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Exploring learning innovation through design thinking to improve geometry problem-solving skills

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Abstract:
This study aims to provide innovative learning solutions for schools in special regions that are striving to improve the quality of education, particularly in improving mathematical problem-solving skills. This study employs a design thinking approach comprising the stages of empathise, define, ideate, prototype, and test. This study consisted of mathematics students and teachers from schools in special areas in Sumba, East Nusa Tenggara, namely SMP Negeri 2 Wewewa Timur, SMP Negeri 3 Wewewa Timur, and SMP Negeri 2 Wewewa Tengah, as well as several other schools whose teachers are members of the Mathematics Teacher Working Group (MGMP). The respondents included 99 students from the three schools and 19 mathematics teachers. Data collection methods included questionnaires, interviews, and observations with the respondents. The findings of this study, considering the conditions and facilities of the schools, indicate that to improve geometric mathematical problem-solving skills in special regions, the following solutions are required: (1) designing E-Modules for CTL-based ethnomathematics learning, (2) developing CTL and PBL learning activities using the CRT approach based on Augmented Reality, and (3) integrating CTL with the CRT approach using GeoGebra as a medium.

Keywords: Mathematical Abilities; Problem-Solving Skills; Design Thinking; Learning Innovation

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Introduction

The development of education today has advanced significantly. The use of technology in learning is no longer a difficult task for educators. The integration of new technology into education has led to significant changes in teaching methodologies, learning experiences, and educational accessibility (Dasilva, 2025). In the digital age, learning materials are no longer limited to textbooks alone. Students can easily access a wide range of learning resources from the internet or other sources. Interactive learning media are also widely available on various platforms, and students can even try them out on their own. The role of teachers in schools could be replaced by technology if

teachers only focus on delivering content. It would be better for teachers to innovate in their teaching methods so that their presence can fulfil the full role of a teacher. In line with this, according to Sulispala (2025), teachers are expected to be innovative, especially in facing the changes occurring in the world of education.

Mathematics is one of the disciplines that students often find difficult, which can lead to low interest and motivation in learning (Ikhlas & Kamid, 2022). Current mathematics education has not yet accustomed students to thinking logically and using concrete objects relevant to the real world (Chuseri et al., 2021). Even now, teachers are not only expected to provide practice problems but also to focus on developing the mathematical skills that students will need. One of these is problem-solving ability. Mathematical problem-solving ability is one of the essential skills students must possess to tackle challenges in education and daily life (Tanjung, 2025). The better a student's problem-solving skills, the more likely they are to be motivated to learn mathematics (Kotu & Weldeyesus, 2022).

The improvement of these skills is inseparable from the learning process carried out by teachers. It includes the NTT region, located in eastern Indonesia. Educational facilities and infrastructure are also a focus of government attention. However, various factors sometimes limit the availability of educational facilities and infrastructure. The NTT region, particularly Sumba Island, has many assets that can be used as learning contexts to facilitate student understanding. From observations, these assets are underutilised by teachers. Many teachers focus on the material from textbooks provided by the government, most of which are set outside the NTT region, making it difficult for students to understand the material. Some teachers focus on basic calculations and only give practice questions without touching on the material that should be taught. Many teachers tend to underutilise the surrounding environment as a learning context.

Innovation in education is not only related to technology. The use of learning models and approaches is also necessary, of course, in relation to learning objectives. Problem solving is one of the important skills that cannot be separated from mathematics because it is an essential part of mathematics learning (Szabo et al., 2020). In mathematics education, problem-solving skills are the first step that can help students develop ideas in building new knowledge and developing mathematical skills (Wardono & Mariani, 2019). A person's mathematics is influenced by their cultural background, as what they do is based on what they see and feel (Santoso et al., 2020).

