E-ISSN: 2798-0472 DOI: 10.52562/biochephy.v5i2.1726

BIOCHEPHY: Journal of Science Education

http://journal.moripublishing.com/index.php/biochephy

IMPROVING CREATIVITY THROUGH PROBLEM-BASED LEARNING: A PHYSICS TEACHING MATERIALS AND INSTRUMENT DEVELOPMENT WITHIN THE CAMBRIDGE FRAMEWORK

Ade Sukandi Novita*, Dwikoranto
Physics Department, State University of Surabaya, 60231, Indonesia
**Corresponding author*: adesukandi.21046@mhs.unesa.ac.id

Abstract: This study aims to develop PBL teaching materials and instrument to improve students' creative thinking skills in the topic electrical circuits. This research method's uses a 4-D development model divided to 4 stages, which are Define, Design, Develop, and Disseminate. the study identified students' difficulties in understanding abstract concepts and their low creative thinking, especially in flexibility and elaboration. The developed materials included a lesson plan, worksheet, and creative thinking test. Validation results showed that all materials and instrument developed achieved a "Very Valid" category and suitable to implement during learning process. Effectiveness was tested through pretest and posttest analysis, yielding an average n-gain of 0.73 (high category), with particularly strong improvements in fluency, flexibility, and elaboration.

Keywords: Validity, 4-D Model, Workshet, Creative Thinking Skills

Abstrak: *Penelitian ini bertujuan untuk mengembangkan bahan ajar dan instrumen PBL guna meningkatkan keterampilan berpikir kreatif siswa dalam topik sirkuit listrik. Metode penelitian ini menggunakan model pengembangan 4-D yang dibagi menjadi 4 tahap, yaitu Define, Design, Develop, dan Disseminate. Penelitian ini mengidentifikasi kesulitan siswa dalam memahami konsep abstrak dan rendahnya keterampilan berpikir kreatif mereka, terutama dalam hal fleksibilitas dan elaborasi. Bahan ajar yang dikembangkan meliputi rencana pelajaran, lembar kerja, dan tes berpikir kreatif. Hasil validasi menunjukkan bahwa semua bahan dan instrumen yang dikembangkan mencapai kategori "Sangat Valid" dan cocok untuk diterapkan selama proses pembelajaran. Efektivitas diuji melalui analisis pretest dan posttest, menghasilkan rata-rata n-gain sebesar 0,73 (kategori tinggi), dengan peningkatan yang signifikan terutama dalam kelancaran, fleksibilitas, dan elaborasi.*

Kata Kunci: *Validitas, Model 4-D, Lembar Kerja, Keterampilan Berpikir Kreatif*

INTRODUCTION

In the 21st century, the learning process is not only focused on knowledge transfer, but globally it is expected to equip students with 21st century learning skills. This competency is a crucial focus aimed at preparing students to face challenges and opportunities in the 21st century, according to Anugerahwati in (Montessori et al., 2023) including critical thinking, creativity, collaboration, communication, character and citizenship, especially in physics learning. According to Torrance in (Coştu, 2024) creative thinking is a process that involves sensitivity to problems, recognition of gaps in knowledge, and creation of new solutions through innovative approaches. This includes the ability to connect seemingly unrelated ideas, create new solutions, and think flexibly and originally. According to (Sari & Putra, 2015) creative thinking skills are one of the skills that are the main focus in the educational paradigm. Creative thinking skills allow students to develop the ability to find new solutions and innovations in dealing with a problem with the right

action. According to Munandar in (Qomariyah et al., 2021) indicators of creative thinking skills include fluency, flexibility, elaboration, and originality.

Physics as one of the science subjects has an important role in shaping logical and systematic thinking (Ghina Dhaniyah Salsabil et al., 2024; Hidayat et al., 2024). Among these skills, creative thinking is the main highlight in the context of 21st century learning, especially in physics learning. In the context of physics learning, where according to physics not only teaches about the laws of the universe contextually, but can also direct students to be able to understand concepts in depth, formulate problems, and be able to solve problems in a logical and creative way. In learning physics, an appropriate learning process is needed so that learning not only focuses on contextual understanding but can also lead students to achieve meaningful learning as one of the requirements for achieving 21st learning skills (Widya Artha et al., 2025; Fitriana et al., 2025). This shows that meaningful learning has an important role as a bridge in every phase of learning. Meaningful learning according to (Adeoye et al., 2024) in schools can be achieved by facilitating learners so that they can achieve skills, such as creative thinking skills.

