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# Development of Creative Alternative Assessments for Mathematics Learning Using a Design Thinking Approach

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**Abstrak.** Asesmen alternatif pembelajaran matematika menghadapi sejumlah tantangan yang perlu dirancang untuk mengukur kemampuan peserta didik secara holistik. Tujuan penelitian ini adalah 1) untuk mengetahui bagaimana pengembangan asesmen alternatif pembelajaran matematika kreatif dengan pendekatan design thinking layak, 2) untuk mengetahui efektivitas pembelajaran matematika asesmen alternatif dengan pendekatan design thinking. Sampel penelitian ini adalah mahasiswa di S2 Pendidikan Matematika Universitas PGRI Semarang. Penelitian ini menggunakan Model pengembangan Plomp J, Nieven N. Pengembangan asesmen alternatif matematika kreatif menggunakan pendekatan design thinking. Data yang dianalisis adalah a) data *pretest*, b) data *posttest*, c) Analisis untuk mengetahui efektivitas, meliputi: perhitungan nilai n-gain (*pretest-posttest*), dan uji ketuntasan. Hasil penelitian; 1) pengembangan asesmen alternatif pembelajaran matematika kreatif dengan pendekatan design thinking layak digunakan, 2) efektivitas pembelajaran matematika asesmen alternatif dengan pendekatan design thinking, ditunjukkan dengan a) rata-rata hasil belajar mahasiswa sebelum dan setelah menggunakan asesmen alternatif pembelajaran matematika kreatif dengan pendekatan *design thinking* mengalami peningkatan, b) hasil belajar mahasiswa dengan menggunakan asesmen alternatif pembelajaran matematika kreatif dengan pendekatan *design thinking* mencapai tuntas.
**Kata kunci:** Pengembangan; Penilaian Alternatif; Pembelajaran Matematika; Desain Berpikir.

***Abstract.*** *Alternative assessments in mathematics education face several challenges that need to be designed to measure students' abilities holistically. The objectives of this research are: 1) to determine the feasibility of developing creative alternative mathematics assessments using a design thinking approach, and 2) to assess the effectiveness of mathematics learning using alternative assessments with a design thinking approach. The research sample consists of graduate students from the Mathematics Education program at PGRI University Semarang. This study employs the development model proposed by Plomp J and Nieveen N. The development of creative alternative mathematics assessments using a design thinking approach is analyzed through: a) pretest data, b) posttest data, and c) effectiveness analysis, including n-gain calculations (pretest-posttest) and completeness testing. The findings indicate that: 1) the development of creative alternative mathematics assessments with a design thinking approach is deemed feasible for use, and 2) the effectiveness of alternative mathematics assessments using a design thinking approach is evidenced by: a) an increase in the average learning outcomes of students before and after using the creative alternative*

*mathematics assessment with a design thinking approach, and b) student learning outcomes meeting the completeness criteria when using the creative alternative mathematics assessment with a design thinking approach.*
***Keywords:*** *Development; Alternative Assessment; Mathematics Learning; Design Thinking*

## INTRODUCTION

The development model known as the Plomp J and Nieveen N Model is a framework used in learning development. This model was developed by J. Plomp and N. Nieveen in 2007. It aims to assist educational development by integrating information and communication technology (ICT) into the learning process. The Plomp J and Nieveen N Model consists of four main stages: analysis, design, development, and implementation.

The development process includes several stages:

1. Analysis Stage: This stage identifies the needs and objectives of the learning process, involving data collection on the learning context, student characteristics, available resources, and potential technologies for use.
2. Design Stage: This involves developing a learning design based on the analysis results. It includes selecting learning strategies, developing learning materials, and planning the use of ICT.
3. Development Stage: The designed learning plan is realized into learning products that can be used in educational contexts. This process includes creating and testing learning prototypes and revising them based on stakeholder feedback.
4. Implementation Stage: This involves the application of the developed learning products in real learning environments, training for instructors and students, monitoring the learning implementation, and evaluating the effectiveness of the learning product.