Based on the results of a study conducted at special regional schools, namely SMP Negeri 2 Wewewa Timur, SMP Negeri 3 Wewewa Timur, and SMP Negeri 2 Wewewa Tengah, with a population of 99 seventh-grade students and 19 mathematics teachers who are members of the Mathematics Teachers' Working Group (MGMP) of SMP in West Sumba Regency, it was found that 56.6% of students experienced difficulties in problem-solving, and 73.7% of teachers reported that students faced challenges in problem-solving. It indicates that problem-solving ability is a mathematical skill that needs to be improved. Additionally, it was found that 49.5% of students chose geometry as the most challenging subject. Similarly, 63.2% of teachers stated that students struggled with geometry material. This situation may be caused by students' lack of understanding of geometry. As mentioned earlier, when teachers teach using contexts that are not well understood by students, it affects their understanding of concepts that are useful for problem-solving. For example, when learning about two parallel lines intersected by a line, many government textbooks use a railway as an example, but in reality, there are no trains in NTT. Given this situation, geometry should be taught using contextual

learning methods that are relevant to what students have seen in their daily lives. According to the constructivist theory proposed by Piaget and Vygotsky (Fitriyah et al., 2025), effective learning must involve direct experience, social interaction, and active student participation in constructing their own knowledge. Therefore, there is a need for something that can connect mathematics outside of school with mathematics inside of school. One way to do this is by using locally-based questions as the starting point for formal mathematics instruction that is appropriate for students at the concrete operational stage of development (Vera et al., 2021). Various learning models, such as PBL, can improve problem-solving skills (Thesalonika, 2025), but the problems presented must be contextual so that they can help students concretize abstract concepts in mathematics using a contextual approach (Nazwa et al., 2025). Contextual issues are not sufficient and need to be adapted to the reality of the surrounding environment or culture to strengthen understanding using the CRT approach (Lestari et al., 2025). Learning media such as AR and GeoGebra can provide interesting illustrations that can make it easier for students to construct understanding (Siti & Nuur Wachid Abdul Majid, 2024). Therefore, a combination of these models, approaches, and media is needed so that students are able to solve problems concretely and according to procedure.

According to research in Man (2022), design thinking is an approach to solving problems practically and creatively. It is most popular in educational software, tools, or models and concepts related to design thinking. In line with this, five studies conducted on a national scale (Aisah & Widodo, 2024; Benamen et al., 2025; Janah et al., 2025; Riyadi et al., 2024; Utomo et al., 2024) tended to focus on the use of learning media for users by employing design thinking and generating creative ideas from the media used, which were limited to applications. Meanwhile, research on learning innovation with design thinking (Nurlailiyah et al., 2025; Purnomo et al., 2025) in mathematics learning focuses more on mathematical abilities. Since most design thinking is only applied to learning media and there is still little research on learning models, the researcher will use design thinking for learning model innovation, namely the combination of the PBL and CTL models with the CRT approach related to students' mathematical abilities, accompanied by learning media.

Research Methods

The research methodology is a qualitative approach that blends meta-analysis and Design Thinking. Design thinking involves ongoing experimentation, sketching, and trying out various concepts and ideas to arrive at solutions that are centred on user-centred problems (Nurlailiyah et al., 2025). Design Thinking is an approach focused on creative problem-solving by involving users at every stage (Ikhwan et al., 2025). The empathy phase is the first of five stages in this approach, and the testing phase is the last (Yulius et al., 2022). The steps in the Design Thinking technique are depicted in the accompanying figure, which also shows the flow of the research process.

According to Gembong (2023), in the Empathise phase, designers need to develop a deep understanding of the characteristics and needs of their product users. In the Define phase, after gaining an understanding of user needs, the next phase is to formulate design objectives. In the Ideate phase, creators will design solution ideas. The Prototype phase is when designers bring their ideas to life in the form of models that

demonstrate the features of the solution. In the final Test phase, testing is a crucial step where designers evaluate the effectiveness of their solutions.

