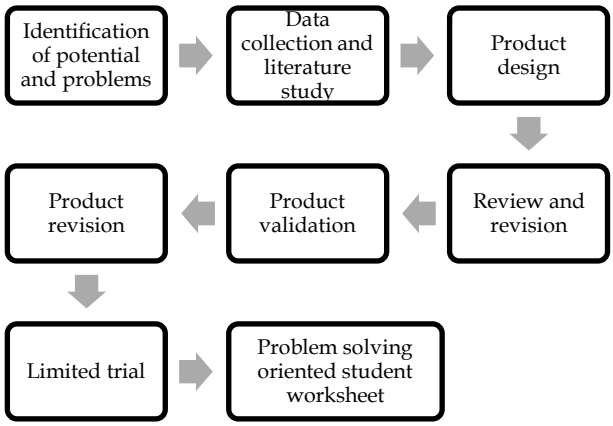

Figure 1. Research process

The review was carried out by the supervisor by providing suggestions for improving the student worksheet that had been developed through filling in the review sheet. After the improvement based on the suggestions from the reviewer was completed, the next step was the validation of the student worksheet by three validators consisting of two chemistry lecturers and one chemistry teacher. The validity criteria were reviewed based on Plomp & Nieveen (2013) which consists of content and construct validity which is compiled based on aspects of content, presentation, linguistic, and graphics. This is related to research by Azizah et al. (2020) which states that a teaching material can be said to be valid and very valid if there is a consistent relationship from each component of the teaching material developed.

The validators will give scores in the range of 1-5 on the validation sheet. The validation result data is in the form of an ordinal scale which can be analyzed by determining the mode on each aspect assessed with the following criteria, if the aspect assessed by the validator has a mode value ≥3, then the aspect is declared valid and if the aspect assessed by the validator has a mode value <3, then the aspect is declared invalid. Based on these value criteria, the student worksheet is declared valid if the aspects assessed by the validator have a mode value ≥3. If there are aspects that do not meet the valid requirements, they must be revised and validated again until they reach the specified criteria (Lutfi, 2021).

After the student worksheets developed were declared valid, the next step was design revision with the aim of improving and perfecting the student worksheets. The revised worksheet was then tried out to 22 students of class XI MIPA 13 SMAN 1 Sidoarjo. The trial was conducted using One Group Pretest Posttest Design, which is a design that contains a pretest before implementation and posttest after implementation in a group without a comparison class (Fraenkel et al., 2011). At the trial stage, the feasibility of the student worksheet was evaluated in light of its practicality and effectiveness.

Practicality in the development of student worksheets considers the outcomes of response questionnaires and student activity observations. The percentage of practicality results is retrieved based on the calculation with the Formula 1.

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

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

The percentage of practicality results obtained is interpreted according to the categories listed in table 1 (Riduwan, 2018).

Tabel 1. Value interpretation category

Percentage (%)	Category
0-20	Not practical
21-40	Less practical
41-60	Practical enough
61-80	Practical
81-100	Very practical

Based on the categories in Table 1, student worksheets with problem solving oriented can be said to be practical if the results of the practicality of students get a percentage of ≥61% which is described as practical or very practical (Riduwan, 2018).

The effectiveness of the student worksheet can be seen from the outcomes of pretest and posttest scores of critical thinking skills of each learner. Student worksheets can be declared effective if there is an increase in the score of student learning outcomes after

using student worksheets (Hidayati et al., 2019). The increase in critical thinking skills assessment results is known through the N-gain test. The normality of the data must be assessed before to the N-gain test with the Kolmogorov Smirnov test using SPSS. Data is said to be normal if it obtains a significant value >0.05 (Priyanto, 2012). For the descriptive analysis of N-gain, the following N-gain criteria were used are high N-gain, if $\langle g \rangle \geq 0.7$, medium N-gain, if $0.7 > \langle g \rangle \geq 0.3$, and low N-gain, if $\langle g \rangle < 0.3$ (Hake, 2002). Based on the N-gain value, the student worksheet with problem solving oriented is considered effective if each student obtains an n-gain rate in the medium or high category.

Result and Discussion

The test that has been carried out produces some data related to the feasibility of the developed Learner Worksheet, including validity, practicality and effectiveness.