Based on the results of researchers' observations at AL Falah Darmo High School regarding the physics learning process through interviews with physics teachers and deputy principals, the implementation of learning has been carried out in accordance with the syllabus with the Cambridge curriculum and has been in accordance with the learner attributes of Cambridge students (Márquez et al., 2016) but in the process teachers still pay less attention to the creative thinking skills of students, this is because the learning methods used are still conventional methods that focus on exam-oriented and teacher-centered where this has not been able to train students' thinking skills, as well as their willingness to think from a variety of different perspectives (Ghaleb, 2024). This is in accordance with research by (Ghaleb, 2024) and (Herdiawan et al., 2019) that most teachers still do not implement meaningful learning in teaching, one example is using learning activities that are still teacher-centered. In addition, the learning tools used are only centered on learning tools provided by Cambridge University, namely textbooks, so that in learning activities, teachers only focus on how students can solve the problems available in the textbook without any creative thinking process. So that in this learning process shows a learning process that is only in the form of knowledge transfer activities from the teacher without any skill development in conducting an experiment and analyzing data (Aditiyas & Kuswanto, 2024). In other words, this shows that teachers have not applied or trained creative thinking skills in detail and optimally to students during learning activities.

Related to the above problems, this is the reason for researchers to develop physics learning tools based on Problem Based Learning to improve students' creative thinking skills, because the learning tool itself is one of the important factors both when planning and implementing the learning process. According to (Novsiani et al., 2022) learning planning is related to the creation and development of devices that are in accordance with the upcoming learning process to determine the success and achievement of the desired skills during the learning process. The tools developed are the Lesson Plan, Students' Worksheet and Creative Thinking Test Instrument based on and in line with the syntax of Problem Based Learning according namely (1) Orienting students to the problem, (2) Organizing students, (3) Guiding individual or group investigations of students, (4) Developing and presenting work, and (5) Analyzing and evaluating the problem-solving process (Owen, 2019; Satriawan et al., 2020; Tulung et al., 2023)

The purpose of this study is to describe the validity of the learning materials and instruments developed and to analyze the effectiveness of the learning materials and instruments developed.

METHOD

The method used in this research is the Research & Development (R&D) method. R&D research is research with 4 main stages that have been adapted and interrelated, namely Define, Design, Develop, and Disseminate (Sivasailam et al., 1974; Sugiyono, 2022)

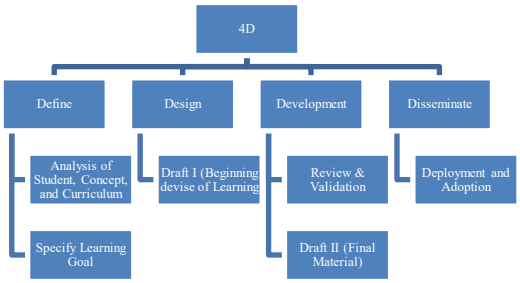

Figure 1 4D Model Research Design

This research was conducted at SMA Al Falah Darmo Surabaya, involving 27 Grade X students at SMA Al Falah Darmo Surabaya during the 2024/2025 academic year. The students who served as research subjects chosen using purposive sampling method based on the recommendation of the physics teacher, according to (Sugiyono, 2015) is a data source sampling technique with certain considerations.

The research instrument included validation sheets and tests (pretest and posttest) which were used to evaluate the quality and effectiveness of learning materials and instrument. The data obtained is in the form of quantitative data obtained from the validation sheet where the validity measurement score uses a Likert scale, with interpretation as in Table 1.

