Vol.12 (2), 2023, 200-205 DOI: 10.23960/jppk.v12.i2.2023.20
Jurnal Pendidikan dan Pembelajaran Kimia
e-ISSN: 2714-9595| p-ISSN 2302-1772
http://jurnal.fkip.unila.ac.id/index.php/JPK/index

Validity of Project-Based Learning-Based Worksheets to Improve Critical Thinking Skills on Acid-Base Material

Adella Icha Ardhani[1], Bertha Yonata[2] *

Chemistry Education, Faculty of Mathematics and Natural Sciences, Universitas Negeri Surabaya, Jl. Ketintang, Ketintang, Kec. Gayungan, Kota Surabaya, Jawa Timur 60231, Indonesia.

Email: adellaicha2001@gmail.com
*Correspondinge-mail: berthayonata@unesa.ac.id

Received: June 23th, 2023 Accepted: July 14th, 2023 Online Published: August 2nd, 2023

Abstract: Validity of Project-Based Learning-Based Worksheets to Improve Critical Thinking Skills on Acid-Base Material. This study aims to obtain the validity of the content and construct validity of project-based learning-based student worksheet to improve students' critical thinking skills on acid-base material. According to Facione, the components of critical thinking skills used include indicators of interpretation, analysis, and inference. student worksheet development research refers to the 4-D development method, which is limited only to the development stage. In this study, content and construct validation sheet instruments were assessed by five validators. From this research instrument, content validation results were obtained using the Aiken validity coefficient (V). The content validation results get a rater rating range of 0.85–1.00 (very valid). While the construct validation results get a median value in the range of 3–4. *Based on these results, student worksheet is declared valid in terms of content and construct so that it can be tested with students.*

Keywords: Student Worksheets, PjBL, critical thinking skills

Abstrak: Validitas LKPD berbasis Project Based Learning untuk Meningkatkan Keterampilan Berpikir Kritis Pada Materi Asam Basa. *Penelitian bertujuan mendapatkan validitas isi dan validitas konstruk LKPD berbasis Project Based Learning untuk Meningkatkan Keterampilan Berpikir Kritis Pada Materi Asam Basa. Komponen keterampilan berpikir kritis yang digunakan yakni menurut Facione meliputi indikator interpretasi, analisis, dan inferensi. Penelitian ini menggunakan metode pengembangan 4-D. Dalam peneltian ini, menggunakan instrumen lembar validasi isi dan konstruk yang dinilai 5 validator. Dari instrumen tersebut didapatkan hasil validasi isi dengan menggunakan koefisien validitas Aiken (V). Hasil validasi isi mendapatkan rentang penilaian rater 0,85 – 1,00 (sangat valid). Sedangkan hasil validasi konstruk mendapat nilai median pada rentang 3–4. Berdasarkan hasil ini, LKPD dinyatakan valid dari segi isi dan konstruk menurut penilaian rater sehingga dapat diuji cobakan ke peserta didik.*

Kata kunci: *LKPD, PjBL, keterampilan berpikir kritis*

▪ INTRODUCTION

Chemistry investigates the rational and empirical structure of matter as well as the significant changes that occur in planned experiments and natural processes (Keenan & Wood, 1966). The three main components of chemistry are product, process, and scientific attitude. As a scientific product, chemistry includes all facts, concepts, principles, theories, and laws (Carin, 1997). In addition, as a scientific process, chemistry includes students' ways of thinking, attitudes, and scientific activities to obtain chemical products (Kemendikbud, 2014). The scientific attitude in chemistry is open, tenacious, not quickly discouraged, honest, and critical of scientific statements (Kemendikbud, 2013). One of the materials studied in chemistry is acid and base. Acid-base material, especially the acid-base indicator sub-material, is one of the materials that includes theories that can be proven by experiments. In conducting experiments, students will go through a critical thinking process where they must be able to relate theory to fact. Students are required to be able to interpret observational data, analyze data, and conclude experimental results.

