# Development of RCODE Learning Materials to Enhance Students' Mathematical Creative Thinking Skills Based on Outcome-Based Assessment

Adi Candra Kusuma[1*)], Doddy Maulana [2], Almas Adibah[3], Muchlis Fajar Hidayat[4]
[1,2,3,4] State Polytechnic of Malang
*) candraraden45@polinema.ac.id

## Abstract

This study aimed to develop RCODE learning materials based on Outcome-Based Assessment (OBA) to improve students' ability to think creatively in mathematics in Fourier series. The study employed a research and development approach based on the Plomp model, comprising the preliminary investigation, design, realization or construction, testing, evaluation, and revision phases. The developed products included a semester learning plan, student assignment plan, teaching module, student worksheets, a mathematical creative thinking skills test, observation sheets, a student response questionnaire, and validation instruments. A limited-scale trial was conducted involving 23 students enrolled in the Applied Bachelor's Program in Electronics Engineering at the State Polytechnic of Malang. Data were collected through observations, interviews, questionnaires, and tests and were subsequently analyzed in terms of validity, practicality, and effectiveness. The validation results yielded an average score of 3.38 (82.5%), which was categorized as highly valid. The practicality assessment yielded an average score of 3.38 (84.5%), indicating that the learning materials could be implemented effectively and received positive responses from the students. The students' average score increased from 56.78 on the pretest to 83.58 on the posttest, with an N-Gain score of 0.62, which was classified as moderate. The average achievement score for the indicators of mathematical creative thinking skills was 8.17. Therefore, the OBA-based RCODE learning materials were considered the instructional model met the criteria of validity, practicality, and effectiveness in improving students' mathematical creative thinking skills.

**Keyword:** RCODE; Outcome-Based Assessment; learning materials; mathematical creative thinking

## Introduction

Creative mathematical thinking is an essential competency that needs to be developed in mathematics education at the college level (Suherman & Vidákovich, 2022). This ability is not only related to mastering formulas and procedures but also encompasses the ability to generate new ideas, use a variety of problem-solving strategies, and formulate flexible and original solutions. Through these abilities, students can examine a problem from various perspectives and are not limited to a single solution method. Creative ability has long been one of the cornerstones of the education of gifted children and the development of their potential and talents for several decades(Alabbasi et al., 2025).

In mathematics education, creative mathematical thinking contributes to the development of a deeper conceptual understanding. Creative students tend to be able to connect mathematical concepts to contextual problems, develop or modify mathematical models, and communicate ideas and reasoning logically and systematically(Maemunah et al., 2025). These conditions support meaningful learning while fostering the development of Higher Order Thinking Skills(Zakiah et al., 2020). Creative mathematical thinking is also an important part of 21st-century skills, particularly in supporting critical thinking, problem-solving, communication, and collaboration(Manurung et al., 2023). In both daily life and the workplace, students are expected to be able to identify problems, explore various alternative solutions, and make the right decisions. Therefore, mathematics instruction must be designed through activities such as exploration, discussion, problem-solving, and reflection so that students' creativity can develop optimally.

Based on the results of the observations, students tend to be accustomed to solving problems by following the examples and procedures explained by the instructor. When presented with problems that differ from the examples or require more than one solution strategy, some students have difficulty developing alternative answers. They more often use general and routine solution methods and are not yet accustomed to examining problems from various perspectives. Every individual fundamentally has the potential to think and act creatively. However, the main challenge in the learning process is how to optimally develop that potential through classroom learning activities (Suripah & Sthephani, 2017). This situation results in the aspects of fluency, flexibility, originality, and elaboration in mathematical thinking not being fully developed(Ceballos et al., 2026). This issue is also influenced by students' perception that mathematics is a difficult, abstract subject that relies heavily on formulas. This perception can undermine students' self-confidence, motivation, and willingness to try different problem-solving strategies. Students become afraid of making mistakes and prefer to wait for solution examples rather than explore their own ideas. Therefore, a learning approach is needed that provides students with opportunities to read and understand problems, connect various concepts, make observations, engage in discussions, and evaluate solution outcomes. This type of learning is expected to transform procedural learning habits into a more active and meaningful learning experience that enhances students' creative mathematical thinking skills.

Strengthening mathematical creative thinking skills is a critical need in college-level mathematics education. These skills can be developed through the implementation of innovative instructional models and an outcome-based assessment system(Utami et al., 2020). This approach is expected to encourage students to actively engage, adopt a reflective attitude, and be productive in generating and developing various mathematical ideas. Mastery of creative mathematical thinking skills not only contributes to improving the quality of the learning process but also supports the development of graduates who are adaptable, competent, and ready to face various challenges at the global level(Agir et al., 2023).

