JPPIPA 10(11) (2024)

Jurnal Penelitian Pendidikan IPA

Journal of Research in Science Education

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

Development of a Problem-Based Five-Tier Assessment Instrument in Phase B Science Learning to Measure Elementary School Students' Critical and Creative Thinking Abilities

Iqbal Muhammad Syaifullah[1*], Undang Rosidin[1], Fatkhur Rohman[1], Ryzal Perdana[1]

[1]Master of Primary School Teacher Training, Faculty of Teacher Training and Education, Universitas Lampung, Bandar Lampung, Indonesia.

Received: April 20, 2024
Revised: July 08, 2024
Accepted: November 25, 2024
Published: November 30, 2024

Corresponding Author:
Iqbal Muhammad Syaifullah
iqbalmsyaifullah@gmail.com

DOI: 10.29303/jppipa.v10i11.7450

© 2024 The Authors. This open access article is distributed under a (CC-BY License)

Abstract: The aim of this research is to develop an assessment instrument for problem-based Phase B science learning that is valid, practical and effective for measuring the critical and creative thinking abilities of students in elementary schools. This type of research is Research and Development (R&D), with development design referring to Borg & Gall theory. The population in this study was class IV students at SDN 4 Bumi Waras Bandar Lampung. Data collection tools use valid and reliable test instruments. The final average validation results from material experts, evaluation experts and language experts obtained a score of 87.75% with very valid criteria. The test results for the educator practitioners were 83% and the students were 82% with very practical criteria. The data analysis technique uses the One-Sample Z-Test to determine the correctness of the results of the assessment scores with a significance level of 95% (α 0.05), with a significance value of 0.023 obtained, indicating that the sig. value < 0.05 means H0 is rejected and H1 is accepted, so Effective assessment instrument for measuring students' critical and creative thinking abilities in elementary schools. Based on this research, it can be concluded that the assessment instruments for problem-based science learning are valid, practical and effective for measuring the critical and creative thinking abilities of students in elementary schools.

Keywords: Assessment instruments; Critical and creative thinking; IPA phase b material; Problem-based

Introduction

This research was conducted with the aim of developing an assessment instrument for problem-based Natural Sciences (IPA) Phase B learning to measure students' critical and creative thinking abilities in elementary schools. According to Moyo et al. (2022), assessment is a process of collecting evidence that is carried out deliberately, systematically and continuously to assess student competence. In essence, assessment is the process of combining data and information and analyzing needs, performance, strengths, as well as descriptions of student development and learning as a measuring tool used to obtain objective qualitative and quantitative information about the world of education (Rosidin et al., 2023; Azharini et al., 2023). Education in Indonesia is currently experiencing various changes and improvements to curriculum policies, namely the transition from the 2013 curriculum to the independent curriculum (Intiana et al., 2023).

The independent curriculum has the concept of freedom to think and innovate regarding technological progress which is the government's focus in the school's obligation to apply 21st century skills (communication, collaboration, creativity, critical thinking), literacy and

How to Cite:
Iqbal Muhammad Syaifullah, Undang Rosidin, Rohman, F., & Perdana, R. (2024). Development of a Problem-Based Five-Tier Assessment Instrument in Phase B Science Learning to Measure Elementary School Students' Critical and Creative Thinking Abilities. *Jurnal Penelitian Pendidikan IPA*, *10*(11), 9189–9199. https://doi.org/10.29303/jppipa.v10i11.7450

Higher Order Thinking Skills (HOTS) (Weber & Greiff, 2023). Critical and creative thinking are manifestations of higher order thinking skills. Critical and creative thinking skills are the ability to analyze information and ask questions based on existing problems and phenomena to solve problems (Firdaus et al., 2022; Dwyer & Walsh, 2020). Nufus et al. (2024) explained that critical and creative thinking is a basic ability that always looks at problems to be analyzed critically and looks for answers creatively so as to obtain new learning for students. This is in accordance with the aim of the independent curriculum which encourages students in learning to master various fields of science with their areas of expertise (Darling-Hammond et al., 2020). So students need to develop skills, including innovation, critical thinking, creativity, problem solving, communication and collaboration in responding to the challenges of the 21st century (Handayani & Koeswanti, 2021; Javaid et al., 2023). Learning by integrating 21st century skills is the aim of increasing students' creativity and critical thinking. The low critical thinking ability of students in Indonesia is influenced by several factors. These factors include the learning model applied by educators and the teaching materials used by students which are still minimal (Patrick et al., 2011).

The problem-based learning model (Problem Based Learning) is one that can be implemented in learning in the independent learning curriculum. Agree with that Ariyani & Kristin (2021) and Handayani & Koeswanti (2021) suggests that one model that can be used as a criterion and solution in training students to think at a higher level is the Problem Based Learning model. Assessment is carried out as an effort to ensure learning achievement against indicators set at the beginning of learning to interpret the progress of students' learning process (Vries et al., 2022). Based on the needs analysis carried out at SD N Gugus Bumi Waras on May 23 2023, through an educator needs analysis questionnaire, the results showed that there were still no learning assessment instruments available to measure critical and creative thinking skills in science learning Phase B, sound and light materials. The available assessments are only limited to cognitive aspects.

The transition to curriculum changes also means that the ongoing learning process has not been carried out in an orderly and systematic manner, learning is still teacher-centered and there are no learning tools available in the independent curriculum that refer to 21st century skills. This is also supported by Sasmita et al. (2021) explained that the ability to think creatively in Indonesia is still recorded as low, this fact can be confirmed from the results of The Global Creativity Index in 2015, Indonesia was ranked 115th out of 139 countries. And the Trends in International Mathematics and Science Study (TIMSS) revealed that in reality 80% of students in Indonesia have low critical thinking skills. Based on this preliminary research, all educators agreed that problem-based assessment instruments should be developed to measure abilities in critical and creative thinking skills in sound and light materials.