Developing the ability to think critically is one of the goals of the study of chemistry. It is mainly used to examine various scientific conclusions and evaluate various worldly phenomena (Kemendikbudristek, 2022). Thus, P21 (*Partnership for 21st Century Learning*) describes a 21st century learning framework that requires students to have the 4Cs: Creativity, Critical Thinking, Communication, and Collaboration (Sutarno et al., 2018). In addition, the Ministry of Education states that 21st century learning will emphasize students' ability to use various resources to solve problems, formulate problems, think analytically, work together, and solve problems (Kemendikbud, 2013). As a result, critical thinking is a very important skill in the 21st century. Therefore, it is hoped that the discipline of chemistry can help improve this ability (Kemendikbudristek, 2022). According to Facione (2015), interpretation, inference, analysis, explanation, evaluation, and self-regulation are traits of critical thinking skills (Facione, 2015). It is a measure of critical thinking ability that consists of three main elements of chemistry: product, process, and scientific attitude. In chemistry, one must have the ability to apply analytical, interpretive, and inference skills to the activity of the process. If one can apply analytical, interpretive, and inference skills in his process activities, the resulting product is considered valid because it has gone through a critical thinking process.

So far, students' critical thinking skills are known to be relatively low, as seen from the results of the 2018 Programme for International Student Assessment (PISA). Based on the survey data, it is known that in the category of mathematical ability, Indonesia is in 79th place, and in the category of science ability, it is in 69th place (OECD, 2019). The results of previous studies also stated that students' critical thinking skills were still relatively low; the test results showed only 1 student completed out of 15 students who took the critical thinking skills test (Wulandari & Novita, 2018).

This is supported by the results of a pre-research questionnaire conducted in public high schools in Surabaya in February 2023 showed that 79.41% of students use student worksheets as an exercise in questions and tasks. The student was not involved in critical thinking skills, on the other hand, student worksheets should be used to train critical thinking skills. This is not in line with expectations that Learner Worksheets will teach skills such as critical thinking, which are essential for today's life (Wulandari & Novita, 2018). In addition, 82.35% of students said that chemistry learning in class often uses the lecture method, so students only focus on what the teacher says and then record it. This causes students' ability to think critically to be honed (Raenovta &; Suyanti, 2016). The average results obtained from the pre-research test were 46% interpretation indicators, 37% analysis, and 34% inference, indicating low learner skills. Thus, the demands of the 21st century have not been met.

Improving critical thinking skills can be done through learning media or simple learning resources, one of which is Student Worksheets. Student Worksheets are printed teaching materials that contain a summary of the material and directions for completing learning tasks that refer to the basic competencies that must be achieved. Student Worksheets are one of the media that can be used as a guide for students' investigations or problem solving (Trianto, 2012). Student Worksheets can be a study guide and make it easier for teachers and students during teaching and learning activities (Prastowo, 2011).

Improving critical thinking skills can be done through Student Worksheets as a learning support (Ismaimuza, 2013). Previous research has shown critical thinking skills improve with the use of valid learner worksheets (Mahmudah & Yonata, 2020). In addition, another study stated that student worksheets were declared effective for improving critical thinking skills (Sari & Nasrudin, 2022). The fact that critical thinking skills are not involved in learning media such as Student Worksheets is a weakness. Therefore, Student Worksheets must be developed that can improve students' critical thinking skills. One of the learning models that can be used as a basis for compiling Student worksheets This is since *PjBL* helps students learn to think critically (Puspitasari & Wulandari, 2022).

PjBL learning helps learners understand concepts, think critically, and work actively and collaboratively. With project-based learning, learners undertake long-term inquiry to answer challenging questions and build skills necessary for today's life (Education, 2010). *Project-Based Learning* (*PjBL*)-based Student Worksheets require students to think, find information, and use reasoning to understand the information. This research is supported by previous research where the *PjBL* learning model in class XII MIPA 5 SMA Negeri 1 Kendal improved critical thinking skills with a percentage of influence of 44.89%. Other studies have also shown that *PjBL-Based* Student Worksheets can improve critical thinking skills based on the improvement of learning outcomes with moderate improvement criteria (Wulandari et al., 2022).

The work and Didik developed are based on the *PjBL* learning model by involving projects in the learning process. This learning can help learners understand concepts, think critically, and work actively by conducting long-term investigations to answer difficult questions, building skills necessary in this century (Education, 2010). Critical thinking skills can be developed through chemistry learning, one of which is the acid-base sub-indicator (Kemendikbudristek, 2022).