The Plomp J and Nieveen N Model provides a comprehensive framework for technology-integrated learning development. By following the structured steps in this model, learning developers can ensure that the developed learning products are relevant, effective, and suited to specific learning context needs.

**Alternative Assessment in Mathematics Learning**

Alternative assessment in mathematics learning allows educators to evaluate students' understanding and mathematical abilities through methods that differ from traditional written tests. This approach aims to provide a more comprehensive picture of students' ability to understand mathematical concepts and apply them in real-world situations.

While the terms "evaluation" and "assessment" are often used interchangeably, there is an essential difference between them. Assessment refers to a method of uncovering the learning process and progress. It continuously provides feedback for improving student learning. Meanwhile, evaluation refers to the judgment of learning outcomes based on data obtained through assessments (Kumano et al., in Anetha L. F. Tilaar, 2018).

One form of alternative assessment in mathematics learning is a mathematics project. In such projects, students are tasked with solving challenging problems or projects requiring the application of mathematical concepts in relevant and meaningful contexts. Examples include creating mathematical models, researching specific mathematical topics, or solving real-world problems involving mathematical concepts.

The main objectives of using assessments in classroom learning are to help educators and learners make professional decisions to improve learning. According to Popham (in Anetha L. F. Tilaar, 2018), assessments aim to:

1. Diagnose students' strengths and weaknesses.
2. Monitor students' progress.
3. Determine students' ability levels.
4. Evaluate the effectiveness of learning.
5. Influence public perception of the effectiveness of learning.
6. Assess classroom teacher performance.
7. Clarify the learning objectives designed by teachers.

Beyond mathematics projects, alternative assessments may also involve the use of portfolios. In mathematical portfolios, students compile evidence of their work, such as problem solutions, mathematical explorations, and reflections on

their learning. This provides a more holistic picture of students' development and allows them to monitor their progress over time.

Alternative assessments in mathematics can also include creative tasks, such as math games or computer simulations. These tasks allow students to apply mathematical concepts in interesting and challenging contexts while developing problem-solving and critical thinking skills. Previous research conducted by Irenata GE. et al. (2023) examined the creative thinking skills of junior high school students with high, medium, and low math abilities in solving multiple solution tasks. By using alternative assessments, educators can gain deeper insight into students' understanding and abilities, while providing more meaningful and effective learning experiences. This approach also helps students develop creative math skills that are relevant to everyday life and the real world.

**Principles and Strategies of Creative Learning**

Creative learning principles include construction, management, curiosity, questioning, collaboration, creative elaboration, guided problem-solving, and an open ethos. Solving a problem creatively requires an appropriate application (Cremin T., 2012; Hirsh R.A., 2010). Purwosetiyono et al. (2018) highlighted the importance of developing creative thinking skills for students to approach mathematical problems from various perspectives based on their learning experiences (Multi-representation).

Creative learning strategies include lesson planning, contextual problems, engaging students, applying creative or non-routine tasks, managing classroom skills, open-ended questions, encouraging creative thinking, and using technology and multimedia. Real-life experiences serve as the foundation for creative thinking in education (Mann E.L., 2006; Tudor R., 2008; Horng J.S. et al., 2005; Purwosetiyono et al., 2020; Purwosetiyono et al., 2023).


**Figure 1. Design Thinking Stages (Razzouk, R., & Shute, V., 2012)**

The steps of design thinking, according to Razzouk, R., & Shute, V. (2012), are as follows:

1. Empathize / Discover (Understand & Observe): Gain a deep understanding of users or stakeholders involved through observation, interviews, and data collection. (Divergent thinking: insights into their experiences and needs).
2. Define (Interpret / Point of View): Clearly identify the problem to be solved and formulate a well-defined problem statement. (Convergent thinking).
3. Ideate: Generate as many ideas or solutions as possible without judgment or prioritization. (Creative Thinking / Divergent thinking).
4. Prototype: Develop selected ideas into simple prototypes or models as representations of potential solutions.
5. Test: Test the prototypes with relevant users or stakeholders to understand how well the solution meets their needs and identify areas for improvement. (Convergent thinking).