Paying attention to the reality that exists in schools as an effort to provide solutions to problems experienced by educators and students, it is important for researchers to develop assessment instruments in the independent curriculum to measure critical and creative thinking skills in elementary schools (Kim et al., 2019; Lia et al., 2020). Indicators of critical and creative thinking skills researchers use state of the art to find out how knowledge develops in the general problem area being researched until the researcher finds a research problem that contributes (Javaid et al., 2023). So that in the assessment process there is a benchmark for measuring valid and objective values in the evaluation aspect to determine students' learning achievements. Based on the background of these problems, research was conducted with the title "development of a problem-based five-tier assessment instrument in Phase B science learning to measure students' critical and creative thinking abilities in elementary schools."

Method

The method used is Research and Development (R&D). The product that researchers developed in this research is a problem-based five-tier assessment instrument in Phase B science learning to measure students' critical and creative thinking abilities using sound and light materials. The method used is based on development by Rashid et al. (2019) which consists of 10 development steps. This development research uses 7 development steps, namely: research and data collection, Planning, Product development, initial field trials, revision of initial field trials, main field trials, revision of operational products. Researchers use the Borg & Gall model because the development stages are divided in detail and in accordance with the research design, resulting in a useful assessment instrument product. This development only uses 7 steps because it requires a large scale and limited time for research products.

This development research has two subjects, namely research subjects and test subjects. The research subject in this development is a problem-based five-tier assessment instrument in Phase B science learning to measure students' critical and creative thinking abilities in elementary schools with sound and light materials. The test subjects in this development research included three groups. The first group is the subject of needs

analysis. The second group is a test of the validity of the product being developed, namely expert practitioners. The third group is subjects to determine the effectiveness of the product. The data sources in this research include steps, namely information collection, design validity stage, and product testing stage. In the information collection stage, data was obtained from filling out questionnaires by educators and students regarding the availability of learning tools in the form of assessment instruments measuring critical and creative thinking abilities, 21st century-based learning processes, determining the flow of learning objectives towards learning outcomes. Development of a problem-based five-tier assessment instrument for Phase B science learning to measure students' critical and creative thinking skills in elementary schools on sound and light materials.

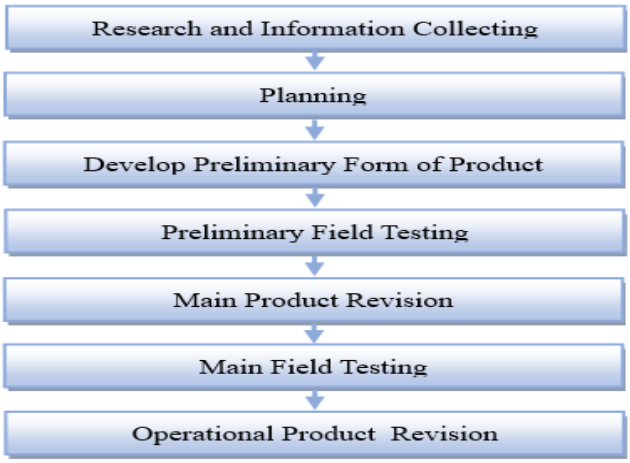

Figure 1. Research and development steps

Expert validation, data is collected based on questionnaire instruments, namely evaluation, material and language to determine the feasibility of the results of the experts' analysis. The practicality test stage is obtained from filling in practicality data by educators and students to see the educator's response to the quality of the assessment instrument product. In the product trial stage, data was obtained from the application of the problem-based five-tier assessment instrument product to determine the effectiveness of the product in measuring students' critical and creative thinking skills (Wijayati et al., 2019). The data analysis technique used is a prerequisite test consisting of validity test analysis, reliability test analysis, differential power test analysis, and question difficulty level analysis. Test expert validity analysis. Test the practitioner's practicality analysis. The effectiveness test consists of the normality test, homogeneity test and z-test to determine the correctness of the score obtained from the assessment instrument against the known variance in the form of Learning Objective Achievement Criteria (KKTP) on the basis of decision making: H0 is accepted if the P-value or Sig. (2-tailed) ≥ 0.05. H0 is rejected if the P-value or Sig. (2-tailed) < 0.05.

Result and Discussion

The type of research carried out is research and development, with the product being developed, in the form of a problem-based five-tier assessment instrument in Phase B science learning to measure students' critical and creative thinking abilities in sound and light materials (Tanjung & Nasution, 2023; Novita et al., 2023). Assessment instrument products are developed using research and development procedures according to Patrick et al. (2011), Surya & Aman (2016) and Handoko et al. (2019), with the results of the following steps.

Research and Information Collecting

This stage begins with analyzing field studies and literature studies. Field studies were carried out to determine needs analysis. The literature study was carried out by examining various sources in the form of books, national and international journals, as well as other sources relevant to the research. Based on field and literature studies, researchers found the problem that learning tools in the independent curriculum, especially assessment instruments to measure critical and creative thinking skills, are not yet available at SDN Gugus Bumi Waras Bandar Lampung, educators have not implemented learning towards the 21st century and 21st century thinking skills. students in Indonesia are still relatively low according to TIMSS and The Global Creativity Index, so all teachers agree that it is necessary to develop a problem-based five-tier assessment instrument in Phase B science learning to measure students' critical and creative thinking abilities.

Planning

The planning stage includes overall research planning, including the preparation of critical and creative thinking instrument indicators, expert validation sheets and assessment instrument design. The researcher synthesizes critical and creative thinking indicators from various expert opinions which the researcher then combines into a new set of indicators that contribute to each other (Suherman & Vidákovich, 2022; O'Reilly et al., 2022). Critical thinking indicators consist of interpretation, analysis, inference, advanced clarification, supposition and integration, explanation (Dinara et al., 2022). Indicators of creative thinking consist of fluency, flexible thinking, originality, elaboration (Nazhifah et al., 2023).