Validity of student worksheets

The aim of validation is to ascertain the validators' evaluation consist of two lecturers and one chemistry teacher regarding the feasibility of the developed student worksheets. There are two criteria in the validity of the student worksheet which includes content and construct validity. The evaluation's findings related to the validity obtained from the validator are then interpreted in accordance with Table 1. Data related to the results of content validity are written in Table 2.

Table 2. Recap of content validity

Aspect Validity	Mode of Student Worksheet 1	Mode of Student Worksheet 2	Criteria
1	4	4	Valid
2	4	4	Valid
3	4	4	Valid
Final Mode	4	4	Valid

Content validity consists of three aspects which include the suitability of the phenomena presented with acid-base material, the suitability of the content of student worksheets with the syntax of the problem solving learning model and the suitability of the content of student worksheets with indicators of critical thinking skills. As may be observed from Table 2, the content validity of student worksheet 1 and student worksheet 2 each obtained a final mode value of 4 with valid criteria. The valid criteria are influenced by the comprehensive analysis that has been carried out in the potential and problem identification and data collection steps with the intention of gathering data that can support the preparation of the developed student worksheets.

The analysis in question includes curriculum and material analysis as well as the collection of literature studies related to the problem solving model and the skills trained. This is in line with one of the steps in preparing teaching materials by Depdiknas (2008), namely analysing learning resources that have a correlation with the material being taught. Another study by Fransisca (2017) also stated that a product can be said to be valid if the content validity has fulfilled several aspects which include curriculum suitability, material, and learning objectives.

Construct validity assesses several aspects including linguistic, presentation, and graphics. Data related to the results of construct validity by the three validators are written in Table 3 as follows.

Table 3. Recap of construct validity

Aspect Validity	Mode of Student Worksheet 1	Mode of Student Worksheet 2	Criteria
Linguistic	4	4	Valid
Presentation	4	4	Valid
Graphics	4	4	Valid
Final Mode	4	4	Valid

As may be observed from Table 3, the construct validity of student worksheet 1 and student worksheet 2 each obtained a final mode value of 4 with valid criteria. The valid criteria were influenced by the preparation of student worksheets which were adjusted to the guidelines for preparing student worksheets by Depdiknas (2008), where the development of teaching materials must pay attention to linguistic aspects which include the use of Indonesian according to linguistic rules, effective and efficient language use, clarity of information, and ease of readability. According to studies conducted by Munawaroh & Sholikhah (2022) that the application of appropriate language can facilitate students in understanding the material. The practicality criteria are also influenced by several aspects which include clarity of content and learning objectives to be achieved, ease of use, and attractiveness of student worksheets (Fahlevi et al., 2022). The statement is consistent with the findings of studies conducted by Rahmawati & Wulandari (2020) that learner worksheets with an attractive appearance motivate students to learn. In addition to the findings of studies by Aufa et al. (2021) which states that good learning media is media with an attractive appearance so that it can attract students to read it.

Based on the description above, the student worksheet developed can be declared valid because each criterion reviewed from content and construct validity gets a final mode value of 4 with valid criteria.

Practicality of student worksheets

Practicality criteria in the development of student worksheets are reviewed based on the results of response questionnaires and observations of student activities. Students' responses are in the form of a questionnaire containing 12 aspects of assessment consisting of 6 positive statements and 3 negative statements related to satisfaction while using the worksheet distributed after the posttest is completed. Meanwhile, the student activity observation is a research instrument that contains the observer's assessment of the dominant activity of students in a group, both relevant and irrelevant activities every 3 minutes. The activities on each student worksheet have been adjusted to the components in the problem solving learning model which include understanding the problem, planning problem solving, solving problems according to the plan, and re-examining the results that have been obtained, so that the activities observed include activities to identify problems, formulate problems and hypotheses, create a framework, design experimental procedures, conduct experiments, answer evaluation questions and formulate conclusions. The student worksheet developed can be declared practical if the results of the response questionnaire and observation of student activities obtain a percentage of ≥61% (Riduwan, 2018). Data related to the results of filling out the response questionnaire by students are written in Table 4 as follows.