In the context of creative mathematics, design thinking can be used to design assessments that are challenging, stimulate creative thinking, and integrate mathematical concepts with real-world applications. This approach encourages students to think divergently, explore solutions, and be problem-solvers in addressing mathematical challenges.

**Effective Learning and Creative Teaching**

Effective learning is a process where students not only acquire knowledge but also develop deep understanding, skills, and attitudes relevant to the subject matter. Various approaches and methods can be employed to create effective learning,

emphasizing teaching strategies that foster a challenging, relevant, and supportive learning environment conducive to student growth. Creative learning promotes effectiveness through cultural factors and problem-solving approaches. These concepts have been studied by researchers from various countries, including Leikin R. et al. (2012); Mastuti A.G. et al. (2016); Agdogan E.E. & Sag G.Y. (2015); Ibragimkyzya S. et al. (2016); Tudor R. (2008); and Kattou M. et al. (2009).

A key element of effective learning is a focus on conceptual understanding. Students are guided to grasp fundamental concepts underlying the facts and information they learn rather than merely memorizing them. Conceptual understanding provides a strong foundation for applying knowledge in diverse contexts and developing robust problem-solving skills.

Effective learning also emphasizes active student engagement in the learning process. This can be achieved through student-centered approaches, where learners actively participate in exploration, discussion, and reflection on the subject matter. Assignments and projects that are both challenging and meaningful further encourage students to take an active role in their learning. Mastuti A.G. et al. (2016) highlighted that creativity in mathematics lies not in the final result but in the processes students engage in to achieve those results.

Effective feedback is another important component of effective learning. Teachers provide clear, focused feedback on students' progress and offer specific guidance on steps to improve their understanding and performance. Quality feedback helps students correct their mistakes, identify areas for improvement, and feel motivated to continue learning. According to Indriana et al. (2021) by providing open-ended questions, students think about how to solve the problem, so there is the potential for new ideas to emerge by producing various correct answers. Quality feedback helps students correct their mistakes, identify areas for improvement, and feel motivated to continue learning.

In mathematics learning, effective teaching is supported by instructional media that facilitates meaningful interactions, fostering the development of conceptual understanding (Ibragimkyzya S. et al., 2016; Dickman B.M., 2014; Nuffield et al., as cited in Salman, 2009). Lastly, effective learning creates an inclusive

environment where all students feel supported and valued. This involves addressing individual student needs, understanding their learning styles, and providing additional support when necessary. Effective learning goes beyond delivering subject material; it also aims to create a setting that enables every student to fully grow and develop.