Develop Preliminary Form of Product

At this stage the five-tier assessment instrument is prepared based on previously planned goals and objectives. The aim of developing this five-tier assessment instrument is to measure students' critical and creative thinking abilities. Furthermore, the contents of the assessment instrument that has been developed consist of part 1 which contains rationality, development assumptions, and development steps. Part 2 contains learning outcomes, science subject objectives, characteristics, question grid, question instruments, answer keys, and scoring guidelines, and part 3 contains the conclusion. The assessment of each five-tier question item is adapted from a combination of student answers on the five-tier test along with the student's conceptual level (Rohman et al., 2023; Royani & Setyarsih, 2022; Sasmita et al., 2021), then synthesized into 6 alternative scores, namely, score 5 for the level of conception (scientific conception), score 4 for the level of conception (almost scientific conception), score 3 for the level of conception (lack of knowledge), score 2 for the level of conception (no understanding of concept), score 1 for the conception level (misconception), score 0 for the conception level (un-code). Then calculate the value of each score using equation 1.

$$\text{Score} = \frac{\sum \text{score obtained}}{\sum \text{score of each item}} \times 100\% \quad (1)$$

Information:

$\sum$ score obtained = the number of scores obtained by students in the assessment.

$\sum$ score of each item = the maximum score for each statement item that students can obtain in the assessment. The total score for each statement item is: number of items x maximum score for each item.

The results of the student assessment instrument scores are then interpreted based on the categories of critical and creative thinking abilities to determine the level of students' thinking abilities (Priyatni & Martutik, 2020; Ku, 2009).

Preliminary Field Testing

This step carries out expert validation tests on assessment instruments and practitioner tests, to determine the feasibility and practicality of the product being developed. The expert validation test was assessed by expert lecturers at the University of Lampung. Based on the results of expert validation, it is stated that the five-tier assessment instrument for students' critical and creative thinking abilities is suitable for use with improvements. The validation results of each expert validator are presented in Table 1.

Table 1 shows that the assessment aspect obtained an assessment percentage of 81.25%, which means that the problem-based five-tier assessment instrument in Phase B science learning to measure students' critical and creative thinking abilities has an assessment aspect in the very high category. The substance aspect received an assessment percentage of 92.3%, which means that the problem-based five-tier assessment instrument in Phase B science learning to measure students' critical and creative thinking abilities had a substance aspect in the very high category. In the language aspect, the assessment percentage was 89.70%, which means that the problem-based five-tier assessment instrument in Phase B science learning to measure students' critical and creative thinking abilities has a very high category for the language aspect. The average assessment based on assessment, substance and language aspects was 87.75% in the very high category.

Table 1. Validation results of assessment instruments

Aspect	Expert Max Score		Evaluation (%)	Category
Assessment	26	32	81.25	Very high
Substance	48	52	92.30	Very high
Language	61	68	89.70	Very high
Average Percentage			87.75	Very high

Next, a practitioner test was carried out involving 2 educators and 28 class IV students. The practicality questionnaire for educators consists of 11 items and for students 10 items. The results of practitioner assessments by educators are presented in Table 2.

Table 2. Recapitulation of practitioner assessment results

Aspect	Per-aspect percentage %	Category
Convenience	90	Easy to understand
Attractiveness	75	Quite interesting
Usefulness	83	Very helpful
Average percentage	83	Very Practical

Table 2 shows the results of the recapitulation of educators' practicality tests from the 3 aspects that were assessed with an average percentage of 83%, which means that the problem-based five-tier assessment instrument in Phase B science learning to measure students' critical and creative thinking abilities received a very practical category. Furthermore, the results of the student response assessment are presented in Table 3.

Table 3 shows the recapitulation results of student responses of 82%, which means that the problem-based five-tier assessment instrument in Phase B science learning to measure students' critical and creative thinking abilities obtained a very practical category.

Table 3. Recapitulation of student response results

Aspect	Per-aspect percentage %	Category
Convenience	82	Easy to understand
Attractiveness	86	Very interesting
Usefulness	77	Quite Useful
Average percentage	82	Very Practical

Main Product Revision

Based on expert data validation, the assessments obtained are used to identify non-conformities, errors or product deficiencies, then product revisions are carried out in accordance with expert input and suggestions for improvement. There are several suggestions from expert validators regarding the instruments that researchers have developed (Elangovan & Sundaravel, 2021; Luque-Vara et al., 2020; Perdana et al., 2020; Marar et al., 2023), including improving several answer option sentences and detailed answers to questions, improving instructions for working on five-tier assessment instruments, improving question diction for answer choices in tier-1, tier-3, language used is aligned with thoughts and the choice of words to be displayed, some writing uses spelling in sentences made more efficient. Before the main field trial was carried out, the researcher conducted a test of the instrument prerequisites first, which consisted of a validity test, reliability test, analysis of differentiating power tests, and a difficulty level test (Cheung et al., 2023).

Validity

Table 4. Validity test results

Question Items	r Count	r Table	Criteria	Information
1	0.46	0.47	Currently	Valid
2	0.51	0.47	Currently	Valid
3	0.67	0.47	Strong	Valid
4	0.26	0.47	Low	Invalid
5	0.55	0.47	Currently	Valid
6	0.55	0.47	Currently	Valid
7	0.72	0.47	Strong	Valid
8	0.42	0.47	Currently	Valid
9	0.69	0.47	Strong	Valid
10	0.58	0.47	Currently	Valid
11	0.49	0.47	Currently	Valid
12	0.61	0.47	Strong	Valid
13	0.62	0.47	Strong	Valid
14	0.49	0.47	Currently	Valid
15	0.66	0.47	Strong	Valid

Validity testing is carried out to determine whether or not an item in this research is valid. The validity test in this research used the SPSS version 26 program. The validity test results are presented in Table 4.