Picture 1. Stages of Design Thinking

A population of seventh-grade pupils and math teachers from three different schools participated in this study: SMPN 2 Wewewa Timur, SMPN 3 Wewewa Timur, and SMPN 2 Wewewa Tengah. In Design Thinking, it is necessary to identify the problems faced by teachers and students in order to find several appropriate alternative solutions that can solve the issues identified earlier, with 99 student respondents and 19 mathematics teacher respondents filling out the questionnaire, while interviews were conducted only with teachers at the three schools. The population was selected only from schools located in special areas. Research references, expert-verified interview questions, Google Forms questionnaires, and observation were all used in the data collection process. The first step in the research process was creating questionnaires and interview questions, which knowledgeable lecturers then approved. Following the distribution of the questionnaires to the three schools, data were gathered using the tools that had been constructed.

This study uses Design Thinking as its research methodology, which includes three phases: (1) Empathise; (2) Define, which covers "How Might We" and user personas; and (3) Ideate, which includes mind mapping and brainstorming. Meta-analysis was then used to support the concepts that emerged during the Ideate phase. The ideas that surfaced during the Ideate phase were taken into consideration while choosing study subjects for the meta-analysis.

Data reduction, data display, and verification were all interactive data analysis methods used in this study. The consistency of the data collected from surveys and interviews was tested using triangulation procedures to assess data validity, and effect size values supporting the emerging study concepts were calculated using meta-analysis. Using JASP 0.19.3 software, the acquired data were meta-analyzed with a significance level of $p < 0.05$, suggesting that the estimated model can be utilized to determine the effect size.

Results and Discussions

The Design Thinking approach was used in a study on learning innovations to enhance problem-solving abilities. The following are the phases of this study's Design Thinking phase:

(1) Empathise stage

In the first step of the Design thinking process, researchers must empathize in order to comprehend users' wants and desires. Finding user demands for the product that has to be developed is the aim of this stage. Additionally, this stage seeks to foster

knowledge and insight, foster an open mind among researchers, and raise self-awareness of the surroundings.

At this point, questionnaires and interviews were used to gather data. To gather preliminary information from seventh-grade pupils and math teachers, the researchers created surveys and interview questions. After experts verified the questionnaires, they were distributed, and interviews were conducted with students and teachers. The study population consisted of respondents from three different schools: SMPN 2 Wewewa Timur, SMPN 3 Wewewa Timur, and SMPN 2 Wewewa Tengah. The following is a table of student respondent data:

Table 1. Student Respondent Data

Name of School	Total	Total in Percent
SMP Negeri 2 Wewewa Timur	33	33.33%
SMP Negeri 3 Wewewa Timur	33	33.33%
SMP Negeri 2 Wewewa Tengah	33	33.33%
Total	99	100%

The results from 99 respondents who completed the Google Form questionnaire about their feelings during mathematics lessons were as follows: 86.9% felt happy, 1% felt sad, 4% felt afraid, and 8.1% reported other feelings such as nervous, lazy, indifferent, and others. Regarding the most challenging topics according to the students, the results were: geometry 49.5%, statistics 48.5%, algebra 37.4%, probability 32.3%, numbers 21.2%, and others 2%. The challenges faced by students include difficulty mastering calculations (45.5%), difficulty understanding questions (44.4%), difficulty understanding concepts/subject matter (36.4%), difficulty analysing/solving problems (56.6%), and challenges related to learning materials, learning environment, learning methods, and others (29.2%). From the results of this questionnaire, it is evident that the subject matter deemed difficult by students is Geometry, and the difficulty experienced is problem-solving. The following is a table of teacher respondent data.