To achieve this goal, instructional tools are needed that can facilitate students' engagement in understanding, connecting, communicating, and reflecting on mathematical concepts. One alternative approach that can be applied is the RCODE learning model, which consists of the stages of Reading, Connecting, Observing, Discussing, and Evaluating. This model organizes the learning process in stages, beginning with building initial understanding through reading activities, connecting new concepts to prior knowledge, observing various forms of mathematical representations, collaboratively discussing ideas, and evaluating and reflecting on both the learning process and outcomes. The RCODE learning model was chosen because its syntax (Reading, Connecting, Observing, Discussing, and Evaluating) systematically facilitates students in building conceptual understanding, connecting knowledge, engaging in discussion, and evaluating their thought processes. Although other models such as Problem-Based Learning (PBL), Project-Based Learning (PjBL), and Discovery Learning can also enhance creative thinking skills, RCODE is considered more suitable for the research problem at hand—namely, students' low ability to develop ideas, connect concepts, and generate various alternatives for solving mathematical problems. The effectiveness of the RCODE model will be validated by measuring students' mathematical creative thinking skills before and after instruction, supported by an analysis of improvements in learning outcomes, the implementation of the instructional process, and student feedback. Thus, the selection of RCODE is based on the alignment of the model's characteristics with the research problem and is substantiated by empirical data.

Through this series of activities, the RCODE model has the potential to develop students' creative mathematical thinking skills in a focused, systematic, and continuous manner. Meanwhile, developments in higher education curricula require the implementation of Outcome-Based Education (OBE), an educational system that emphasizes the achievement of student learning outcomes (Roza et al., 2025). In line with this approach, the learning evaluation process needs to implement Outcome-Based Assessment (OBA) an assessment system oriented toward the attainment of competencies as formulated in the learning outcomes. The implementation of OBE encompasses the entire educational process, from curriculum design, the formulation of learning objectives and outcomes, the selection of learning strategies and methods, to the development of a supportive educational environment. Within this framework, Outcome-Based Assessment (OBA) serves as an assessment system that ensures that the evaluation process and instruments are aligned with the established learning outcomes(Marnita & Zulprianto, 2022). Outcome-based assessment emphasizes that the entire assessment process must be structured consistently and aligned with the established learning outcomes(Gnanapriya & Savitha, 2023). Through the implementation of OBA, the assessment process can be carried out in a more systematic, measurable, targeted, and accountable manner, as each assessment indicator is developed based on expected learning outcomes. In line with (Kusuma et al., 2026) To analyze the extent of improvement in the mathematical critical thinking skills of D-III Electronics Engineering students after participating in instruction using the RCODE model. This study aims to determine the categories of students' critical thinking skills before and after the implementation of the ReCODE learning model, to measure the improvement in critical thinking skills following the implementation of the ReCODE model, and to analyze the similarities in the average critical thinking skills of students taught using the ReCODE model (Afdal et al., 2024). Based on this explanation, the purpose of this study is to identify RCODE The instructional model met the criteria of validity, practicality, and effectiveness in improving students' mathematical creative thinking skills.

**Method**

This study employs a Research and Development (R&D) approach. The development procedure follows Plomp’s model, which comprises five main stages: preliminary investigation, design, realization or construction, testing, evaluation, and revision, and implementation(Kusuma & Junus, 2022). developing instructional materials because it encompasses needs analysis, design, development, and validation, ensuring that the resulting product meets criteria for validity, practicality, and effectiveness. However, the implementation stage in this study was not carried out on a broader scale but was limited to the university where the research was conducted. The research subjects were 23 students enrolled in the Applied Electronics Engineering Undergraduate Program, Class 1C, in the even semester of the 2025/2026 academic year, taking the Mathematics 2 course on Fourier Series.

The product developed is a mathematics learning package using the RCODE model based on Outcome-Based Assessment (OBA). This package includes the Semester Learning Plan (RPS), Student Assignment Plan (RTM), learning modules, student worksheets (LKM), and a test instrument for students’ Mathematical Creative Thinking Skills (KBKM). Procedures for developing the learning materials and research instruments in this study.

The Preliminary Investigation phase involves a literature review of relevant books, articles, and journals, accompanied by a preliminary study of the research subject. This activity aims to identify needs and issues, establish research boundaries, and determine the competencies to be achieved. The initial analysis covers the curriculum, graduate learning outcomes, and student characteristics. The Design phase produces a preliminary design of the instructional materials, a guide for educators on implementing the instruction, a research support system, and a design outlining the expected learning outcomes. The Realization/Construction phase resulted in a preliminary draft of the OBA-based RCODE instructional package. The package includes the Course Syllabus (RPS), Teaching Plan (RTM), instructional modules, worksheets (LKM), a test of creative mathematical thinking skills, student activity observation sheets, instructional implementation sheets, student response questionnaires, and instructional package validation sheets. In addition, a support system and instructional implementation scenarios were developed.