Based on Table 4, with the test criteria if r count > r table with a significance level of 1% or $\alpha = 0.01$, r table = 0.47. Instrument item number 4 was declared invalid because the calculated r value < r table, namely 0.26 < 0.47. The calculation results show that there is 1 question instrument that is invalid, namely question number 4, because it is less than the parameter criteria, namely 0.47. Therefore, 14 question instruments are valid and can be used. Meanwhile, 1 item of the invalid instrument was discarded.

Reliability

Reliability testing is carried out to determine the level of accuracy or consistency of the questions in this research. The reliability test in this research used the SPSS version 26 program. The results of the reliability test are presented in Table 5.

Table 5. Reliability test results

Cronbach's Alpha	N of Items
0.838	15

Based on Table 5, the reliability test results obtained a Cronbach's Alpha value of 0.838. Therefore, the reliability of the assessment instrument items can be used and is categorized as very high. An assessment instrument is said to be good if it has high validity and reliability values (Petra & Aziz, 2020). The higher the validity and reliability values of the assessment instrument, the more accurate the data obtained from the research results (Taber, 2018).

Differentiating Power

Discriminating power testing is used to determine whether or not a question item is capable of categorizing students in the upper group, namely those who have high ability, and students in the lower group, namely students who have low ability (Petropoulos et al., 2022). Testing of differentiating power in this study used the SPSS version 26 program. The results of the differentiating power analysis are presented in Table 6.

Based on Table 6, the calculation results are then interpreted to determine the different power criteria. There is 1 question instrument in the category Not Good, the question must be thrown away" in item number 4. Furthermore, 3 question instruments are in the Good category and 11 question instruments are in the Very Good category. A total of 14 question instruments can be used in research.

Table 6. Differentiating power test results

Question Items	Discriminating Power Index	Criteria
1	0.38	Good
2	0.40	Very good
3	0.61	Very good
4	0.15	Not Good, the question must be discarded
5	0.43	Very good
6	0.45	Very good
7	0.64	Very good
8	0.34	Good
9	0.61	Very good
10	0.53	Very good
11	0.41	Very good
12	051	Very good
13	0.55	Very good
14	0.38	Good
15	0.60	Very good

Level of Difficulty

Testing the level of difficulty in this study aims to find out whether the questions are in the easy, medium or difficult category. Testing the level of difficulty in this research used the SPSS version 26 program. The results of the level of difficulty test are presented in Table 7.

Table 7. Test results for difficulty level of questions

Question Items	Difficulty Power Value	Criteria
1	0.77	Easy
2	0.30	Hard
3	0.76	Easy
4	0.48	Medium
5	0.60	Medium
6	0.30	Hard
7	0.53	Medium
8	0.69	Medium
9	0.30	Hard
10	0.88	Easy
11	0.77	Easy
12	0.69	Medium
13	0.66	Medium
14	0.65	Medium
15	0.64	Medium

Based on Table 7, the calculation results are then interpreted to determine the level of difficulty [36]. There are 3 question instruments with the "Difficult" criteria in question instruments number 2, 6, and 9. Question instruments in the Easy category are found in question items number, 1, 3, 10, and 11. Furthermore, there are 8 question instruments in the medium category.

Main Field Testing

A problem-based five-tier assessment instrument in Phase B science learning to measure critical and creative thinking abilities after going through various feasibility, validity and reliability testing processes of the assessment instrument, then the instrument was tested on 51 students to determine the effectiveness of the assessment instrument product developed. Instrument development products are said to be effective if they are able to become valid, practical and effective assessment instruments for measuring students' critical and creative thinking skills. The assessment instrument that was tested on students was then tested for the z-test hypothesis. The One-Sample z-test in hypothesis testing is used to determine whether a finding is statistically significant or not regarding the correctness of the score obtained from the assessment instrument against the known variance in the form of Learning Objective Achievement Criteria (LOAC) on the basis of decision making: H0 is accepted if the P-value or Sig.(2-tailed) ≥ 0.05. H0 is rejected if the P-value or Sig. (2-tailed) < 0.05. Prerequisite tests are required before hypothesis testing is carried out.

Test of Normality

The normality test was carried out to determine whether the data obtained came from a normally distributed population or not, so a one-sample Kolmogorov-Smirnov normality test was carried out. The basis for decision making is: H0: accepted if the significance value is > 0.05 then the data is normally distributed. The normality test in this study using the SPSS version 26 program is presented in Table 8.

Table 8. One-sample Kolmogorov Smirnov normality test results

N		51
Normal Parameters[a,b]	Mean	74.70
	Std. Deviation	5.18
Most Extreme Differences	Absolute	0.109
	Positive	0.089
	Negative	-0.109
Test Statistic		0.109
Asymp. Sig. (2-tailed)		0.179[c]

Based on Table 8, the significance value (2-tailed) is 0.17, indicating that the sig. > 0.05 then H0 is accepted and the data is normally distributed.

Test of Homogeneity of Variances

The homogeneity test is carried out to determine that two or more groups of data come from the same variance (homogeneous). The basis for decision making is: H0: accepted if the significance value is > 0.05 then the data is homogeneously distributed. The homogeneity test in this study used one way ANOVA with the help of the SPSS version 26 program which is shown in Table 9.

Table 9. Test results of homogeneity of variances

		Levene Statistic	df1	df2	Sig.
Assessment Instrument Test Results	Based on Mean	1.42	1	49	0.238
	Based on Median	1.17	1	49	0.283
	Based on Median and with adjusted df	1.17	1	46.22	0.283
	Based on trimmed mean	1.42	1	49	0.238

Based on Table 9, the significance value obtained is 0.23, indicating that the sig. > 0.05 then H0 is accepted and the data is homogeneously distributed.

Uji-z One-Sample Test

The z-test was carried out on 51 students with a significance level of 95% (α 0.05). The major hypothesis is: H0: assessment instrument products are not effective in measuring students' critical and creative thinking abilities; H1: assessment instrument products are effective for measuring students' critical and creative thinking abilities. The basis for decision making, namely; H0: accepted if the P-value or significance is ≥ 0.05. H0: rejected if the P-value or significance is < 0.05. The z-test of the assessment instrument to measure critical and creative thinking skills in this research using the SPSS version 26 program is presented in Table 10.