Table 1 Likert Scale

Score	Criteria
1	Not Good
2	Less Good
3	Good
4	Very Good

The data analysis technique used in this study is to use statistical tests by testing the level of validity and reliability of learning devices and instruments. [20] states that to test the validity level of the developed device, namely by calculating the average value of all sub-indicators, namely by calculating the percentage of product validity, with the following formula:

$$Validity\ (\%) = \frac{\Sigma\ Score\ obtained}{\Sigma\ Maximum\ Score} \times 100\%$$

With interpretation of the results of the formula is converted into the criteria for the percentage level of validity in Table 2 below.

Table 2 Criteria for Learning Materials and Instrument Validity

Value Interval	Criteria
1,00 – 1,74	Not Valid
1,75 – 2,49	Less Valid
2,50 – 3,24	valid
3,25 – 4,00	Very valid

The learning materials and instrument is considered valid if it receices the most frequent score (mode) ≥ 3. The data obtained from the pretest and posttest are analyzed using the n-gain score with the following formula:

$$g = \frac{Spost\ - Spre}{Smax - Spre}$$

With interpretation of the results of the formula above is converted in the criteria in the table 3 below:

Table 3 Criteria for n-gain (Hake, 1999)

n-gain score	Category
g ≥ 0,7	High
0,7 > g ≥ 0,3	Medium
g < 0,3	Low

The learning materials is considered effective if it reaches at least a medium category of n-gain score.

RESULT AND DISCUSSION

This section presents the result of the research on the development of a learning materials and instruments to enhance students' creative thinking skills on the topic electrical circuit.

Define

This stage is carried out with the observation method in the form of interviews with physics subject teachers with purpose to analyze the obstacles experienced during the physics learning process with the aim of obtaining the problems / obstacles experienced, understanding the characteristics of students, concepts and curriculum used during the learning process as well as media adjustments to the curriculum applied at school (Rizki & Linuhung, 2016). This stage involved several steps: 1) Students' analysis, interviews showed that most of 10th grade students still struggled to understand abstract concept in electrical circuits. Their creative thinking skills was considered as low, especially in elaborating the answer and flexibility indicator. This stage revealed that physics subject was still dominated by conventional method and have not integrated with creative thinking skills or problem-based approaches; 2) Concept analysis, conducted to classify the key concepts students would learn through the learning materials aligned the curriculum applied, which is Cambridge Curriculum.

Design

Then after the define stage, continued with the design stage, where at this stage begins with designing and developing products in the form of learning materials and instruments that will be used during the learning process based on the problem-based learning model that will be used during learning activities with the aim of improving students' creative thinking skills by adjusting the curriculum applied at school, namely the Cambridge curriculum. The selected teaching materials to be developed are: students's worksheet and lesson plan, while the instruments to be developed is creative thinking's test.

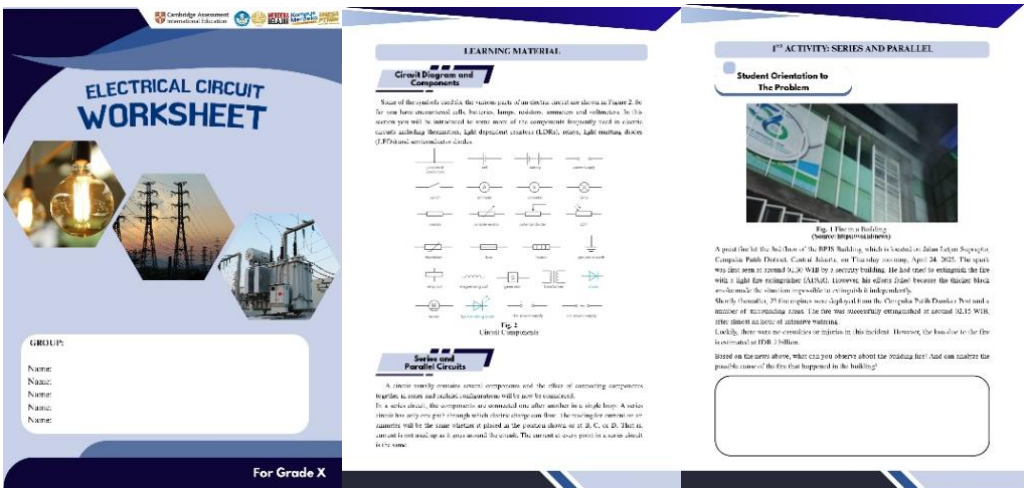

Figure 2 Sample Display of Electrical Circuit Students' Worksheet

The validity of each teaching materials and instrument consists of several aspects which contains language, design, and material validity for each item.