Based on the description that has been given, the purpose of this study is to produce *PjBL-based* Student Worksheets on valid acid-base material. This Student Worksheet is expected to be a supporting medium that can hone and improve students' critical thinking skills.

▪ METHOD

This research uses Thiagarajan's (1974) 4-D development model, which aims to produce viable products. This model has four steps: defining, designing, developing, and dessiminate. This development is limited only to the development step because this research was carried out only to determine the feasibility of the worksheets the students developed (Ibrahim, 2014). This research was conducted at Surabaya State University in 2023 at the stage of *defining*, *designing*, and *developing* expert validation sections.

The first step of this research is a definition that is useful for determining the learning objectives to be achieved and consists of five steps. First, analyze the front end to find out the basic problem at hand. Second, analyze students to determine their academic abilities and knowledge development. Third, task analysis is a design used to determine the material lesson. Fourth, concept analysis to find out the concepts of matter. Fifth, analyze learning objectives to create goals that must be achieved by learners.

The next step, the design, consists of reviewing the curriculum to compile Student Worksheets, then choosing the format and design of the Student Worksheet device, which includes the cover, part of the content of the student worksheet, critical thinking skills components contained in the Student Worksheet, a material summary, and PjBL model syntax.

In the development stage, Student Worksheets are reviewed by chemistry lecturers using a study sheet that contains the suitability of aspects of Student Worksheets with learning models and indicators of critical thinking skills, which are then revised according to the suggestions given. Then, the Student Worksheet is validated by five validators by providing assessment scores in the range 0-4. Once validated, the data is analyzed using the Aiken validity coefficient (V) and median to determine their validity.

Research Instruments

This research instrument consists of a student worksheet study sheet and a student worksheet validation sheet. Sheets containing evaluation components include content feasibility, language, presentation, graphics, suitability of *the project-based learning* model, and conformity with critical thinking skills components.

Data Collecting Techniques

This research data was obtained through the validity assessment method.

Data Analysis Techniques

The Aiken validity coefficient (V) is used to evaluate the validity of the content of student worksheets. This coefficient is based on the results of an expert's assessment by several people of an item about the extent to which the item represents the measured content. Each validator will score each aspect on a scale in Table 1.

Table 1. Item assessment criteria for student worksheet validation

Score	Kategory
0	Very invalid (VI)
1	Invalid (I)
2	Quite valid (QV)
3	Valid (V)
4	Very valid (VV)

The scores of the assessment results from all validators are then calculated using the following Aiken (V) validity coefficient formula.

$$V = \frac{\sum s}{[n\ (c\ -\ 0)\ ]}$$

(Aiken adaptation, 1985)

Information:
s = r - lo
r = sum of scores from raters
lo = lowest validity score
c = highest validity score
n = number of appraisers

Then the data is interpreted as in the table.

Table 2. Interpretation of the Aiken coefficient of validity

Interval V	Criterion
V>0.8	High Validity (HV)
0.4<V≤ 0.8	Medium Validity (MV)
0.4≤V	Low Validity (LV)

(Retnawati, 2016).

Student worksheets are declared to meet the criteria if the validity coefficient of Aiken V > 0.4 with a predicate of medium validity or high validity, so that student worksheet is declared suitable for use.

While the construct identification of student worksheets is obtained from the median of expert assessment data, which is analyzed quantitatively using median statistics (Haladyna & Rodriguez, 2013). Next, the median result is shown in Table 3.

Table 3. Median Results Interpretation Criteria

Score Range	Kategory
0 – 0,9	Very invalid (VI)
1,0 – 1,9	Invalid (I)
2,0 – 2,9	Quite valid (QV)
3,0 – 3,9	Valid (V)
4	Very valid (VV)

(Riduwan adaptation, 2015)

The worksheets that students developed are said to meet the criteria if the median value is in the range of 3 (valid) and 4 (very valid), so that the Student Worksheets are declared suitable for use.

▪ RESULT AND DISCUSSION

The validation results of the developed Student Worksheets were analyzed using the Aiken validity coefficient (V) for content validation and the median for construct validation.