Table 10. One-sample Z-test results

	95% Confidence Interval of the Difference					
	t	df	Sig.(2-tailed)	Mean Difference	Lower	Upper
Assessment Instrument Test Results	2.34	50	0.023	1.70	0.25	3.16

Based on Table 10, the significance value of the One-Sample Test z-test results is 0.023, indicating that the sig. < 0.05, then H0 is rejected and H1 is accepted, indicating that the product the researcher developed, namely a problem-based five-tier assessment instrument in Phase B science learning, is effective for measuring students' critical and creative thinking abilities by obtaining interpretations of participants' critical and creative thinking abilities students are presented in Figure 2.

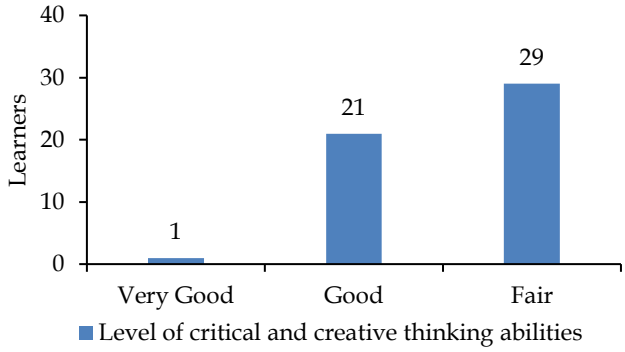

Figure 2. Critical & creative thinking ability score graph

Based on Figure 2, the score obtained from the problem-based five-tier assessment instrument test in Phase B science learning to measure students' critical and creative thinking abilities, it is known that there is 1 student who has the level of critical and creative thinking abilities in the Very Good category, next There are 21 students who have a level of critical and creative thinking ability in the Good category, and 29 students have a level of critical and creative thinking ability of "Fair". Based on this description, the assessment instrument that the researcher developed has fulfilled the three aspects which are the main objectives of this development research, namely: the assessment instrument developed is valid, practical and effective for measuring the critical and creative thinking abilities of students in elementary schools. An assessment instrument is said to be valid, practical and effective if there is ease in preparing, using, interpreting, obtaining assessment results, and has met the criteria for valid and reliable assessment instruments, and has an interpretation of the level of students' critical and creative thinking abilities.

Operational Product Revision

Refinement of this final product was carried out based on the results of trials and analysis of problem-based five-tier assessment instruments in Phase B science learning to measure students' critical and creative thinking abilities. The product of developing this assessment instrument, which consists of determining learning outcomes, as well as formulating question indicators, a grid of five-tier multiple choice questions and assessments, has met the feasibility

elements, has gone through validation tests from experts and practitioners who have obtained very high criteria, and has passed the stage. validity test with question item number 4 is invalid, so that the total of 14 assessment instrument items are valid, the reliability of the assessment instrument is in the very high category, the differential power analysis shows that question number 4 has poor criteria, the question must be discarded, and has a level of difficulty, difficult, easy, moderate and effective based on statistical tests carried out to determine the correctness of the test scores of the assessment instruments developed in the form of critical and creative thinking ability scores for elementary school students. The following are the results of the final revision of the problem-based five-tier assessment instrument in Phase B science learning to measure elementary school students' critical and creative thinking abilities.

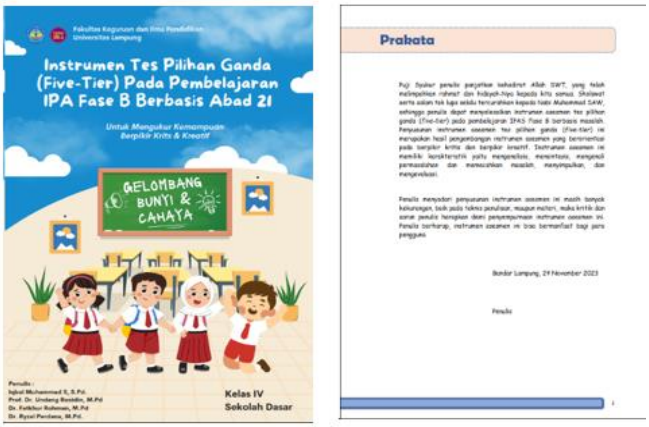

Figure 3. Cover and preface of the instrument

D. Kisi-kisi Soal

Tabel 2. Kisi-Kisi Soal

Materi	Kemampuan Berpikir Kritis: Indikator	Kemampuan Berpikir Kritis: Karakteristik	Nomor Soal	Jumlah Soal
Cahaya	Interpretation	Kegiatan memahami dan mengungkapkan makna pengalaman, situasi, evaluasi, data, prosedur, aturan, dan kriteria.	1 & 14	2
Cahaya	Analysis	Sebagai proses mengidentifikasi inferensial yang diinginkan dan sesuai pada kenyataan.	2	1
Cahaya	Inference	Membuat deduksi dan mempertimbangkan hasil deduksi, membuat induksi dan mempertimbangkan hasil induksi, membuat serta mempertimbangkan nilai keputusan.	3	1
Cahaya & Gelombang bunyi	Advanced Clarification	Mengidentifikasi istilah dan mempertimbangkan definisi, mengacu pada asumsi yang tidak dinyatakan.	4	1
Gelombang bunyi	Supposition and integration	Mempertimbangkan dan memikirkan secara logis, premis, alasan, asumsi, posisi dan usulan lain, menggabungkan kemampuankemampuan lain dan disposisi–disposisi dalam membuat serta mempertahankan sebuah keputusan.	5 & 6	2