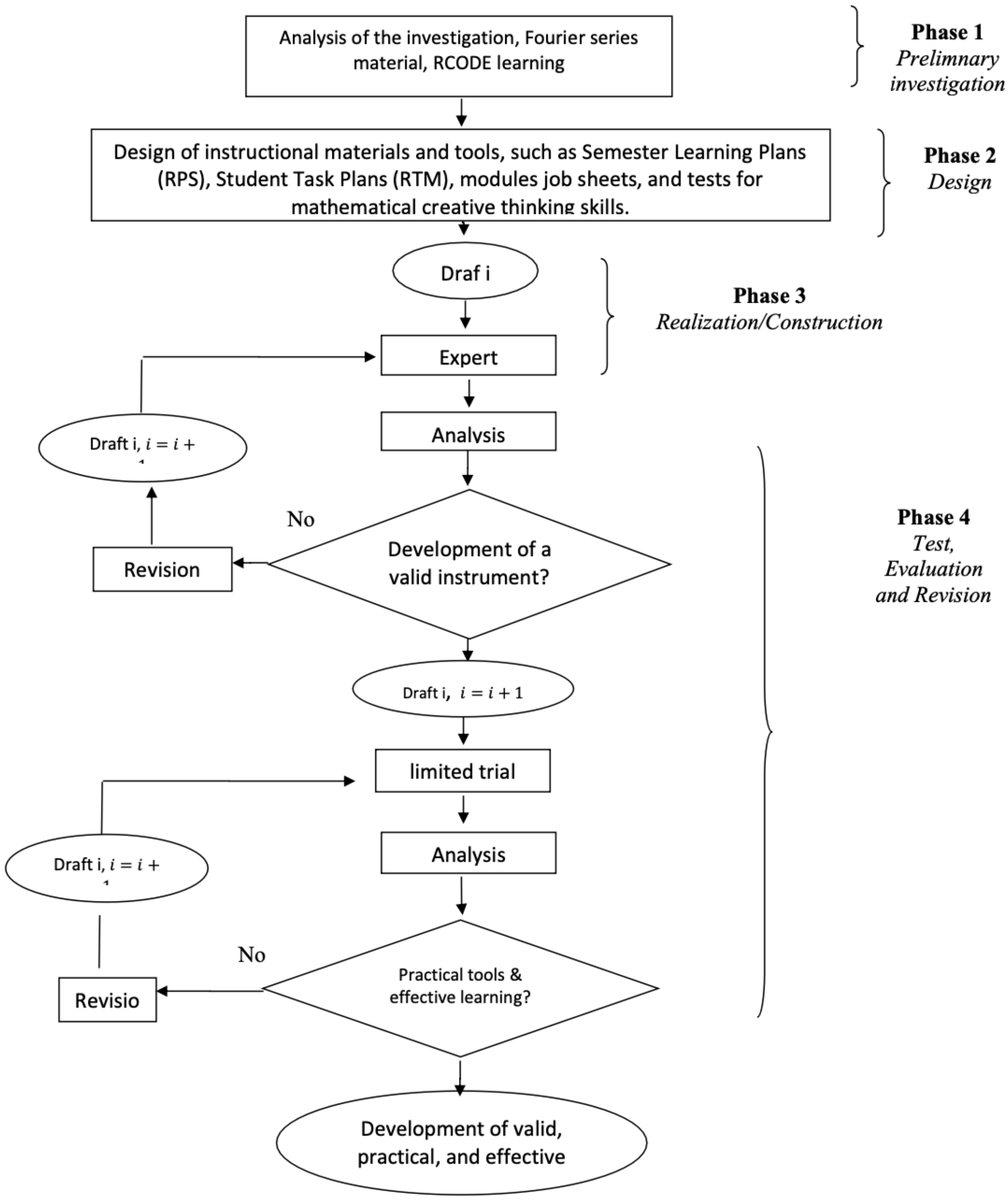


**Figure 1.** The Plomp Approach

The Test, Evaluation, and Revision phase involved validation and limited pilot testing to assess the validity, practicality, and effectiveness of the instructional materials. The evaluation results were used as the basis for revisions through a feedback cycle until the materials met the established criteria. Data collection was conducted through observation, interviews, questionnaires, and tests. Data analysis included tests of normality, homogeneity, mean achievement, proportion of mastery, and improvement. Class 1C served as the experimental sample and was taught using the RCODE approach with Outcome-Based Assessment (OBA), while Class 1A served as the control group and was taught using the expository approach.

**Table 1.** Criteria for Testing Instructional Materials

| **Score** | **Criteria** |
|---|---|
| 81,25% ≤ P≤ 100% | Very Valid/Practical |
| 62,25% ≤ P<81,25% | Valid/Practical |
| 43,75% ≤ P<62,25% | Not Very Valid/Practical |
| 25,00% ≤ P<43,75% | InValid/Practical |

Source: (Hidayati Husna & Pritasari, 2024)

The implementation phase was carried out in accordance with the conditions prevailing during the study, particularly at the research site and in the surrounding environment. Other stages were also carried out with due consideration for the evolving situation and conditions in the field. Once the evaluation process was completed and a viable product was produced, that product could, in principle, be applied to a wider area. However, in this study, implementation was limited to the schools that served as the research sites and was not extended to other areas.

## Results and Discussion

The research was conducted during the even semester of the 2025/2026 academic year with students in Class 1C of the Applied Bachelor's Degree Program in Electronic Engineering serving as the experimental group. Creative mathematical thinking is one of the key competencies students need to possess in order to tackle various learning challenges and increasingly complex real-world problems. This ability is not only related to the mastery of mathematical formulas and procedures but also encompasses the ability to generate new ideas, formulate various alternative solution strategies, and develop flexible, appropriate, and original solutions to mathematical problems. Through creative thinking, students can analyze a problem from various perspectives so that they do not rely solely on a single approach to solving it.