Table 4. Outcomes from the student response questionnaire

Statement Type	Percentage (%)	Category
Positive	96.12	Very practical
Negative	89.48	Very practical
Average	92.80	Very practical

The conclusion obtained from Table 4 is that it can be seen that the student response questionnaire related to satisfaction with the use of student worksheets achieved a mean percentage of 92.80% with a very practical category. Therefore, the student worksheets with problem solving oriented to train students' critical thinking skills on acid-base material developed can be stated to have met the criteria of practicality. This is proved by study findings that indicate the learning media developed can be declared practical if the students' response questionnaire obtains practical criteria (Hamimi et al., 2018).

The acquisition of the findings of the student response questionnaire to state the practicality of the student worksheet is also supported by the analysis of the results of student activity observations. Data related to the results of the observation of students' activities are written in Table 5.

Table 5. Learner activity observation results

Types of Student Worksheets	Percentage of Relevant Activity	Percentage of Irrelevant Activities
Student Worksheet 1	95.55	4.45
Student Worksheet 2	96.12	3.88

Based on the data from the observation of students' activities displayed in Table 5, each activity observed by the observer in learning activities using student worksheets with problem solving oriented to train students' critical thinking skills on acid-base material obtained a percentage of relevant activities ≥61%. The first meeting obtained a percentage of relevant activities of 95.55% with irrelevant activities of 4.45%. Meanwhile, the second meeting obtained a percentage of relevant activities of 96.12% with a percentage of irrelevant activities of 3.88%. Overall, relevant activities at each meeting obtained a greater percentage than irrelevant activities. Then, the decrease in the percentage of irrelevant activities from the previous 4.45% on student worksheet 1 to 3.88% on student worksheet 2 proves that the activities carried out by students during the trial of student worksheets were well implemented. According to studies conducted by Armağan et al. (2009) which asserts that the problem solving learning approach can improve student cooperation.

Based on the description above, the student worksheet developed can be declared practical and has met the criteria for practicality because the findings of the response questionnaire and observation of student activity each obtained a percentage of ≥61% (Riduwan, 2018). This statement is reinforced by Irsalina & Dwiningsih (2018) which states that practicality is an aspect of feasibility testing which is reviewed based on the results of filling out response questionnaires and student activity observation sheets.

Effectiveness of student worksheets

The effectiveness of student worksheets with problem solving oriented to train students' critical thinking skills on acid-base material is apparent from the findings of pretest and posttest scores of critical thinking skills. The pretest was conducted to determine the critical thinking skills of students before learning activities began, whereas the purpose of the posttest was to assess students' critical thinking skills at the end of learning (Ilfiana et al., 2021).

The effectiveness test is carried out by giving 10 multiple choice questions whose preparation has been enhanced to reflect the critical thinking skills indicators that are trained to students. The critical thinking skills that are trained on this student worksheets are based on

the indicators of critical thinking skills as stated by Facione (2023), the indicators of critical thinking skills that are trained consist of interpretation, analysis, evaluation, and inference.

Each students' improved scores on the critical thinking skills test are determined by analyzing their pretest and posttest findings with the N-gain test. Before the N-gain test is carried out, the normality of the data must be assessed with the Kolmogorov Smirnov test using SPSS to ensure that the research data obtained is normally distributed or not. Data is stated to be normal if a significant value is obtained >0.05 (Priyanto, 2012). Data related to the normality test are written in Table 6.

Table 6. Normality test results on pretest and posttest values

Aspect	N	α	Asymp. Sig (2 tailed)	Criteria
Pretest	22	0.05	0.052	Normal
Posttest	22	0.05	0.376	Normal

Table 6 explains that the acquisition of Asymp. Sig (2 tailed) value on pretest and posttest >0.05, namely 0.052 on pretest and 0.376 on posttest. Therefore, the pretest and posttest results can be declared normally distributed which can then be tested using the N-gain test. Data related to the N-gain test is written in Table 7.