Materi	Kemampuan Berpikir Kreatif: Indikator	Kemampuan Berpikir Kreatif: Karakteristik	Nomor Soal	Jumlah Soal
Cahaya	Kelancaran	Mencetuskan banyak ide, banyak jawaban, banyak penyelesaian masalah, banyak pertanyaan dengan lancar, Memberikan banyak cara atau saran untuk melakukan berbagai hal, Memikirkan lebih dari satu jawaban.	8	1
Gelombang bunyi	Berpikir Luwes (Fleksibel)	Menghasilkan gagasan-gagasan yang seragam, mampu mengubah cara atau pendekatan, arah pemikiran yang berbeda beda.	9 & 10	2
Gelombang bunyi	Keaslian	Mampu melahirkan ungkapan yang baru dan unik, memikirkan cara yang tidak lazim, mampu membuat kombinasi-kombinasi yang tidak lazim dari bagian-bagiannya.	11 & 13	2
Gelombang bunyi	Elaborasi	Mampu memperkaya dan mengembangkan suatu gagasan atau produk, menambah atau merinci detail-detail dari suatu objek, gagasan atau situasi sehingga menjadi lebih menarik.	12	1

Figure 4. Grid of critical and creativity thinking skills

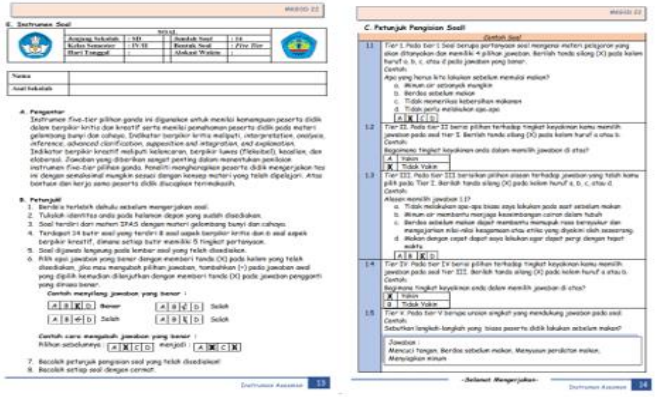

Figure 5. The form of the instruments for critical and creativity thinking skills

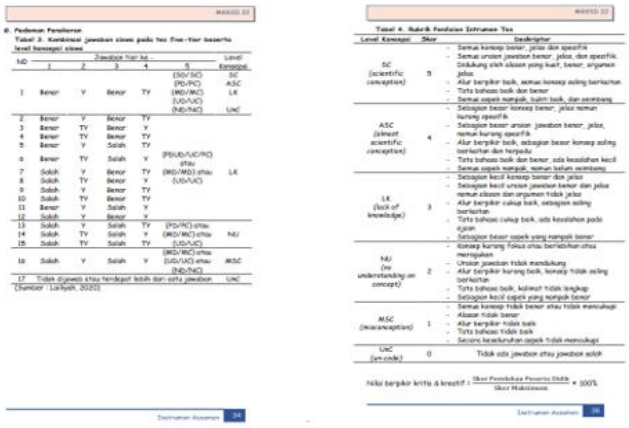

Figure 6. Instrument scoring guidelines

Conclusion

The research results of the problem-based five-tier assessment instrument in Phase B science learning to measure students' critical and creative thinking abilities have met the objectives of development research, namely: recapitulation of expert validity of 87.85% with very valid criteria. Practicality obtained an average percentage of 82% with very practical criteria. This instrument is empirically feasible based on the validity test obtained by the r table is 0.47. With a significance level of 1% or $\alpha = 0.01$, the 14 five-tier questions are valid. The five-tier assessment instrument was declared reliable with a score of 0.838 with very high criteria. and has the distinguishing power of the Very Good category totaling 11 question instruments, the Good category totaling 3 question instruments with 3 levels of difficulty of the question instruments, namely, difficult, medium and easy. The results of the One-Sample Test z-test obtained a significance value of 0.023, indicating that the sig value < 0.05 means H0 is rejected and H1 is accepted. This shows that the correct score of the five-tier assessment instrument is effective in obtaining students' critical and creative thinking ability scores, namely: 1

student obtained the critical and creative thinking ability category with the Very Good category, then 21 students obtained the thinking ability category. critical and creative "Good", and 29 students in the Enough category.

Acknowledgments
The researcher would like to thank the validation expert lecturer at the University of Lampung who has assisted the researcher in validating the instrument product developed. The school where the researcher conducted the research is SDN 4 Bumi Waras Bandar Lampung which has given the researcher the opportunity to carry out this research.

Author Contributions
Conceptualization, I.M.S., U.R., and F.R.; methodology, F.R., and R.P.; software, U.R., and F.R.; validation, U.R., and R.P.; investigation, I.M.S., and U.R.; writing-original draft preparation, writing, I.M.S.; review and editing, U.R., F.R., and RP.

Funding
This article was funded from the researcher's personal funds.

Conflicts of Interest
There is no conflict of interest.

References

Ariyani, B., & Kristin, F. (2021). Model Pembelajaran Problem Based Learning untuk Meningkatkan Hasil Belajar IPS Siswa SD. *Jurnal Imiah Pendidikan dan Pembelajaran*, *5*(3), 353. https://doi.org/10.23887/jipp.v5i3.36230

Azharini, R., Handoko, H., Rosidin, U., & Perdana, R. (2023). Analysis of Student Needs for E-Assessment Tools Oriented to Higher Order Thinking Skills (HOTS) in Thematic Learning to Measure Soft Skills and Hard Skills Competence. In R. Perdana, Sunyono, G. E. Putrawan, T. Y. Septiawan, & B. Saputra (Eds.), *Proceedings of the 4th International Conference on Progressive Education 2022 (ICOPE 2022)* (Vol. 746, pp. 79–87). Atlantis Press SARL. https://doi.org/10.2991/978-2-38476-060-2_9

Cheung, G. W., Cooper-Thomas, H. D., Lau, R. S., & Wang, L. C. (2023). Reporting Reliability, Convergent and Discriminant Validity with Structural Equation Modeling: A Review and Best-Practice Recommendations. *Asia Pacific Journal of Management*, *41*, 745-783. https://doi.org/10.1007/s10490-023-09871-y