In college-level mathematics education, the ability to think creatively in mathematics plays a strategic role in helping students develop a deeper conceptual understanding. Students with mathematical creativity tend to be better able to connect mathematical concepts to various contextual situations, develop and modify mathematical models, and present ideas and arguments logically, coherently, and systematically(Azis, 2024). These abilities can support a more meaningful learning process that is oriented toward the development of higher-order thinking skills (HOTS). Thus, strategies to enhance students' creative mathematical thinking skills must be a primary focus in the implementation of higher education.

The preliminary investigation phase serves as the foundation for developing the RCODE learning tool based on Outcome-Based Assessment (OBA). A review of books, articles, and journals was conducted to establish a theoretical foundation regarding the RCODE model using OBA, as well as mathematical creative thinking skills. Additionally, a preliminary study of the research subject helped identify learning conditions, student needs, and issues that arise in the mathematics learning process. A curriculum analysis was conducted to ensure that the developed materials align with the existing learning structure. An analysis of graduate learning outcomes served as the basis for determining the competencies students must achieve, while an analysis of student characteristics was necessary to ensure that the content, activities, and assessment formats are appropriate for their ability levels and learning needs. The instruments used to grade students—both for assignments and test questions—do not yet utilize OBA and do not provide assessment rubrics. Thus, the initial investigation phase serves not only to identify problems but also to ensure that the developed materials are relevant to the curriculum, student characteristics, and expected learning outcomes. The findings from this stage point to the need for instructional design that not only focuses on the delivery of content but also encourages students to read, connect concepts, observe mathematical representations, discuss problem-solving strategies, and evaluate their learning outcomes. This need formed the basis for selecting the RCODE model, integrated with OBA, to support the development of students' creative mathematical thinking skills.

The design phase produces a preliminary design of the instructional materials, developed based on the results of the initial investigation. At this stage, instructional components are designed in a structured manner, taking into account the interrelationships among learning outcomes, content, student activities, instructional strategies, and assessment methods. This design is essential to ensure that each learning activity has a clear direction and supports the achievement of student competencies. The stages of the RCODE model are integrated into the instructional design. The Reading activity is designed to build students' initial understanding of the material, using Fourier series as a sample topic. The Connecting stage is used to link new concepts to prior knowledge. The Observing stage facilitates students in observing patterns, data, graphs, and mathematical representations. The Discussing stage provides students with the opportunity to present, compare, and develop alternative solutions. Furthermore, the Evaluating stage is designed to help students assess the process and results of problem-solving.

**Table 2.** Description of Research Material

| Program Learning Outcomes | Course Learning Outcomes | Discussion | Assessment Types and Criteria |
|---|---|---|---|
| An ability to identify and apply knowledge of mathematics, natural sciences, information technology, and electrical engineering required for applied engineering procedures, processes, systems, or methodologies | Students are able to solve electrical engineering problems using Fourier series | - Periodic functions<br>- Fourier series concepts<br>- Odd and even function<br>- Applications of Electrical Engineering | Type: Job Sheet/ worksheet, Test Questions<br>Criteria: Based on assessment rubric |

The integration of OBA into the design phase is realized through the formulation of assessment indicators aligned with learning outcomes. Consequently, learning activities and assessments measure not only content mastery, but also students' abilities to generate diverse ideas, utilize flexible strategies, develop detailed solutions, and provide original answers. This design demonstrates alignment among learning objectives, instructional processes, and assessment. Beyond the core tools, the design phase also includes teaching implementation guidelines for educators, activity scenarios, research support systems, and expected learning impacts. These guidelines are essential to ensure that every stage of the RCODE model is implemented consistently, rather than relying solely on individual educator interpretation during the learning process

In the realization or construction phase, the developed design is translated into an initial draft of OBA-based RCODE learning materials. The resulting products include the Semester Learning Plan (RPS), Student Assignment Plan (RTM), teaching module, Student Worksheet (LKM)/Jobsheet, mathematical creative thinking ability test, student activity observation sheet, learning implementation sheet, student response questionnaire, and instrument validation sheet. The development of the RPS serves to provide overall direction for instructional execution, including learning outcomes, content, methods, learning experiences, and assessment systems. The RTM is designed to guide students in completing assignments aligned with the targeted competencies. The teaching module functions as a learning resource that systematically contains content and activities, while the LKM is used to facilitate students in actively engaging with the RCODE stages. The learning process is carried out over four meetings on the topic of Fourier series.

**Table 3.** Test Item Validatio

| Questions item | Validity | Reliability | Difficulty level | Discriminity | Information |
|---|---|---|---|---|---|
| 1 | Valid | Very high | Easy | Good | Used |
| 2 | Valid | | Moderate | Good | Used |
| 3 | Invalid | | difficult | Good | Not Used |
| 4 | Invalid | | Moderate | Good | Not Used |
| 5 | Valid | | difficult | Good | Used |
| 6 | Valid | | Moderate | Good | Not Used |

Based on the table, out of the six test items, four items are declared valid, namely numbers 1, 2, 5, and 6, while items 3 and 4 are not valid. The test instrument has very high reliability, thus it is considered consistent in measuring students' abilities. In terms of difficulty level, the questions are categorized as easy, medium, and hard, with good to very good discrimination power. Based on the analysis results, questions number 1, 2, and 5 were used, while questions number 3 and 4 were not used because they were not valid. Question number 6 was not used based on considerations of time allocation, indicator suitability, or instrument needs.