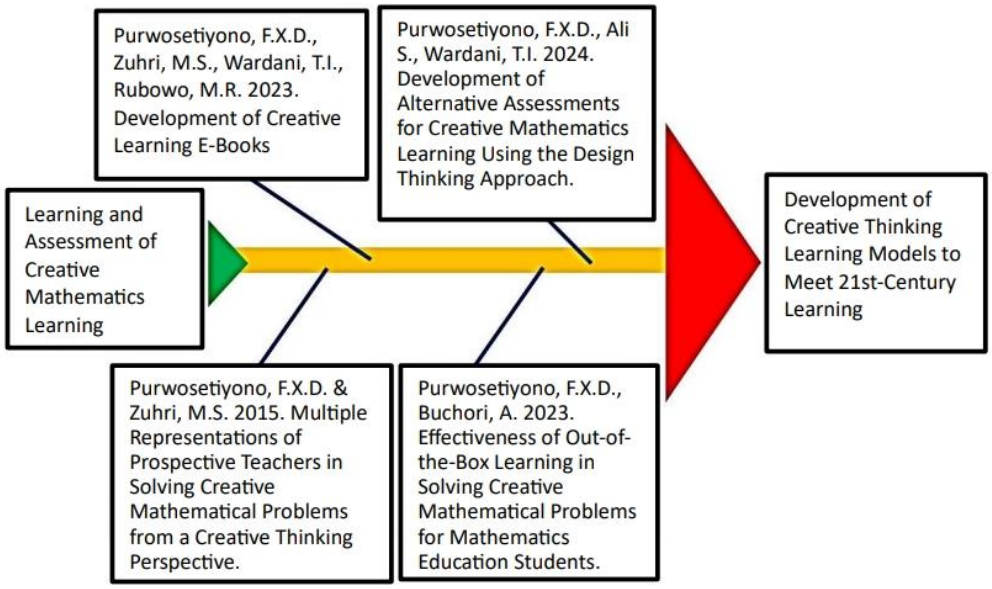


**Figure 2. Research Road Map**

## Research Objectives

The objectives of this study are:

1. To determine the feasibility of developing creative alternative assessments for mathematics learning using a design thinking approach based on expert evaluation.
2. To evaluate the practicality of using creative alternative assessments for mathematics learning with a design thinking approach.
3. To assess the effectiveness of alternative mathematics assessments with a design thinking approach.

   It is hoped that this research will make a significant contribution to the development of innovative and result-oriented practices in creative mathematics assessment.

## RESEARCH METHODS

This study develops creative alternative mathematics assessments using a design thinking approach, adopting the development model by Plomp and Nieveen. The development process consists of four stages: preliminary research, prototyping, assessment, and systematic reflection and documentation. The Plomp J. and Nieveen N. Development Model (2007: 25) comprises the following stages:

1. Preliminary Research: Conduct a comprehensive analysis of the context and problems, along with the development of a conceptual framework based on literature review.
2. Prototyping Stage: a) Design Guidelines: Develop prototypes of creative alternative mathematics assessment guidelines or books using a design thinking approach and learning outcome tests. b) Optimize Prototypes Through Design Cycles: Create instruments such as validation sheets for the assessment guidelines and learning outcome tests. c) Formative Evaluation: Conduct formative evaluations on specific subtopics of the developed instruments. d) Revisions: Iteratively revise the product based on feedback, ensuring it is ready for use in the learning process. It is important to note that each cycle in this research is part of the study it self, addressing research or evaluation questions with appropriate research design).
3. Assessment Stage (Summative Evaluation): This stage consists of two steps: a) Small-Group Trial: To test the feasibility of learning implementation using a validated product model, to assess student and instructor responses in small groups (using student response questionnaires). b) Product Trial: At this step, a limited trial is conducted to determine whether learning using creative alternative mathematics assessments with a design thinking approach is effective in specific school contexts.
4. Systematic Reflection and Documentation: This is an ongoing activity that continues throughout all research cycles. At the end of the study, researchers compile a comprehensive analysis to support retrospective analysis, followed by specifying design principles and articulating them within the conceptual framework.

**Trial Design**

The trial stage employs an experimental design. The research variables in the limited trial are defined to test the influence of students' creative thinking abilities (Variable X) on their learning outcomes (Variable Y).

**Research Sample**

The sample for the limited trial consists of students from Class 2A in the Master of Mathematics Education program at Universitas PGRI Semarang. The sampling technique used is random cluster sampling, as the sample was randomly selected from the population without considering strata. Data Collection Techniques: a) Tests: Used to measure students' achievement or success in learning activities. Specifically, the test measures students' learning outcomes. b) Questionnaires: Used to gather responses from students and instructors during small-group trials.

**Research Instruments**

The research instruments consist of: a) Test Sheets: These include test questions designed to assess students' learning outcomes. b) Student Response Questionnaires: Used to collect data on student responses to the learning process.