Development

In this stage, which is the stage where the device that has been designed and developed will go through the assessment stage, namely in the form of validation by 3 validators. The validity test aims to determine the level of feasibility and validity of devices and instruments that will be used in the learning process. Validation was carried out by 2 expert validators, namely lecturers of the Physics Education Study Program at Surabaya State University and 1 practitioner validator, namely physics subject teachers at Al Falah Darmo Surabaya High School. The validation results for devices and instruments can be seen in Table 4 below.

Table 4 Validity Result

Learning Materials	Average Validity Score	Category
Students' Worksheet	3,80	Very Valid
Lesson Plan	3,95	Very Valid
Creative Thinking's Test	4,00	Very Valid

Based on the validation results in Table 4 above, the learning materials and instrument developed have a very valid category so that overall, it can be concluded that the materials developed and are in a category that is feasible to implement in the learning process.

Worksheet in the form of questions or exercises given to students to do certain tasks [23]. In education, worksheets are used to measure students' understanding of the material taught and monitor their learning progress. worksheet can also be used as an evaluation tool, in this study worksheet was prepared according to the syllabus of the Cambridge Curriculum and also based on the syntax of PBL. Based on the overall assessment of the validators, this students' worksheet suitable for use in learning and has met the valid criteria in terms of language, format, content, and design and graphics with score 3,80. Creative Thinking Test was prepared according to Creative Thinking's indicators such as fluency, flexibility, originality and elaboration. Based on overall assessment of the validators, the tests developed are valid and feasible to implement in learning process and has met the valid criteria with score 4,00.

Effectiveness of the materials developed was measured using pretest and posttest assessment to evaluate the impact of the PBL-oriented worksheet on students' creative thinking skills in the electrical circuits' topic. The tests were compiled based on indicators of creative thinking skills including fluency, flexibility, originality and elaboration. Result of the tests given to students score an n-gain of 0,73 (high category). results of tests of creative thinking skills' indicator can be seen in the Figure 3 below.

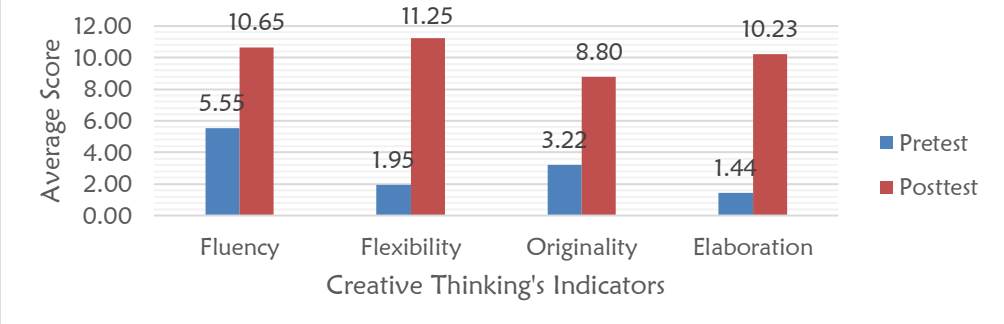

Figure 3 Pretest-Posttest Result

The creative thinking skills' indicator was divided into fluency, flexibility, originality and elaboration aspects: fluency aspect scored 0,73 (high), flexibility aspect scored 0,88 (high), originality aspect scored 0,60 (medium), and elaboration aspect scored 0,79 (high). The lower score in originality aspect was attributed to students are more accustomed to convergent answers. Therefore, when asked to think originally, they tend to be less accustomed to imagining or exploring alternative ideas.

Disseminate

The dissemination stage in the 4-D development model is the final stage in the educational media development process. At this stage, the learning media that has been developed will be distributed or disseminated to the target users or students (Montori & Jacobus, 2025). The dissemination stage is where the product can be disseminated and introduced to the wider community beyond the scope of the development itself. Several factors that must be considered when conducting dissemination are user analysis, strategy and theme, dissemination timing, and selection of dissemination media. The dissemination stage is carried out by implementing the materials and instrument during the physics learning in electrical circuits' topic.