The test of creative thinking skills in mathematics is developed to measure the achievement of students' abilities after participating in the learning process (Kusuma, 2020) The instrument needs to represent indicators of fluency, flexibility, originality, and elaboration in solving mathematical problems. Meanwhile, the observation sheet for student activities and the implementation of learning is prepared to determine whether the RCODE stages can be applied as designed. The student response questionnaire is used to obtain information regarding ease of use, clarity of presentation, usefulness, and student acceptance of the learning device. The quality of the device is reviewed based on the aspects of validity, practicality, and effectiveness. The validity of the learning device is determined based on the assessment results of the validators regarding the aspects of content, presentation, language, conformity with the RCODE model stages, and its relation to the OBA principles. The validation of the learning device is conducted by 1 expert validator and 2 peer validators with an average assessment using a Likert scale (1-4) (Eva Weddakarti et al., 2023).

**Table 4.** Expert and Peer Validation Results

| Devices | Notes | Score | Criteria |
|---|---|---|---|
| RPS | Adjust the CPMK, learning activities, and assessments | 3,56 | Very Valid |
| RTM | Clarify task instructions and assessment criteria Improve | 3,57 | Very Valid |
| Modul | The systematics, language, and material examples | 3,33 | Very Valid |
| Jobsheet/ Worksheet | Clarify the work steps according to the RCODE stages and scoring rubric | 3,00 | Valid |
| test questions | Align the question items with the indicators and scoring rubric | 3,27 | Valid |
| Average | | **3,36** | **Very Valid** |

Based on the table, an average score of 3.36 (84%) was obtained with a very good criterion, indicating that the learning device has a high level of validity and is suitable for use in learning activities. Suggestions and feedback from the validators were used to improve the clarity of instructions, the systematic presentation, the alignment of learning achievement indicators, and the wording of the instruments. After the revision, the OBA-based RCODE learning device was declared to meet the valid criteria.

The practicality of the device is reviewed based on the implementation of learning and student responses. The trial was conducted with 23 students by applying the stages of Reading, Connecting, Observing, Discussing, and Evaluating. The practicality indicator can be seen from the learning implementation instrument, which was observed by 2 colleagues and thru a questionnaire of positive student responses.

**Table 5.** Results of the Practicality Indicator of Learning Devices

| Practical | Score |
|---|---|
| Implementation of learning | 3,50 |
| Positive response from students | 3,26 |
| **Avarage** | 3,38 |

The results of the table show that the average percentage of learning implementation and positive student responses reached 84.5% (3.38). This indicates that most of the learning activities designed in the RPS and supporting devices can be implemented according to the stages of the RCODE model. Students responded positively to the clarity of instructions, presentation of materials, ease of use of LKM and teaching modules, as well as the discussion and evaluation activities conducted during the learning process. Based on these results, the OBA-based RCODE learning tools are deemed to meet practical criteria

The effectiveness of the learning devices is reviewed based on the results of the KBKM test and the students' learning completeness. The individual mastery criterion is set at a minimum score of 66. The test results show that the students' posttest KBKM scores are better than their pretest scores. These findings indicate an Students' mathematical creative thinking skills improved following their participation in RCODE-based learning on OBA. This improvement is evident in the students' ability to generate various alternative solutions, connect mathematical concepts, develop ideas, and evaluate the strategies used for problem-solving.

**Table 6.** Results of Normality Testing

| | Kolmogorov-Smirnov[a] | | |
|---|---|---|---|
| | **Statistic** | **Df** | **Sig.** |
| Data | .083 | 47 | .200* |

a. Lilliefors Significance Correction

The experimental class data consisted of 23 students, while the control class had 24 students. The normality test result showed a significance value of sig=0.200 > 0.05, which means the research data is normally distributed.

**Table 7.** Homogeneity Testing

| | | Levene's Test for Equality ofvariances | |
|---|---|---|---|
| | | F | Sig. |
| **Data** | Equel variances assumed | 1.255 | .275 |
| | Equel variances not assumed | | |

Homogeneity Test: The data shows that the homogeneity test result is sig=0.275>0.05, which means the variance between the experimental class and the control class is the same. Average completeness testing with $n = 23$, $\overline{x} = 75$, $\mu_0 = 66$, $s = 8.180$ obtained $t = 5.277$. The test was conducted with the above calculations, t calculated ≥ t (1-α) with a significance of 5%, df = (23-1) = 12 is 1.717, meaning t calculated > t table or 5.277 > 1.717, which means the average score of the experimental class students' mathematical creative thinking ability test exceeds 66. Classically, around 75% of students score at least 66. With n = 23, π_0=0.75, x = 21, Z=1.806. Based on the calculation results, it is greater than the Z table value of 1.645 at a 5% significance level. Therefore, H0 is rejected and H1 is accepted. This result indicates that the proportion of students who scored more than 66 has exceeded 75%. Thus, the majority of students have met the established completion criteria. In addition, the positive response from students and the implementation of learning at 81.5% also support the achievement of the effectiveness aspect of the device. The testing of the improvement in mathematical creative thinking skills is conducted by comparing the initial test scores and the final test scores obtained by students during the learning process. The extent of the improvement in ability is calculated using the Normalized Gain (N-Gain) formula.