Table 7. Results of the N-Gain test for student

Name	Pretest Score	Posttest Score	N-gain	Criteria
AFBR	13.33	83.33	0.81	High
ANM	36.67	76.67	0.63	Medium
ADS	23.33	73.33	0.65	Medium
CAW	20.00	63.33	0.54	Medium
DRZ	26.67	93.33	0.91	High
DAK	26.67	83.33	0.77	High
ERR	43.33	83.33	0.71	High
HAM	13.33	73.33	0.69	Medium
KMU	13.33	70.00	0.65	Medium
LJP	16.67	76.67	0.72	High
MRA	43.33	86.67	0.76	High
MHAS	23.33	70.00	0.61	Medium
MSA	26.67	80.00	0.73	High
NEA	20.00	66.67	0.58	Medium
NR	20.00	63.33	0.54	Medium
NZA	20.00	80,00	0.75	High
RA	20.00	73.33	0.67	Medium
REP	46.67	90.00	0.81	High
SYP	26.67	90.00	0.86	High
SAS	30.00	93.33	0.90	High
TARH	23.33	73.33	0.65	Medium
ZQACA	10.00	86.67	0.85	High

Table 7 explains that the acquisition of the N-gain value of students is in the medium and high criteria. The results obtained show that the use of student worksheet with problem solving oriented has an effect on increasing pretest and posttest scores, so that student worksheets can be declared effective for training students' critical thinking skills. The statement is consistent with the findings of study by Rahmawati & Nasrudin (2016) which states that students' critical thinking skills have increased from before and after learning by using the problem solving learning approach with an N-gain score of 0.85 in the high category.

Based on the Tabel 7, the developed student worksheet can be declared feasible based on the effectiveness data of the student worksheet. Student worksheets are said to be effective if they obtain an N-gain value of $0.7 > g \geq 0.3$ with a medium category or $g \geq 0.7$ with a high category (Hake, 2002). In this study, the N-gain value was gained in the range of 0.54-0.91 with moderate to high criteria.

Conclusion

In light of the aforementioned research's findings, the validity of the student worksheets assessed based on content validity and construct validity each gained a mode value of 4 with valid criteria, the practicality of the student worksheets assessed based on student responses gained a percentage of 92.80% with very practical criteria, and the relevant activities of students in the first and second meetings each gained a percentage of 95.55% and 96.12%, and the last one is effectiveness of the student worksheets assessed based on pretest and posttest results of critical thinking skills tested with the N-gain test obtained the medium and high criteria. Therefore, it can be stated that the student worksheets with problem solving oriented is declared feasible and can be used in learning activities to train students' critical thinking skills on acid-base material.

Acknowledgments
The author would like to express gratitude to the students of class XI MIPA 13 at SMAN 1 Sidoarjo who were involved in the development of this student worksheets.

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

Funding
There was no outside support for this research.

Conflict of Interest
No conflicts of interest are disclosed by the authors.

References

Alberida, H., Sari, M., Razak, A., Syamsuriza, S., & Rahmi, Y. L. (2022). Problem Solving: A Learning Model to Foster Argumentation and Critical Thinking Ability for Students with Different Academic Abilities. *Jurnal Penelitian Pendidikan IPA*, *8*(3), 1393–1400. https://doi.org/10.29303/jppipa.v8i3.1208

Amijaya, L. S., Ramdani, A., & Merta, I. W. (2018). Pengaruh Model Pembelajaran Inkuiri Terbimbing Terhadap Hasil Belajar Dan Kemampuan Berpikir Kritis Peserta Didik. *Jurnal Pijar Mipa*, *13*(2), 94–99. https://doi.org/10.29303/jpm.v13i2.468

Armağan, F. Ö., Sağir, Ş. U., & Çelik, A. Y. (2009). The effects of students' problem solving skills on their understanding of chemical rate and their achievement on this issue. *Procedia - Social and Behavioral Sciences*, *1*(1), 2678–2684. https://doi.org/10.1016/j.sbspro.2009.01.473

Asma, R., Asrial, & Maison. (2020). Development of Interactive Electronic Student Worksheets on Electromagnetic Induction Based on Scientific Approaches. *Jurnal Penelitian Pendidikan IPA*, *6*(2), 136–143. https://doi.org/10.29303/jppipa.v6i2.387

Aufa, M. N., Rusmansyah, R., Hasbie, M., Jaidie, A., & Yunita, A. (2021). The Effect of Using e-module Model Problem Based Learning (PBL) Based on Wetland Environment on Critical Thinking Skills and Environmental Care Attitudes. *Jurnal Penelitian Pendidikan IPA*, *7*(3), 401–407. https://doi.org/10.29303/jppipa.v7i3.732