Darling-Hammond, L., Flook, L., Cook-Harvey, C., Barron, B., & Osher, D. (2020). Implications for Educational Practice of the Science of Learning and Development. *Applied Developmental Science*, *24*(2), 97–140. https://doi.org/10.1080/10888691.2018.1537791

Dinara, H. A., Rahmawati, F., & Chasanah, A. (2022). Analysis of Students' Mathematical Critical Thinking Ability on Polyhedron in Term of Learning Styles. *Union: Jurnal Ilmiah Pendidikan Matematika*, *10*(3), 269–280. https://doi.org/10.30738/union.v10i3.12387

Dwyer, C. P., & Walsh, A. (2020). An Exploratory Quantitative Case Study of Critical Thinking Development Through Adult Distance Learning. *Educational Technology Research and Development*, *68*(1), 17–35. https://doi.org/10.1007/s11423-019-09659-2

Elangovan, N., & Sundaravel, E. (2021). Method of Preparing a Document for Survey Instrument Validation by Experts. *MethodsX*, *8*, 101326. https://doi.org/10.1016/j.mex.2021.101326

Firdaus, R. M., Andayani, E., Yudiono, U., & Walipah, W. (2022). Implementasi Triple Helix of Economic Education Terintegrasi Sustainable Develompent Goals (SDGs) dalam Konteks Merdeka Belajar Kampus Merdeka. *Jurnal Riset Pendidikan Ekonomi*, *7*(1), 71–77. https://doi.org/10.21067/jrpe.v7i1.6404

Handayani, A., & Koeswanti, H. D. (2021). Meta-Analisis Model Pembelajaran Problem Based Learning (PBL) untuk Meningkatkan Kemampuan Berpikir Kreatif. *Jurnal Basicedu*, *5*(3), 1349–1355. https://doi.org/10.31004/basicedu.v5i3.924

Handoko, H., Tola, B., Supriyati, Y., & Rangka, I. B. (2019). The Change of National Exam System from Paper-Based Test into Computer-Based Test. *Proceedings of the First International Conference on Technology and Educational Science, ICSTES 2018*. Bali, Indonesia. https://doi.org/10.4108/eai.21-11-2018.2282048

Intiana, S. R. H., Prihartini, A. A., Handayani, F., Mar'i, M., & Faridi, K. (2023). Independent Curriculum and the Indonesian Language Education Throughout the Era of Society 5.0: A Literature Review. *AL-ISHLAH: Jurnal Pendidikan*, *15*(1), 911–921. https://doi.org/10.35445/alishlah.v15i1.3140

Javaid, M., Haleem, A., Singh, R. P., Khan, S., & Khan, I. H. (2023). Unlocking the Opportunities Through ChatGPT Tool Towards Ameliorating the Education System. *BenchCouncil Transactions on Benchmarks, Standards and Evaluations*, *3*(2), 100115. https://doi.org/10.1016/j.tbench.2023.100115

Kim, S., Raza, M., & Seidman, E. (2019). Improving 21st-Century Teaching Skills: The Key to Effective 21st-Century Learners. *Research in Comparative and International Education*, *14*(1), 99–117. https://doi.org/10.1177/1745499919829214

Ku, K. Y. L. (2009). Assessing Students' Critical Thinking Performance: Urging for Measurements Using

Multi-Response Format. *Thinking Skills and Creativity*, *4*(1), 70–76. https://doi.org/10.1016/j.tsc.2009.02.001

Lia, R. M., Rusilowati, A., & Isnaeni, W. (2020). NGSS-Oriented Chemistry Test Instruments: Validity and Reliability Analysis with the Rasch Model. *REID (Research and Evaluation in Education)*, *6*(1), 41–50. https://doi.org/10.21831/reid.v6i1.30112

Luque-Vara, T., Linares-Manrique, M., Fernández-Gómez, E., Martín-Salvador, A., Sánchez-Ojeda, M. A., & Enrique-Mirón, C. (2020). Content Validation of an Instrument for the Assessment of School Teachers' Levels of Knowledge of Diabetes Through Expert Judgment. *International Journal of Environmental Research and Public Health*, *17*(22), 8605. https://doi.org/10.3390/ijerph17228605

Marar, S., Hamza, M. A., Ayyash, M., & Abu-Shaheen, A. (2023). Development and Validation of an Instrument to Assess the Knowledge and Perceptions of Predatory Journals. *Heliyon*, *9*(11), e22270. https://doi.org/10.1016/j.heliyon.2023.e22270

Moyo, S. E., Combrinck, C., & Staden, S. V. (2022). Evaluating the Impact of Formative Assessment Intervention and Experiences of the Standard 4 Teachers in Teaching Higher-Order-Thinking Skills in Mathematics. *Frontiers in Education*, *7*, 771437. https://doi.org/10.3389/feduc.2022.771437

Nazhifah, N., Wiyono, K., Ismet, I., & Azairok, M. (2023). Profile of Physics Creative Thinking Skills for High School Students in The 21st Century. *JIPFRI (Jurnal Inovasi Pendidikan Fisika dan Riset Ilmiah)*, *7*(1), 1–11. https://doi.org/10.30599/jipfri.v7i1.2131

Novita, L., Windiyani, T., Sukmanasa, E., & Utari, R. L. (2023). Higher Order Thinking Skills in Evaluation of IV Grade Thematic Materials in Elementary Schools. *Jurnal Ilmiah Sekolah Dasar*, *7*(3), 498–507. https://doi.org/10.23887/jisd.v7i3.57003

Nufus, H., Muhandaz, R., Hasanuddin, H., Nurdin, E., Ariawan, R., Fineldi, R. J., Hayati, I. R., & Situmorang, D. D. B. (2024). Analyzing the Students' Mathematical Creative Thinking Ability in Terms of Self-Regulated Learning: How Do We Find What We are Looking for? *Heliyon*, *10*(3), e24871. https://doi.org/10.1016/j.heliyon.2024.e24871