**Table 8**. Calculation of N Gain

| Score | Pretest | Posttest | NGain |
|---|---|---|---|
| **Average** | 56,78 | 83,58 | 0,62 |

N Gain Calculation Based on the calculation results, a Normalized Gain (N-Gain) value of 0.62 was obtained. This value falls within the range, thus categorizing it as a moderate improvement. These results indicate that the implementation of RCODE learning can significantly enhance students' creative mathematical thinking abilities. After participating in RCODE learning, students experienced improvements in understanding problems, connecting various mathematical concepts, observing available information, discussing alternative solutions, and evaluating the accuracy of the answers produced. Although the improvement achieved has not reached a high category, the N-Gain value of 0.62 indicates that RCODE learning is quite effective in helping students achieve most of the potential improvement in their abilities based on their initial scores. Thus, the implementation of RCODE learning has a positive impact on the enhancement of students' mathematical critical thinking skills, but further refinement in the learning implementation is needed to reach a higher category of improvement. Based on the improvement in KBKM test results and the achievement of student learning completeness, the OBA-based RCODE learning device is declared to meet the effectiveness criteria.

**Table 9.** Indicator of students' creative mathematical thinking ability

| Indicator | Score |
|---|---|
| Fluency | 8,45 |
| Flexibility | 8,20 |
| Originality | 7,65 |
| Elaboration | 8,38 |
| Sum | 32,68 |
| Average | 8,17 |

Based on Table 8, the students' mathematical creative thinking ability received an average score of 8.17 (scale of 0–10). The results indicate that the learning process has been able to encourage students to develop various aspects of creativity in solving mathematical problems. The fluency indicator received the highest score, which is 8.45. This indicates that during the learning process, students are able to generate several ideas, answers, or alternative solutions to the given problems. The elaboration indicator received a score of

8.38, which reflects the students' ability to develop answers in detail, organize solution steps systematically, and provide explanations for the strategies used. The flexibility indicator received a score of 8.20. This score indicates that students have been able to use various methods, perspectives, or representations in solving mathematical problems. Meanwhile, the originality indicator received the lowest score, which is 7.65. Although still considered good, these results indicate that students' ability to generate strategies or answers that are truly unique and different from commonly used methods still needs improvement. Overall, the results indicate that the learning process has provided students with the opportunity to explore various possible solutions, choose appropriate strategies, develop ideas, and explain their answers in detail. However, the learning activities still need to provide more open-ended questions, non-routine problems, and opportunities for discussion so that students' originality can develop more optimally.