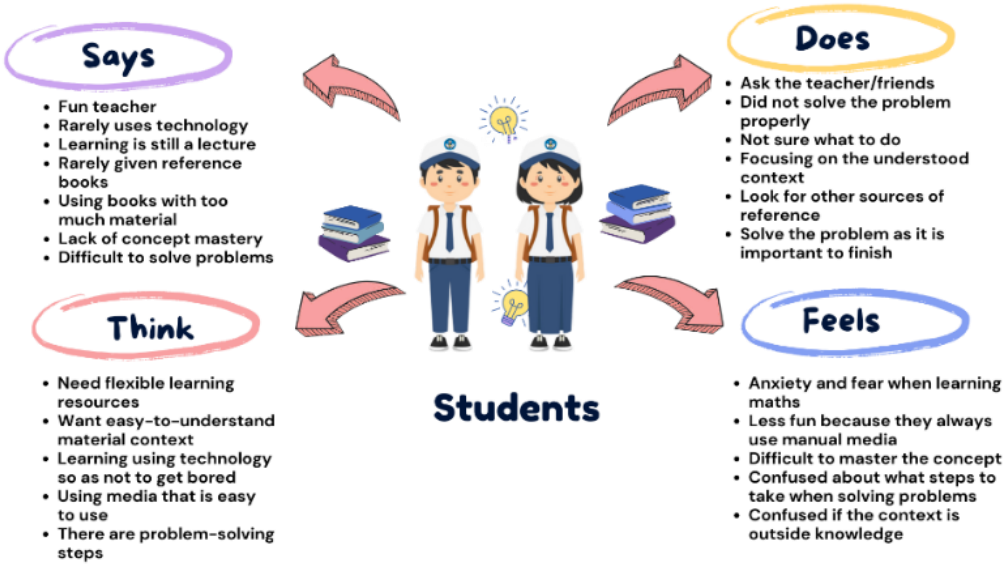
Tabel 2. Teacher Respondent Data

Name of School	Total	Total in Percent
SMP Negeri 2 Wewewa Timur	2	10.53%
SMP Negeri 3 Wewewa Timur	5	26.32%
SMP Negeri 2 Wewewa Tengah	2	10.53%
Mathematics teacher and member of the Mathematics Teacher Working Group (MGMP) for junior high schools in Sumba Barat Daya	10	42.62%
Total	19	100%

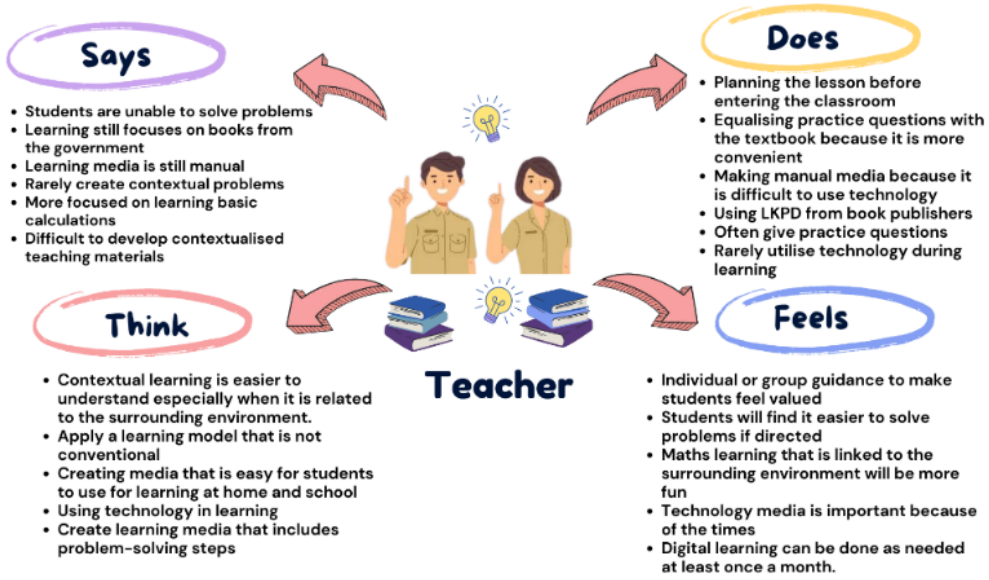
From the results of the questionnaire distributed to teachers, it was found that teachers were 100% prepared when teaching, 94.7% prepared learning media, 47.4% presented contextual problems, and 15.8% taught as usual. Regarding the most challenging subject matter for teachers to teach to students, the results were: geometry 63.2%, statistics 63.2%, algebra 47.4%, probability 47.4%, and numbers 10.2%. Meanwhile, the difficulties faced by students include: difficulty mastering basic