**Expert Validation**

Expert validation was conducted by two specialists to validate the instruments for creative alternative mathematics assessments with a design thinking approach, as well as the corresponding assessment book. Validation by experts ensures the product is valid based on their evaluation.

**Data Analysis**

The data collected using the instruments were analyzed. The analysis included: a) Student learning outcomes data. b) Trial test data. c) Trial analysis to determine effectiveness, including normality, homogeneity, n-gain calculations (pretest-posttest), and completeness testing.

## RESULT AND DISCUSSION

The results of developing creative alternative mathematics assessments using a design thinking approach include: 1) Data presentation, 2) Data analysis, and 3)

Product development.

These are presented sequentially, based on input from instructional media design experts, subject matter experts, and field trial results. The product's effectiveness was determined through an analysis of pretest-posttest results from students in Class 2A of the Master's in Mathematics Education program. These test results were analyzed both initially and at the final stages.

**Expert Validation Results of the Assessment Book**

The developed product, *Creative Alternative Mathematics Assessment Book*, serves as a reference material for the *Mathematics Assessment* course in the Master's in Mathematics Education program. The book was evaluated by two validators (lecturers at Universitas PGRI Semarang).

Based on the expert validation of the assessment book, a validation score of 88.25% was achieved. After converting this score using a scale conversion table, the achievement level of 88.25% falls under the "highly feasible" category. Despite this rating, the experts recommended several revisions and improvements to the book. The researchers refined the book to make it more appealing, added additional references, and adjusted the learning outcomes in line with the study's goals.

**Field Research Results**

The field research was conducted on students in Class 2A of the Master's in Mathematics Education program at Universitas PGRI Semarang during the second semester of 2024. A cluster random sampling method was used to select the sample, as the population was randomly sampled without considering strata. The experimental group (Class 2A) was treated with learning activities using creative alternative mathematics assessments with a design thinking approach.

To evaluate the validity, reliability, difficulty level, and discriminative power of the instrument items tested on the experimental group, instrument trials were conducted on students in Class 1A as the trial group.

**Data Analysis Results**

Preliminary data analysis was performed to determine whether the data were normally distributed and homogeneous. For the normality test using creative alternative mathematics assessments with a design thinking approach, the largest

absolute difference value was $L_{hitung}$ = 0,083 with n = 3 and a significance level of = 0,05. The critical value was $L_{tabel}$ = 0,148. Since $L_{hitung} < L_{tabel}$ maka $H_0$ was accepted, indicating that the learning outcome data for the experimental group were normally distributed.

To verify homogeneity, the Bartlett test was conducted. In the homogeneity calculation (detailed in Appendix 23), the value $\chi^2_{hitung}$ = 2,220 . was obtained. From the distribution table with (1-α) = (1 – 0,05) = 0.95, and degrees of freedom *df*=1, the critical value $\chi^2$ = 3,841. since $\chi^2$ (hitung) < $\chi^2$ the sample was determined to have homogeneous variance.

Effectiveness levels were evaluated using the average n-gain score, as outlined by Eka and Yudhanegara (2017):

**Table 1. N-Gain Effectiveness Levels**

| Average N-Gain | Average N-Gain | Average N-Gain |
|---|---|---|
| n-gain ≥ 0.70 | High | Effective |
| 0.30 ≤ n-gain < 0.70 | Medium | Quite Effective |
| n-gain<0.30 | Low | Less Effective |

The results of the n-gain data analysis are as follows.

**Table 2. N-Gain Test Analysis Results**

| | N | Minimum | Maximum | Mean | Std. Deviation |
|---|---|---|---|---|---|
| n-gain score | 15 | 0.43 | 0.92 | 0.7220 | 0.10842 |
| n-gain percent | 15 | 43.48 | 92.00 | 72.2007 | 10.84171 |
| Valid N (listwise) | 15 | | | | |

A significant difference in the improvement of students' learning outcomes is observed from the average n-gain score, which reached 0.7220. This indicates that the average learning outcomes of students in the experimental class significantly increased after using creative alternative mathematics assessments with a design thinking approach compared to before the intervention. Individually, students' learning outcomes exceeded the minimum mastery criteria (KKM) of 75. Based on individual mastery results, all 15 students in the experimental class achieved mastery, with a classical mastery rate of 100%.