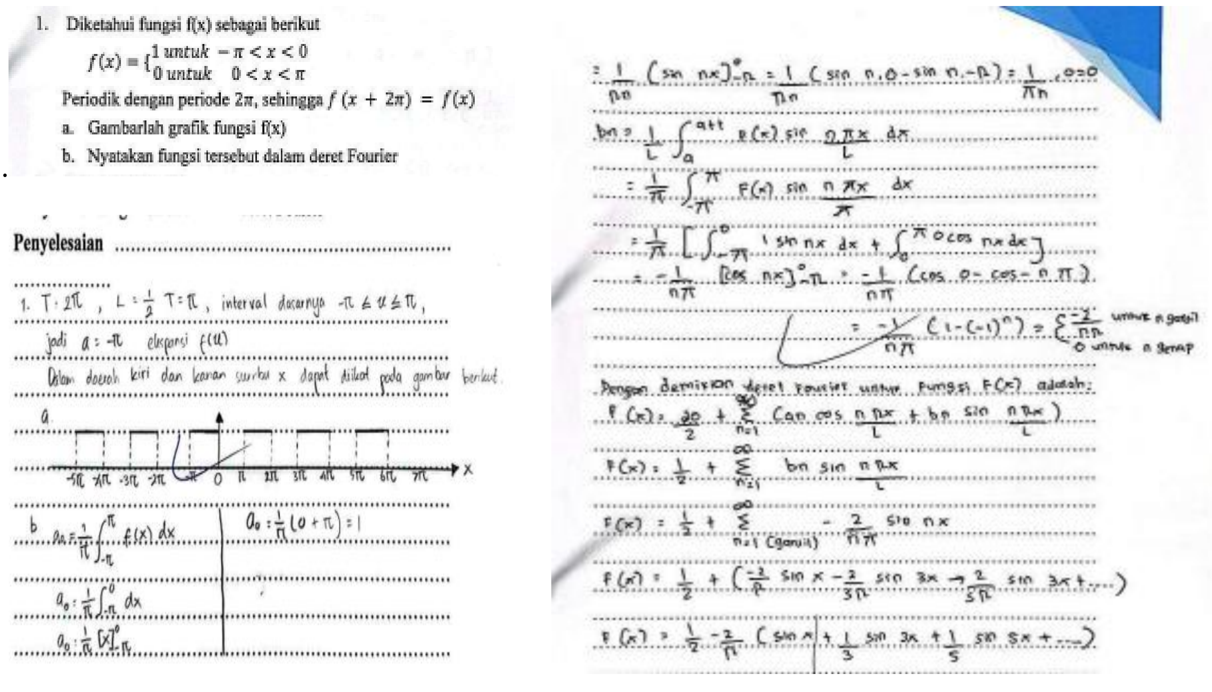


**Figure 2.** Example of Student Problem Solving

The students' answers to question number 1 demonstrate their ability to think creatively in mathematics thru the presentation of functions in the form of graphs and Fourier series. The aspect of fluency is evident in the students' smoothness in arranging the steps of the solution sequentially, starting from determining the period, drawing the graph, to calculating the coefficients of the Fourier series. The aspect of flexibility is demonstrated thru the use of visual and symbolic representations in explaining the function. The ability to elaborate is evident in the detailed process of calculating coefficients and the development of the pattern of Fourier series terms. However, the aspect of originality has not yet been prominently observed because the students are still using common solution procedures without presenting alternative approaches. Overall, the answer is stronger in terms of fluency, flexibility of representation, and ability to elaborate compared to the originality of the strategy. In line(Wilkie, 2024) Mathematics learning shows an increased orientation toward providing equal opportunities for all students to develop creative thinking skills. The results presented (Cen et al., 2026) indicate that the assessment of mathematical creative thinking skills requires an approach that integrates gradual analysis with in-depth qualitative diagnosis thru the study of work results and student interviews.

## Conclusion and Suggestion

This research produced the RCODE learning device based on Outcome-Based Assessment on Fourier series material, which consists of Semester Learning Plans, Student Assignment Plans, teaching modules, student worksheets, mathematical creative thinking ability tests, and supporting assessment instruments. The validation results obtained an average score of 3.53 or 88.3%, categorizing the learning device as very valid. The practicality assessment results obtained an average score of 3.38 or 84.5%, indicating that the device can be applied according to the stages of Reading, Connecting, Observing, Discussing, and Evaluating, and received positive responses from students. The learning device also meets the criteria for effectiveness. The average student score increased from 56.78 on the initial test to 83.58 on the final test, with an N-Gain value of 0.62, which falls into the moderate improvement category. The average score for the indicators of mathematical creative thinking ability reached 8.17 on a scale of 0–10. The fluency indicator received the highest score of 8.45, followed by elaboration at 8.38, flexibility at 8.20, and originality at 7.65. The results indicate that RCODE learning can help students generate various alternative solutions, use diverse mathematical representations, develop ideas systematically, and evaluate solution strategies. However, the ability of originality still needs to be improved thru the provision of open-ended questions, non-routine problems, and learning activities that give students more space to produce unique solutions. Thus, the RCODE learning device based on OBA is declared the criteria of validity, practicality, and effectiveness in improving students' mathematical creative thinking skills. Subsequent research is recommended to conduct trials with a larger number of students, different mathematics materials, and various study programs or universities to determine the effectiveness of the device more broadly. In addition, the learning tools need to be continuously refined based on the evaluation results, student responses, and the development of learning outcomes. Further development can also be directed toward the use of digital learning media and the implementation of learning over a longer period to ensure that the improvement in students' creative mathematical thinking reaches a high category.

**References**

Afdal, R. A., Hasanuddin, H., Saenab, S., & Makassar, U. N. (2024). Penerapan Model Pembelajaran Reading, Connecting, Observing, Discussing, Evaluating (ReCODE) untuk Meningkatkan Keterampilan Berpikir Kritis Peserta Didik Kelas VIII SMP IT Nurul Fikri. *Celebes Science Education-CSE* , *3*(1), 1–10. https://doi.org/10.26858/cse.v3i1

Agir, N., Effendi, M., Matore, E. M., Faamanatu-Eteuati, N., & Marquez, N. (2023). Outcome-Based Assessment in The Evaluation of Education Programs Through a Systematic Literature Review. *International Journal of Academic Research in Progressive Education and Development*, *12*(2). https://doi.org/10.6007/ijarped/v12-i2/18095

Alabbasi, A. M. A., Lamb, K. N., Acar, S., Plucker, J. A., Alabbasi, G. M., & Aljasim, F. A. (2025). Examining the effect of primary education thinking skills curriculum on the creative thinking abilities of gifted female students. *Thinking Skills and Creativity*, *58*. https://doi.org/10.1016/j.tsc.2025.101908

Azis, S. (2024). Kemampuan Berpikir Kreatif peserta Didik melalui Model ReCODE pada Pembelajaran Biologi. *Journal on Education*, *6*(3), 15748–15758.