Azizah, U., & Nasrudin, H. (2022). Problem Solving Thinking Skills: Effectiveness of Problem-Solving Model in Teaching Chemistry College Students. *Jurnal Penelitian Pendidikan IPA*, *8*(3), 1462–1469. https://doi.org/10.29303/jppipa.v8i3.1700

Azizah, U., Nasrudin, H., & Mitarlis. (2020). The Validity of Problem-Solving Based Teaching Materials for The Exploration of Conceptual Change and Metacognitive Skills. *Proceedings of the 7th Mathematics, Science, and Computer Science Education International Seminar, MSCEIS 2019*. https://doi.org/10.4108/eai.12-10-2019.2296377

Darwis, D., Latif, M., & Rahman, A. (2020). Pengaruh Penerapan Model Blended-Problem Based Learning terhadap Kemampuan Berpikir Kritis Peserta Didik pada Materi Asam dan Basa. *Jurnal Riset Pendidikan Kimia*, *10*(2), 79–87. https://doi.org/https://doi.org/10.21009/JRPK.102.03

Depdiknas. (2008). *Panduan Pengembangan Bahan Ajar*. Jakarta: Depdiknas.

Ekawisudawati, E., Wijaya, M., & Danial, M. (2021). Analisis Miskonsepsi Peserta Didik pada Materi Asam Basa Menggunakan Instrumen Three-Tier Diagnostic Test. *Chemistry Education Review (CER)*, *5*(1), 62. https://doi.org/10.26858/cer.v5i1.26359

Facione, P. A. (2023). Critical Thinking : What It Is and Why It Counts. *Insight Assessment*, *1*(1), 1–28. https://insightassessment.com/wp-content/uploads/2023/12/Critical-Thinking-What-It-Is-and-Why-It-Counts.pdf

Fahlevi, A., Dewi, A. N., & Sari, F. P. (2022). *Development of Electronic Student Worksheet Based on Guided Inquiry on The Topic of Photosynthesis*. *8*(3). https://doi.org/10.29303/jppipa.v8i3.1674

Fara, U., Noer, H., & Rasidin, U. (2019). Pengembangan Lkpd Berbasis Inkuiri Terbimbing Untuk Meningkatkan Kemampuan Komunikasi Matematis Siswa. *JPPM (Jurnal Penelitian Dan Pembelajaran Matematika)*, *12*(2), 242–253. http://dx.doi.org/10.30870/jppm.v12i2.6160

Fraenkel, J. R., Wallen, N. E., & Hyun, H. (2011). *How to Design and Evaluate Research in Education* (8a ed.). New York: McGraw-Hill Education.

Fransisca, M. (2017). Pengujian Validitas, Praktikalitas, dan Efektivitas Media E-Learning di Sekolah Menengah Kejuruan. *VOLT : Jurnal Ilmiah Pendidikan Teknik Elektro*, *2*(1), 17. https://doi.org/10.30870/volt.v2i1.1091

Hake, R. (2002). *Analyzing Change/Gain Score*. USA: Indiana University.

Hamimi, L., Ikhsan, M., & Abidin, Z. (2018). Pengembangan Perangkat Pembelajaran Pembuktian Menggunakan Model Pembelajaran Guided Inquiry untuk Meningkatkan Kemampuan Geometri Siswa Sekolah Menengah Atas. *Jurnal Didaktik Matematika*, *5*(1), 16–26. https://doi.org/10.24815/jdm.v5i1.10124

Hanum, A., Azizah, U., & Cahyaningrum, S. E. (2019). Training Students' Critical Thinking Skills Through Implementation of Problem Solving Models On Reaction Rate Materials. *International Journal of Scientific and Research Publications*, *9*(11), 369–373. https://doi.org/10.29322/IJSRP.9.11.2019.p9543

Hidayati, & Masril. (2019). Penggunaan LKM untuk Menunjang Kegiatan Laboratorium Virtual Fisika Inti. *Jurnal Penelitian Pendidikan IPA*, *5*(2), 149–153. https://doi.org/10.29303/jppipa.v5i2.250

Hidayati, Masril, Darvina, Y., & Zakiya, Z. (2019). Efektivitas Lembar Kerja Siswa Virtual Laboratory pada Materi Gerak Lengkung di Kelas X SMAN. *Jurnal Eksakta Pendidikan (JEP)*, *3*(1), 47–54. https://doi.org/https://doi.org/10.24036/jep/vol3-iss1/320