**Discussion**

The expert validation stage aimed to determine the feasibility of the *Creative Alternative Mathematics Assessment Reference Book*. This stage involved two validators who evaluated the book using an expert validation form. The validation results showed an overall percentage score of 88.25%. This score indicates that the *Creative Alternative Mathematics Assessment Reference Book* falls under the "highly feasible" category. To improve the quality of the product, revisions were made based on the validators' suggestions, which served as the basis for refinement.

Preliminary data analysis revealed that the pretest scores of students were normally distributed $\chi^2_{calkulated} < \chi^2_{table}$, indicating that both classes started with similar conditions or were homogeneous, making them suitable as samples. Subsequently, each class was treated differently, with the experimental group receiving the creative alternative mathematics assessment using a design thinking approach.

The effectiveness of the creative alternative mathematics assessment with a design thinking approach was evaluated as part of the development research. This was done by determining the classical mastery of students. Results showed that all 15 students in the experimental group achieved mastery. 1) A significant improvement in students' learning outcomes was evidenced by the increased average n-gain score. This indicates a substantial enhancement in students' learning outcomes before and after using the assessment. 2) Classical mastery in the experimental class reached 100%. This is in line with the research of Buchori et al. (2022) which states that the learning process results in changes in learning outcomes every time questions or tests are given in the experimental class, thus allowing for very effective changes in student achievement. However, in that case, it is still necessary to develop story questions in the form of descriptions that are more open-ended. Because according to Indriana, et al. (2021) that open-ended questions by paying attention to creative thinking indicators in this study are considered effective in measuring the level of students' creative thinking abilities.

According to Dogge D.T. and Berke K.L. (2010), teachers have limited time to plan various experiences that create positive and engaging classroom environments. A comprehensive and integrated curriculum, with daily activities offering detailed guidance for each day of the semester, can help students learn more actively and creatively. It can also include student-generated ideas and activities to explore their creative thinking while making learning enjoyable. Purwosetiyono and Zuhri (2017) highlighted that factors that influence students' problem-solving abilities in creative thinking include awareness, ability to associate problems, courage to ask questions, and readiness supported by adequate resources. Also added by Selfiani, et al. (2022) that this learning requires students to actively conduct investigations in solving problems so that this learning can form high-level thinking skills and improve students' ability to think creatively. Clear rules or guidelines in learning are needed to ensure that problem solving can be done in a fun and motivating way, thus encouraging students to think creatively.

This study acknowledges certain limitations and weaknesses. According to Nadzifah N, et al. (2024) Researchers collect valid data by comparing the results of written tests that have been given with interviews with students, this will obtain a good qualitative study. Especially for students with low abilities, the results of Zuhri's research, et al. (2023) said that students with low mathematical abilities meet the flexible aspect while the fluency and originality aspects are not met.Future research should involve deeper and broader research to obtain case studies and also broader insights into the effectiveness of creative alternative mathematics assessments with a design thinking approach.

## CONCLUSION

The following conclusions are derived from this study on the development of creative alternative mathematics assessments using a design thinking approach: 1) The development of creative alternative mathematics assessments with a design thinking approach is feasible for use. 2) The effectiveness of mathematics learning using creative alternative assessments with a design thinking approach is demonstrated by: a) An increase in the average learning outcomes of students before

and after using the assessments. b) Students achieving complete mastery when using the creative alternative mathematics assessments with a design thinking approach.

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We recognize that this research is far from perfect, and we welcome constructive criticism and suggestions for further improvement. May the results of this study provide meaningful contributions to science and serve as a valuable reference for future research.

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