Ceballos, H., Bogaart, T. van den, van Ginkel, S., Spandaw, J., & Drijvers, P. (2026). How collaborative problem solving promotes higher-order thinking skills: A systematic review of design features and processes. *Thinking Skills and Creativity*, *59*. https://doi.org/10.1016/j.tsc.2025.102001

Cen, J., Bokhove, C., & McIntyre, N. (2026). Cross-cultural differential item functioning in the PISA 2022 creative thinking assessment. *Thinking Skills and Creativity*, *61*. https://doi.org/10.1016/j.tsc.2026.102210

Eva Weddakarti, Silvia Rahmi Ekasari, Adi Candra Kusuma, & Heru Prasetyo. (2023). Validitas Modul Ajar Kemampuan Berfikir Kritis melalui Case Based Learning untuk Mahasiswa. *JURNAL PENDIDIKAN MIPA*, *13*(3), 763–769. https://doi.org/10.37630/jpm.v13i3.1166

Gnanapriya, K. M., & Savitha, S. (2023). Assessment of Learning Outcomes in Outcome Based Education. *International Journal of Academic Research In Progressive Education And Development*, *12*(2), 2483–2497. https://doi.org/http://dx.doi.org/10.6007/IJARPED/v12-i2/18095

Hidayati Husna, R. ’, & Pritasari, A. C. (2024). Pengembangan Perangkat Pembelajaran Model Project Based Learning Untuk Menumbuhkan Kemmapuan Berfikir Kritis (Development of Project-Based Learning Instructional Tools to Foster Critical Thinking Skills). *JOURNAL OF MATHEMATICS LEARNING INNOVATION (JMLI)*, *3*(1), 45–59. https://doi.org/10.35905/jmlipare.v3i1

Kusuma, A. C. (2020). *The practicality of Problem Based Learning tools with a scientific approach to improve students ' critical thinking ability*. *9*(1), 1–10. https://doi.org/10.15294/ujme.v9i1.37081

Kusuma, A. C., Al Azhar, G., Wahono, W. T., Hendra Putra, D. R., Sumarmo, A. S. H., & Hidayat, A. R. (2026). Peningkatan Kemampuan Berfikir Kritis Matematis Melalui Implementasi Pembelajaran RCODE (Reading, Connecting, Observing, Discussing, Evaluating). *AKSIOMA: Jurnal Program Studi Pendidikan Matematika*, *15*(1), 223–235. https://doi.org/10.24127/ajpm.v15i1.14747

Kusuma, A. C., & Junus, M. (2022). Pengembangan Perangkat Pembelajaran Daring Dengan Pendekatan Problem Based Learning Untuk Meningkatkan Kemampuan Pemecahan Masalah Matematik Mahasiswa. *JPM: Jurnal Pendidikan Matematika*, *8*(1), 37–46.

Maemunah, S., Fitriani, N., Nurfauziah, P., Siliwangi, I., Terusan, J., & Sudirman, J. (2025). Meningkatkan Pemahaman Konsep Matematis mellaui Discovery Learning Berbantuan Geogebra. *Jurnal Pembelajaran Matematika Inovatif* , *8*(6), 761–776. https://doi.org/10.22460/jpmi.v8i6.28261

Manurung, M. L., Harahap, N. P., Maia Faiza Nasution, Meido Krisna Sipayung, & Maria Christina Aprilia Naibaho. (2023). Peran Komunikasi Dan Kolaborasi Matematika Dalam Mengembangkan Keterampilan Abad 21 Peran Komunikasi Dan Kolaborasi Matematika Dalam Mengembangkan Keterampilan Abad 21 (The Role Of Mathematics Communication And Collaboration In Developing 21 st Century Skills). *JPNM (Jurnal Pustaka Nusantara Multidisplin)*, *1*(4), 1–5.

Marnita, R. A., & Zulprianto, Z. (2022). Implementation of Outcome-Based Assessment in English Morphology Courses at the. *4th International Conference on Educational Development and Quality Assurance* , 285–288. https://www.k12academics.com

Roza, Y., Id, I. D., Andriyani, Y., Kurniawan, R., & Adnan, A. (2025). Toward Precision on Evaluation: Hierarchical Weighting-Based Assessment on Implementation of Outcome-Based Curriculum. *Journal of Curriculum Studies Research*, *7*(2), 53–72. https://doi.org/10.46303/jcsr.2025.11

Suherman, S., & Vidákovich, T. (2022). Assessment of mathematical creative thinking: A systematic review. *Thinking Skills and Creativity*, *44*. https://doi.org/10.1016/j.tsc.2022.101019

Suripah, S., & Sthephani, A. (2017). Kemampuan berpikir kreatif matematis mahasiswa dalam menyelesaikan akar pangkat persamaan kompleks berdasarkan tingkat kemampuan akademik. *PYTHAGORAS Jurnal Pendidikan Matematika*, *12*(2), 149–160. https://doi.org/10.21831/pg.v12i2.16509

Utami, R. W., Endaryono, B. T., & Djuhartono, T. (2020). Meningkatkan Kemmapuan Berfikir Kreatif Matematis Siswa Melalui Pendekatan Open-Ended. *Faktor Jurnal Ilmiah Kependidikan*, *7*(1), 43–48. https://doi.org/http://dx.doi.org/10.30998/fjik.v7i1.5328.g2997

Wilkie, K. J. (2024). Creative thinking for learning algebra: Year 10 students' problem solving and problem posing with quadratic figural patterns. *Thinking Skills and Creativity*, *52*. https://doi.org/10.1016/j.tsc.2024.101550

Zakiah, N. E., Fatimah, A. T., & Sunaryo, Y. (2020). *Implementasi Project-Based Learning Untuk Mengeksplorasi Kreativitas Dan Kemampuan Berpikir Kreatif Matematis Mahasiswa*. https://jurnal.unigal.ac.id/index.php/teorema/article/view/4194