Husamah, Fatmawati, D., & Setyawan, D. (2018). OIDDE learning model: Improving higher order thinking skills of biology teacher candidates. *International Journal of Instruction*, *11*(2), 249–264. https://doi.org/10.12973/iji.2018.11217a

Ilfiana, A., Widodo, W., & Setiarso, P. (2021). The Improvement of Student's Critical Thinking Skills Through the Development of Science Learning Material Based Socioscientific Issues with Interactive Multimedia-Assisted on Gadget. *Jurnal Penelitian Pendidikan IPA*, *7*(4), 496–501. https://doi.org/10.29303/jppipa.v7i4.764

Irsalina, A., & Dwiningsih, K. (2018). Analisis Kepraktisan Pengembangan Lembar Kegiatan Peserta Didik (LKPD) Berorientasi Blended Learning pada Materi Asam Basa. *Jurnal Kimia Dan Pendidikan Kimia (JKPK)*, *3*(3), 171–182. https://doi.org/10.20961/jkpk.v3i3.25648

Ismathulhuda, A., Hardeli, H., Alizar, A., & Yerimadesi, Y. (2022). Validity and Practicality of Project-Based e-Student Worksheet on Thermochemical Materials to Improve Learning Outcomes. *Jurnal Penelitian Pendidikan IPA*, *8*(3), 1433–1441. https://doi.org/10.29303/jppipa.v8i3.1691

Kaliky, S., & Juhaevah, F. (2018). Analisis Kemampuan Berpikir Kritis Siswa Kelas X SMA dalam Menyelesaikan Masalah Identitas Trigonometri Ditinjau dari Gender. *Jurnal Matematika Dan Pembelajaran*, *6*(2), 111. https://doi.org/10.33477/mp.v6i2.663

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

Munawaroh, N., & Sholikhah, N. (2022). Pengembangan LKPD Berbasis Problem Based Learning Melalui Video Interaktif Berbantuan Google Site Untuk Menstimulasi Kemampuan Berpikir Kritis. *Jurnal Ecogen Universitas Negeri Padang*, *5*(2), 167–182. https://doi.org/https://doi.org/10.24036/jmpe.v5i2.12860

Narmaditya, B. S., Wulandari, D., & Sakarji, S. R. B. (2018). Does problem-based learning improve critical thinking skills? *Jurnal Cakrawala Pendidikan*, *37*(3), 568–572. https://doi.org/10.21831/cp.v38i3.21548

Noprinda, C. T., & Soleh, S. M. (2019). Pengembangan Lembar Kerja Peserta Didik (LKPD) Berbasis Higher Order Thinking Skill (HOTS). *Indonesian Journal of Science and Mathematics Education*, *2*(2), 168–176. https://doi.org/10.24042/ijsme.v2i2.4342

Plomp, T., & Nieveen, N. (2013). *Educational Design Research - Part A: An Introduction*. Netherlands: Netherlands Institute for Curriculum Development.

Polya, G. (1973). *How to Solve It: A New Aspect of Mathematical Method* (2nd ed). Princeton, New Jersey: Princeton University Press.

Priyanto, D. (2012). *Cara kilat belajar analisis data dengan SPSS 20* (ED.1). Yogyakarta: C.V Andi Offset.

Rahmawati, D., & Nasrudin, H. (2016). Implementation of Problem Solving Learning Model to Train Critical Learning Skill on Electrolyte and Non Electrolyte Solution Matrial at X Grade SMAN 12 Surabaya. *UNESA Journal of Chemical Education*, *5*(2), 286–294. Retrieved from https://ejournal.unesa.ac.id/index.php/journal-of-chemical-education/article/view/15781

Rahmawati, L. H., & Wulandari, S. S. (2020). Pengembangan Lembar Kegiatan Peserta Didik (LKPD) Berbasis Scientific Approach Pada Mata Pelajaran Administrasi Umum Semester Genap Kelas X OTKP di SMK Negeri 1 Jombang. *Jurnal Pendidikan Administrasi Perkantoran (JPAP)*, *8*(3), 504–515. https://doi.org/10.26740/jpap.v8n3.p504-515

Riduwan. (2018). *Skala Pengukuran Variabel-variabel Penelitian*. Bandung: Alfabeta.