Table 4. Content Validation Results Data

Aspects	Aiken coefficient of validity (V)		Criterion
	student worksheet 1	student worksheet 2	
Suitability of student worksheet to the material	1.00	0.95 – 1.00	HV
Compatibility of the material with PjBL components	0.95 – 1.00	0.95 – 1.00	HV
Compatibility of student worksheet with PjBL model	1.00	1.00	HV
Compatibility of student worksheet with aspects of critical thinking skills	0.85 – 0.90	0.95 – 1.00	HV

Aspects	Aiken coefficient of validity (V)		Criterion
	student worksheet 1	student worksheet 2	
Compatibility of PjBL components with aspects of critical thinking skills	1.00	0.95 – 1.00	HV

Based on the data presented in Table 4, the validity of the content is reviewed in five aspects. First, the suitability of student worksheets with the material includes learning outcomes and learning objectives. In worksheet 1, students get an Aiken validity coefficient of 1.00, and in worksheet 2, students get an Aiken validity coefficient of 0.95–1.00, including high validity criteria. These results show that the worksheets of students have met the suitability criteria where the preparation is based on the curriculum used and the independent curriculum learning is based on the project. In addition, the aspects listed are in accordance with the learning objectives to be achieved, where learners must be able to determine, analyze, and conclude.

Second, the compatibility of the material with the PjBL component includes aspects of the suitability of the student worksheet material with the PjBL learning model and the suitability of the student worksheet material with the *PjBL* project. Based on Table 4, the validity coefficient of Aiken obtained for student worksheet 1 and 2 is 0.95–1.00, including high validity criteria. This indicates that the *PjBL* model is appropriate and can be applied to the selected material. This compatibility is reflected in the section on phenomena related to acid-base matter in life. In this section, learners are asked to determine how to identify solution properties using artificial acid-base indicators as project 1 in poster form and natural acid-base indicators as project 2. It can make learners go through the process of inquiry, respond to questions about complex problems or challenges, and practice skills demanded in the 21st century (Education, 2010). Projects in the form of posters and products are chosen because, to make a poster and choose product packaging, students go through a critical thinking process. Students must identify the selection of design, layout, and way of presentation and conclude the content that must be listed on the poster before making the poster. This is in accordance with previous research, which also used posters as the final project (Insyasiska, 2015).

Third, the compatibility of student worksheets with the *PjBL* model includes aspects of PjBL syntax and the presentation of *Pj*BL syntax in order. Based on the data presented in Table 4, in worksheets 1 and 2, students 1 and 2 get an Aiken validity coefficient of 0.95–1.00, including high validity criteria. This result shows that the *PjBL* syntax contained in the student worksheet has met the correct sort criteria. The PjBL syntax must be presented in order because the preparation of this student worksheet is indeed based on the PjBL pattern, so it must be validated for suitability. *PjBL* syntax can make students more actively participate in the learning process and encourage them to build their own knowledge. This is in accordance with constructivism theory, namely that people will actively build their knowledge based on their own experience (Nurlina et al., 2021). Project-based learning is one of the learning methods that involves students independently in the learning process. Previous research has shown that the *PjBL* model can increase student activity in learning (Saputri et al., 2020).

Fourth, the compatibility of student worksheets with aspects of critical thinking skills on Student Worksheet 1 gets an Aiken validity coefficient of 0.85–0.90, and on Student Worksheet 2, it gets an Aiken validity coefficient with a range of 0.95–1.00, including high validity criteria. These results show that critical thinking skills are contained in the student worksheet. The critical thinking skills component used is a component according to Facione Yakni's interpretation, analysis, and inference (Facione, 2015). These three components must be reflected because the purpose of compiling this Student Worksheet is to improve critical

thinking skills. With the inclusion of these components in these two activities, it can facilitate students honed skills so that they can improve over time.

Fifth, the compatibility of the *PjBL* component with aspects of critical thinking skills of the material on Student Worksheet 1 gets an Aiken validity coefficient of 1.00, and Student Worksheet 2 gets an Aiken validity coefficient with a range of 0.95–1.00, including high validity criteria. The interpretation component is at the stage of project implementation and determining fundamental questions so that students can be trained in their skills by interpreting the experimental data obtained and interpreting the phenomena presented. For the analysis component, it is at the project implementation stage, namely after getting observational data, so that students are trained in their skills by relating the facts and data obtained with theory. While component inference is at the project implementation stage after data analysis is completed, the ability to draw conclusions from the results of the analysis can be trained. With the inclusion of this critical thinking skills component, it is hoped that students can be facilitated in honing their skills. Previous research showed that the *PjBL* model had a positive effect with a percentage of 44.99% on critical thinking skills (Zahroh, 2020).