CONCLUSION

Based on the results of the research and development using the 4D model, it can be concluded that the learning materials and instruments developed—specifically the students' worksheet, lesson plan, and creative thinking test—are valid and feasible to be implemented in the classroom. The materials were developed in alignment with the Cambridge Curriculum and designed using a Problem-Based Learning (PBL) approach to foster students' creative thinking skills in the topic of electrical circuits. The validation results from expert and practitioner validators show that all developed components fall under the "very valid" category, with an average score of 3,80 for the worksheet, 3,95 for the lesson plan, and 4,00 for the creative thinking test. Furthermore, the effectiveness test showed a significant improvement in students' creative thinking skills after using the PBL-based materials, as reflected in the average n-gain score of 0.73, which falls into the high category.

ACKNOWLEDGEMNET

The author would like to express sincere gratitude to the academic supervisor, teachers, and students at SMA Al Falah Darmo Surabaya who participated and contributed in this research. Appreciation is also extended to the expert validators who provided insightful feedback and constructive suggestions to improve the quality of the learning materials and instruments developed.

REFERENCES

Adeoye, M. A., Prastikawati, E. F., & Abimbowo, Y. O. (2024). Empowering Learning: Pedagogical Strategies for Advancing 21st Century Skills and Quality Education. *Journal of Nonformal Education*, *10*(1), 10–21. https://doi.org/10.15294/jone.v10i1.1451

Aditiyas, S. E., & Kuswanto, H. (2024). Analisis Implementasi Keterampilan Proses Sains Di Indonesia Pada Pembelajaran Fisika : Literatur Review. *Jurnal Penelitian Pembelajaran Fisika*, *15*(2), 153–166. https://doi.org/10.26877/jp2f.v15i2.15912

Coştu, F. (2024). Enhancing Gifted Students' Creative Thinking Through Science Laboratory. *European Journal of Education*, *59*(4). https://doi.org/10.1111/ejed.12784

Ghaleb, B. D. S. (2024). Effect of Exam-Focused and Teacher-Centered Education Systems on Students' Cognitive and Psychological Competencies. *International Journal of Multidisciplinary Approach Research and Science*, *2*(02), 611–631. https://doi.org/10.59653/ijmars.v2i02.648

Ghina Dhaniyah Salsabil, Winda Sari, Ikmawati Ikmawati, & Kurniawan Kurniawan. (2024). Hakikat Sains : Pengertian, Fungsi, dan Penerapan dalam Proses Pembelajaran. *Populer: Jurnal Penelitian Mahasiswa*, *3*(4), 37–45. https://doi.org/10.58192/populer.v3i4.2664

Hake, R. R. (1999). Analyzing Change/Gain Scores Woodland Hills Dept. of Physics. *Physics*, *1*(1).

Herdiawan, H., Langitasari, I., & Solfarina, S. (2019). Penerapan PBL untuk Meningkatkan Keterampilan Berpikir Kreatif Siswa pada Konsep Koloid. *EduChemia (Jurnal Kimia Dan Pendidikan)*, *4*(1), 24. https://doi.org/10.30870/educhemia.v4i1.4867

Hidayat, F. A., Isnawati, I., & Ramadany, L. D. (2024). Profile of Science Practicum Course, Logical Thinking Ability, and Systems Thinking for Prospective Science Teacher Students in Sorong Regency. *Equator Science Journal*, *2*(2), 1–10. https://doi.org/10.61142/esj.v2i2.114

Márquez, B. V., Ontiveros, M. Á. C., & Pons, M. O. (2016). Developing the Cambridge learner attributes. *Developing the Cambridge Learner Attribute*, *11*(128–1).

Montessori, V. E., Murwaningsih, T., & Susilowati, T. (2023). Implementasi keterampilan abad 21 (6c) dalam pembelajaran daring pada mata kuliah Simulasi Bisnis. *JIKAP (Jurnal Informasi Dan Komunikasi Administrasi Perkantoran)*, *7*(1), 65. https://doi.org/10.20961/jikap.v7i1.61415

Montori, S., & Jacobus, S. N. (n.d.). *Penerapan Model Four-D (4D) dalam Pengembangan Media Video Materi Keanekaragaman: Meningkatkan Toleransi dan Kebhinekaan pada Peserta Didik*.