calculations (63.3%), difficulty understanding concepts/material (73.7%), difficulty understanding questions (42.1%), and difficulty solving problems (73.7%). It aligns with students' views that problem-solving skills remain an area of mathematical ability that needs improvement, as well as geometry, which is also considered a challenging subject.

Then, to understand the problems and needs of teachers and students, it is necessary to create an empathy map. This empathy map provides an overview of the perspectives of students and teachers through their collaborative thinking. The results of this empathy map are useful in decision-making and enable the provision of more appropriate and effective solutions. The following are the results of the empathize stage mapping of teachers and students.



Picture 2. Student Empathise Map



Picture 3. Teacher Empathise Map

From the results of the empathetic stage mapping of teachers and students, several issues were identified: (1) Learning is still conventional, using textbooks as a learning reference. While traditional teaching materials remain important, integrating them with more dynamic media and learning resources can provide students with a more engaging and diverse learning experience (Andang, et al., 2024). (2) Students find it difficult to solve problems because they do not know the steps to take, so teachers need to apply a learning model that helps students solve problems. Mathematical problem-solving involves four aspects: (a) understanding the problem, (b) planning the solution, (c) solving the problem, and (d) reviewing the results obtained (Saparudin & Pabolo, 2017). (3) Many students are already familiar with technology, and even summative assessments are now conducted using CBT, so it is necessary to design learning that uses technology to make learning more interesting. The rapid development of information technology has created a more connected and dynamic world. Digital literacy is crucial for enhancing students' critical thinking and problem-solving skills (Cynthia & Sihotang, 2023). (4) Geometric shapes remain the most challenging topic for students to understand. Geometry material is not only presented as a series of abstract concepts. Still, it is also enriched with cultural values relevant to students (Prahmana & D'Ambrosio, 2020), (5) most teachers rarely use contextual/cultural problems in mathematics learning. Yet, many assets around us can be used as learning contexts. To understand students' problem-solving conjecturing, which often has relevance to local culture, thereby expanding their understanding of mathematics in a broader context (Sutarto et al., 2022), (6) many students complain about learning resources being limited to textbooks, which are only available at school. When obtaining materials from the internet, they become confused about what they are learning because the materials are too broad, and they have not yet understood the concepts. In today's global era, more advanced learning methods are used. The learning resources required will automatically be different from before. Instructional resources are now digital, meaning they no longer depend on paper and can only be accessed through technology (Cynthia & Sihotang, 2023).