The results of construct validation include three aspects, namely linguistic criteria, presentation criteria, and graphic criteria, as in Table 5.

Table 5. Construct Validation Results Data

Aspects	Median		category
	student worksheet activity 1	student worksheet activity 2	
Language	4	4	VV
Presentation	4	4	VV
Graphic	4	4	VV

Based on Table 5, the suitability of the work with linguistic criteria is a very valid criterion with a median value of 4. This shows that the work being developed is clear and concise, and there are no sentences that have double meaning, so students can easily understand the content of this student worksheet. The suitability of the work and the presentation criteria get a very valid score with a median value of 4. This result shows that the components listed are complete, the *cover* is made to reflect the contents, and a place to write answers is available with sufficient size. Furthermore, the suitability of the work based on graphic criteria is a very valid criterion with a median value of 4. Because the image illustrations, *cover* designs, and print quality used make students interested in reading it, it is expected to strengthen student understanding.

Based on the data presented in Tables 4 and 5, the results of the validation of the contents and constructs of the work envelope based on project-based learning can be declared very valid.

▪ CONCLUSION

The validity of the worksheets of students is declared very valid in the content and construct aspects, which have an Aiken validity coefficient > 0.8 and a median of 3 (valid) and 4 (very valid). This shows that project-based learning-based worksheets can be tested on students so that they are expected to improve critical thinking skills and will become innovations that can improve students' skills so that they are useful in everyday life.

▪ REFERENCES

Aiken. (1985). Three coefficients for analyzing the reliability and validity of ratings, Educational and Psychological Measurument. *Journal Articles; Reports - Research;*

Numerical/Quantitative Data, *45*(1), 131–142.
Carin, A. A. (1997). *Teaching Science Through Discovery Eighth Edition*. Upper Saddle River: Prentice-Hall, Inc.
Education, B. I. for. (2010). *What is Project Based Learning.* http://bie.org/
Facione, P. A. (2015). *Critical Thingking: What It Is and Why It Counts*. Millbrae California: Measured Reasons LLC.
Haladyna, T. M., & Rodriguez, M. C. (2013). *Developing and validating test items*. New York: Routledge. https://doi.org/10.4324/9780203850381
Ibrahim, M. (2014). *Model Pengembangan Perangkat Pembelajaran menurut Jerold E. Kemp & Thiagarajan*. Surabaya: PSMS PSS Unesa.
Insyasiska, D. (2015). Pengaruh Project Based Learning Terhadap Motivasi Belajar, Kreativitas, Kemampuan Berpikir Kritis, Dan Kemampuan Kognitif Siswa Pada Pembelajaran Biologi. *Jurnal Pendidikan Biologi*, *Vol 7*.
Ismaimuza, D. (2013). *Pengembangan Kemampuan Berpikir Kritis Matematis untuk SMP*. Prosiding Seminar Nasional Sains dan Matematika Jurusan Pendidika MIPA FKIP UNTAD, Palu.
Keenan & Wood, J. H. (1966). *General Collage Chemistry 3rd editions*. New York: Harper& Row Inc.
Kemendikbud. (2013). *Peraturan Menteri Pendidikan dan Kebudayaan Republik Indonesia Nomor 54 Tahun 2013 tentang Standar Kompetensi Lulusan.* Jakarta: Kementrian Pendidikan dan Kebudayaan Republik Indonesia. http://direktori.madrasah.kemenag.go.id/media/files/Permendikbud54TH2013.pdf
Kemendikbud. (2014). *Permendikbud No. 59 tahun 2014 Lampiran III, PMP Mata Pelajaran* Kimia *SMA*. Jakarta: Kementrian Pendidikan dan Kebudayaan Republik Indonesia.
Kemendikbudristek. (2022). *Kepmendikbudristek No. 33 tahun 2022 lampiran II, CAPAIAN PEMBELAJARAN PADA PENDIDIKAN ANAK USIA DINI, JENJANG PENDIDIKAN DASAR, DAN JENJANG PENDIDIKAN MENENGAH PADA KURIKULUM MERDEKA*. Jakarta: Kementrian Pendidikan dan Kebudayaan Republik Indonesia.
Mahmudah, K. A., & Yonata, B. (2020). Development of Student Worksheet Based on Inquiry and Internet Assisted Learning to Practice Critical Thinking Skills in Submateries of Reaction Rates. *Jurnal Pendidikan Dan Pembelajaran Kimia*, *9*(3), 55–66. https://doi.org/10.23960/jppk.v9.i3.202006
Nurlina, Nurfadilah, & Bahri, A. (2021). *TEORI BELAJAR DAN PEMBELAJARAN*. Makasar : LPP UNISMUH MAKASSAR.
OECD. (2019). *PISA 2018 Result Combined Executive Summaries*. PISAOECD Publishing.
Prastowo, A. (2011). *Panduan Kreatif Membuat Bahan Ajar Inovatif: Menciptakan Metode Pembelajaran yang Menarik dan Menyenangkan*. Yogyakarta : Diva Press.
Puspitasari, R. O., & Wulandari, S. S. (2022). Pengaruh Model Project Based Learning (PjBL) terhadap Kemampuan Berpikir Tingkat Tinggi Siswa Kelas XI OTKP di SMKS Ketintang Surabaya. *Journal of Office Administration : Education and Practice*, *2*(1), 12–19. https://doi.org/10.26740/joaep.v2n1.p12-19
Retnawati, H. (2016). *Analisis Kuantitatif Instrumen Penelitian (Panduan Peneliti, Mahasiswa & Psikometrian)*. Yogyakarta : Parama Publishing.
Riduwan. (2015). *Skala Pengukuran Variabel-Variabel Penelitian*. Bandung : Alfabeta.
Saputri, F. D., Yamtinah, S., & Susilowati, E. (2020). Penerapan Model Pembelajaran Project Based Learning Berbantuan LKS Pada Materi Asam Basa Untuk Meningkatkan Aktivitas Dan Prestasi Belajar Siswa Kelas XI SMA Batik 2 Surakarta Tahun Ajaran 2018 / 2019. *Jurnal Pendidikan Kimia*, *9*(1), 75–81.
Sari, A. P., & Nasrudin, H. (2022). Guided Inquiry-Based Worksheet Development to Improve