O'Reilly, C., Devitt, A., & Hayes, N. (2022). Critical Thinking in the Preschool Classroom—A Systematic Literature Review. *Thinking Skills and Creativity*, *46*, 101110. https://doi.org/10.1016/j.tsc.2022.101110

Patrick, D. L., Burke, L. B., Gwaltney, C. J., Leidy, N. K., Martin, M. L., Molsen, E., & Ring, L. (2011). Content Validity—Establishing and Reporting the Evidence in Newly Developed Patient-Reported Outcomes (PRO) Instruments for Medical Product Evaluation: ISPOR PRO Good Research Practices Task Force Report: Part 2—Assessing Respondent Understanding. *Value in Health*, *14*(8), 978–988. https://doi.org/10.1016/j.jval.2011.06.013

Perdana, R., Rudibyani, R. B., Budiyono, B., Sajidan, S., & Sukarmin, S. (2020). The Effectiveness of Inquiry Social Complexity to Improving Critical and Creative Thinking Skills of Senior High School Students. *International Journal of Instruction, 13*(4), 477–490. https://doi.org/10.29333/iji.2020.13430a

Petra, T. Z. H. T., & Aziz, M. J. A. (2020). Investigating Reliability and Validity of Student Performance Assessment in Higher Education Using Rasch Model. *Journal of Physics: Conference Series*, *1529*(4), 042088. https://doi.org/10.1088/1742-6596/1529/4/042088

Petropoulos, F., Apiletti, D., Assimakopoulos, V., Babai, M. Z., Barrow, D. K., Taieb, S. B., Bergmeir, C., Bessa, R. J., Bijak, J., Boylan, J. E., Browell, J., Carnevale, C., Castle, J. L., Cirillo, P., Clements, M. P., Cordeiro, C., Cyrino Oliveira, F. L., Baets, S. D., Dokumentov, A., … Ziel, F. (2022). Forecasting: Theory and Practice. *International Journal of Forecasting*, *38*(3), 705–871. https://doi.org/10.1016/j.ijforecast.2021.11.001

Priyatni, E. T., & Martutik, M. (2020). The Development of a Critical–Creative Reading Assessment Based on Problem Solving. *SAGE Open*, *10*(2), 215824402092335. https://doi.org/10.1177/2158244020923350

Rashid, Y., Rashid, A., Warraich, M. A., Sabir, S. S., & Waseem, A. (2019). Case Study Method: A Step-by-Step Guide for Business Researchers. *International Journal of Qualitative Methods*, *18*, 160940691986242. https://doi.org/10.1177/1609406919862424

Rosidin, U., Herliani, D., & Viyanti, V. (2023). Development of Assessment Instruments in Project-Based Learning to Measure Students Scientific Literacy and Creative Thinking Skills on Work and Energy Materials. *Jurnal Penelitian Pendidikan IPA*, *9*(6), 4484–4494. https://doi.org/10.29303/jppipa.v9i6.2421

Rohman, F., Santi, T., Alamin, A., Pramudiyanti, P., Syahnia, S. M., & Yuninda, D. (2023). Participant Worksheet Education Based on Contextual Teaching and Learning to Develop Science Process Skills. *Scientific Journal of Education and Learning, 7*(3). https://doi.org/10.23887/jipp.v7i3.62991

Royani, A., & Setyarsih, W. (2022). Development of Google Form-Based Five-Tier E-Diagnostic Test to Identify Conception Levels and Track Students' Misconceptions on Thermodynamics Materials.

Prisma Sains: Jurnal Pengkajian Ilmu dan Pembelajaran Matematika dan IPA IKIP Mataram, *10*(3), 450. https://doi.org/10.33394/j-ps.v10i3.5209

Sasmita, Z. A. G., Widodo, W., & Indana, S. (2021). Contextual Based Learning Media Development to Train Creative Thinking Skill in Primary School. *IJORER: International Journal of Recent Educational Research*, *2*(4), 468–476. https://doi.org/10.46245/ijorer.v2i4.124

Suherman, S., & Vidákovich, T. (2022). Assessment of Mathematical Creative Thinking: A Systematic Review. *Thinking Skills and Creativity*, *44*, 101019. https://doi.org/10.1016/j.tsc.2022.101019

Surya, A., & Aman, A. (2016). Developing Formative Authentic Assessment Instruments Based on Learning Trajectory for Elementary School. *REID (Research and Evaluation in Education)*, *2*(1), 13–24. https://doi.org/10.21831/reid.v2i1.6540

Taber, K. S. (2018). The Use of Cronbach's Alpha When Developing and Reporting Research Instruments in Science Education. *Research in Science Education*, *48*(6), 1273–1296. https://doi.org/10.1007/s11165-016-9602-2

Tanjung, Y. I., & Nasution, I. R. (2023). The Development of Creative Thinking Test Instruments with Torrance Indicators on Direct Current Electricity Materials. *Jurnal Pendidikan Fisika Indonesia*, *18*(2), 134–143. https://doi.org/10.15294/jpfi.v18i2.32117

Vries, J. A. D., Dimosthenous, A., Schildkamp, K., & Visscher, A. J. (2022). The Impact on Student Achievement of an Assessment for Learning Teacher Professional Development Program. *Studies in Educational Evaluation*, *74*, 101184. https://doi.org/10.1016/j.stueduc.2022.101184

Weber, A. M., & Greiff, S. (2023). ICT Skills in the Deployment of 21st Century Skills: A (Cognitive) Developmental Perspective Through Early Childhood. *Applied Sciences*, *13*(7), 4615. https://doi.org/10.3390/app13074615

Wijayati, N., Sumarni, W., & Supanti, S. (2019). Improving Student Creative Thinking Skills Through Project Based Learning. *KnE Social Sciences*. https://doi.org/10.18502/kss.v3i18.4732