Rizki, A., Khaldun, I., & Pada, A. U. T. (2021). Development of Discovery Learning Student Worksheets to Improve Students' Critical Thinking Skills in Chemical Balance Materials. *Jurnal Penelitian Pendidikan IPA*, *7*(4), 707–711. https://doi.org/10.29303/jppipa.v7i4.829

Rosidin, U., Kadaritna, N., & Hasnunidah, N. (2019). Can argument-driven inquiry models have impact on critical thinking skills for students with differentpersonality types? *Jurnal Cakrawala Pendidikan*, *38*(3), 511–526. https://doi.org/10.21831/cp.v38i3.24725

Sani, I. N., Bahar, A., & Elvinawati, E. (2020). Perbandingan Model Pembelajaran Problem Solving Dan Problem Based Learning Terhadap Kemampuan Berpikir Kritis Siswa Kelas Xi Mia Man 2 Kota Bengkulu. *Alotrop, Jurnal Pendidikan Dan Ilmu Kimiaan Ilmu Kimia*, *4*(2), 107–116. https://doi.org/https://doi.org/10.33369/atp.v4i2.13834

Saputri, A. C., Sajidan, Rinanto, Y., Afandi, & Prasetyanti, N. M. (2019). Improving students' critical thinking skills in cell-metabolism learning using Stimulating Higher Order Thinking Skills model. *International Journal of Instruction*, *12*(1), 327–342. https://doi.org/10.29333/iji.2019.12122a

Saputri, F., & Laksono, E. W. (2023). Pengembangan LKPD Berbasis Literasi Konten Kearifan Lokal pada Materi Asam dan Basa. *Jurnal Pendidikan Matematika Dan Sains*, *11*(1), 48–54. https://doi.org/https://doi.org/10.21831/jpms.v

11i1.49875
Sugiyono. (2017). *Statistika untuk Penelitian*. Bandung: Alfabeta.
Swart, R. (2017). Purposeful Use of Technology to Support Critical Thinking. *JOJ Nursing & Health Care*, *4*(1). https://doi.org/10.19080/jojnhc.2017.04.555626
Triyanto, S. A., Prayitno, B. A., & Probosari, R. M. (2014). Penerapan Model Pembelajaran Blended-Problem Solving melalui Aplikasi Moodle untuk Meningkatkan Kemampuan Berpikir Kreatif Kelas XI IPA 4 SMA N 3 Surakata Tahun Pelajaran 2012/2013. *Bio-Pedagogi*, *3*(1), 99. https://doi.org/10.20961/bio-pedagogi.v3i1.5326
Vong, S. A., & Kaewurai, W. (2017). Instructional model development to enhance critical thinking and critical thinking teaching ability of trainee students at regional teaching training center in Takeo province, Cambodia. *Kasetsart Journal of Social Sciences*, *38*(1), 88–95. https://doi.org/10.1016/j.kjss.2016.05.002
Wazni, M. K., & Fatmawati, B. (2022). Study of Science Process Skills Student Using Worksheet based on Science Process Skills. *Jurnal Penelitian Pendidikan IPA*, *8*(2), 436–443. https://doi.org/10.29303/jppipa.v8i2.1281
Widyastuti, S. (2018). Fostering critical thinking skills through argumentative writing. *Jurnal Cakrawala Pendidikan*, *37*(2), 182–189. https://doi.org/10.21831/cp.v37i2.20157
Wulandari, C., Susilaningsih, E., & Kasmui. (2018). Estimasi Validitas dan Respon Siswa Terhadap Bahan Ajar Multi Representasi: Definitif, Makroskopis, Miksroskopis, Simbolik pada Materi Asam Basa. *Jurnal Phenomenon*, *08*(2), 165–174. https://doi.org/10.21580/phen.2018.8.2.2498
Yessi, M., Sudyana, I. N., & Fatah, A. H. (2019). Pembelajaran Asam Basa Menggunakan LKS Berbasis Learning Cycle 7E untuk Meningkatkan Penguasaan Konsep dan Keterampilan Berpikir Kritis Siswa SMA. *QUANTUM: Jurnal Inovasi Pendidikan Sains*, *10*(1), 27–37. https://doi.org/http://dx.doi.org/10.20527/quantum.v10i1.5687