Critical Thinking Skills on Colloidal Properties Sub Material. *Jurnal Pendidikan Dan Pembelajaran Kimia*, *11*, 25–31.

Sutarno, S., Setiawan, A., Suhandi, A., Kaniawati, I., & Hamdani, D. (2018). Model Higher Order Thinking Virtual Laboratory: Model Praktikum Fisika Berbasis Keterampilan Berpikir Kritis dan Pemecahan Masalah Secara Kreatif. *Jurnal Pendidikan Eksakta.*, *3*.

Trianto. (2012). *Model Pembelajaran Terpadu Konsep, Strategi, dan Implementasinya dalam Kurikulum Tingkat Satuan Pendidikan (KTSP)*.

Wulandari, Mustaji, & Setyowati, N. (2022). Pengembangan Lembar Kegiatan Peserta Didik Berbasis Project Based Learning Untuk Meningkatkan Kemampuan Berpikir Kritis Dan Keterampilan Sosial Bagi Siswa Kelas IV Sekolah Dasar. *EDUKASIA: Jurnal Pendidikan Dan Pembelajaran*, *3*, 733–742. http://www.jurnaledukasia.org/index.php/edukasia/article/view/188

Wulandari, R., & Novita, D. (2018). Pengembangan Lembar Kerja Peserta Didik (LKPD) Berbasis Project Based Learning Pada Materi Asam Basa Untuk Melatihkan Keterampilan Berpikir Kritis. *Unesa Journal of Chemical Education*, *7*(2), 129–135. https://jurnalmahasiswa.unesa.ac.id/index.php/journal-of-chemical-education/article/view/23880

Zahroh, F. (2020). PENGARUH MODEL PEMBELAJARAN PROJECT BASED LEARNING TERHADAP KEMAMPUAN BERPIKIR KRITIS SISWA PADA MATERI ELEKTROKIMIA. *Jurnal Phenomenon*, *10*.