Novsiani, D., Verawati, N. N. S. P., Harjono, A., & Zuhdi, M. (2022). Pengembangan Perangkat Pembelajaran Fisika Berbasis Model Inkuiri Terbimbing untuk Meningkatkan Kemampuan Berpikir Kreatif Peserta Didik. *Jurnal Ilmiah Profesi Pendidikan*, *7*(2c), 723–728. https://doi.org/10.29303/jipp.v7i2c.624

Owen, C. (2019). Problem-Based Learning. In *Learning and Teaching in Higher Education: Perspectives from a Business School*. https://doi.org/10.4337/9781788975087.00027

Qomariyah, D. N., Subekti, H., Ipa, J., Matematika, F., Ilmu, D., Alam, P., & Surabaya, U. N. (2021). *PENSA E-JURNAL : PENDIDIKAN SAINS ANALISIS KEMAMPUAN BERPIKIR KREATIF: STUDI EKSPLORASI SISWA DI SMPN 62 SURABAYA*. https://ejournal.unesa.ac.id/index.php/pensa/index

Rizki, S., & Linuhung, N. (2016). Design Research and Development 4D Model for Developing Mathematics Teaching Materials. *The First International Conference on Law, Economics and Education*.

Sari, Y. I., & Putra, D. F. (2015). Pengaruh Model Pembelajaran Treffinger terhadap Kemampuan Berpikir Kritis dan Kreatif Mahasiswa Universitas Kanjuruhan Malang. *Jurnal Pendidikan Geografi*, *20*(2), 30–38. https://doi.org/10.17977/um017v20i22015p030

Satriawan, M., Rosmiati, R., Widia, W., Sarnita, F., Suswati, L., Subhan, M., & Fatimah, F. (2020). Physics learning based contextual problems to enhance students' creative thinking skills in fluid topic. *Journal of Physics: Conference Series*, *1521*(2). https://doi.org/10.1088/1742-6596/1521/2/022036

Sivasailam, T., Semmel, D. s., & Sommel, M. I. (1974). Instructional Decelopment For Training Teachers Of Exception Children. In *A sourcebook ERIC* (Issue Mc).

Sugiyono. (2015). Sugiyono, Metode Penelitian dan Pengembangan Pendekatan Kualitatif, Kuantitatif, dan R&D , (Bandung: Alfabeta, 2015), 407 1. *Metode Penelitian Dan Pengembangan Pendekatan Kualitatif, Kuantitatif, Dan R&D*, *2015*.

Sugiyono, Prof. Dr. (2022). Metode Penelitian Kuantitatif, Kualitatif dan R&D. Edisi 2|Cetakan Ke-29, Februari 2022. In *@2022, Penerbit Alfabeta, Bandung*.

The Impact of Thematic Worksheet-Assisted Meaningful Learning Implementation on Students' Mathematical Concept Understanding and Metacognitive Skills 1 Eni Fitriana, 2 Deny Hadi Siswanto, 2 Akhmad Hanama Article history*. (2025). *4*(02), 54–67. https://doi.org/10.56741/pbpsp.v4i02.788

Tulung, L. T., Manalu, C. R., Purba, E. N., & Situmeang, N. (2023). Meta Analisis Pengaruh Penerapan Model Pembelajaran Problem Based Learning Terhadap Kemampuan Berpikir

Kritis Dan Pemecahan Masalah. *INPAFI (Inovasi Pembelajaran Fisika)*, *11*(01). https://doi.org/10.24114/inpafi.v11i01.43839

Widya Artha, I. N., Agustini, K., & Suartama, K. (2025). Kajian Literatur Tentang Implementasi Pembelajaran Bermakna di Sekolah Menengah Atas. *Jayapangus Press Cetta: Jurnal Ilmu Pendidikan*, *8*(4). https://jayapanguspress.penerbit.org/index.php/cetta

Click or tap here to enter text.