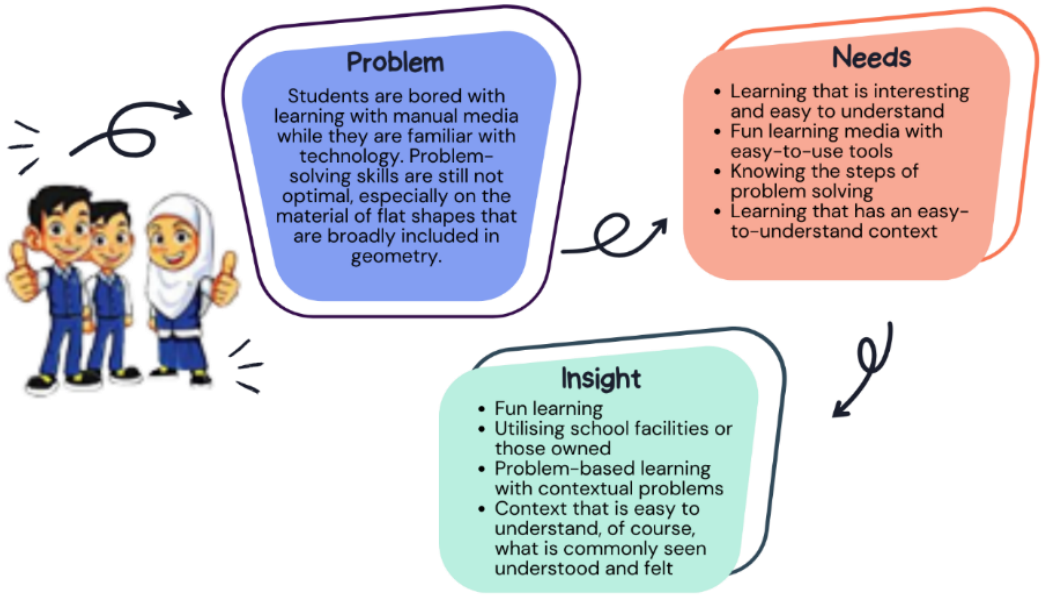
(2) Define Stage

The process of recognizing and elucidating the issues discovered in the preceding stage, namely empathy, is known as the Define stage. As the second step in the design thinking process, the define stage is dedicated to defining the problem: what user problems are we trying to solve? (Yulius et al., 2022).

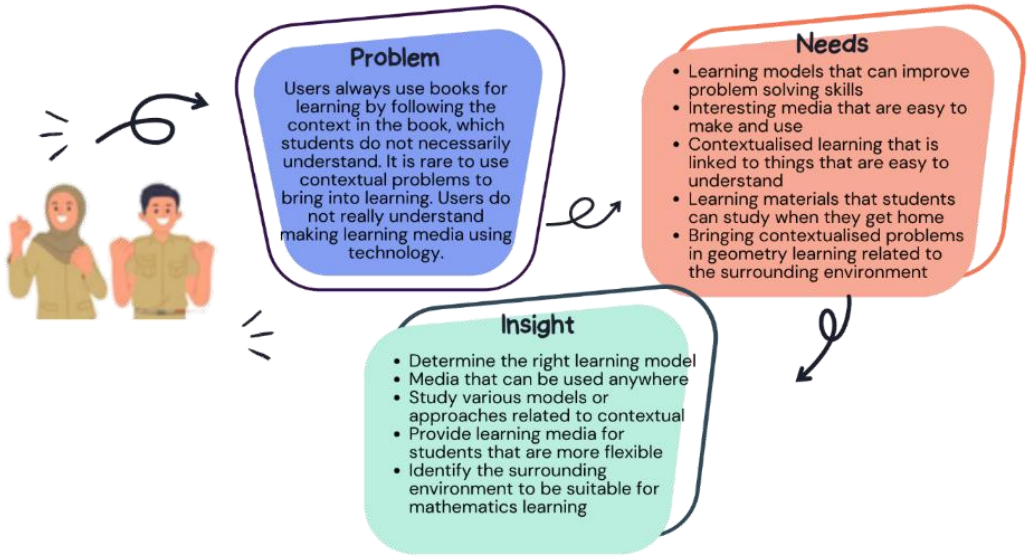
At this stage, the information data is collected and then analysed to understand the focus of the problem, which is then refined into the main problem that must be solved. Every issue found during the empathy stage will be resolved using a precise and well-defined strategy. The perspective techniques used in this process include user personas and the 'How Might We' framework (Purnomo et al., 2025).

a. User Persona

This user persona was created from data obtained from questionnaires and interviews conducted during the empathize stage. This profile helps designers understand the needs, behaviours, experiences, and goals of users (Regita & Rani, 2023). The following are the results of user personas for students and teachers.



Picture 4. User persona of Student

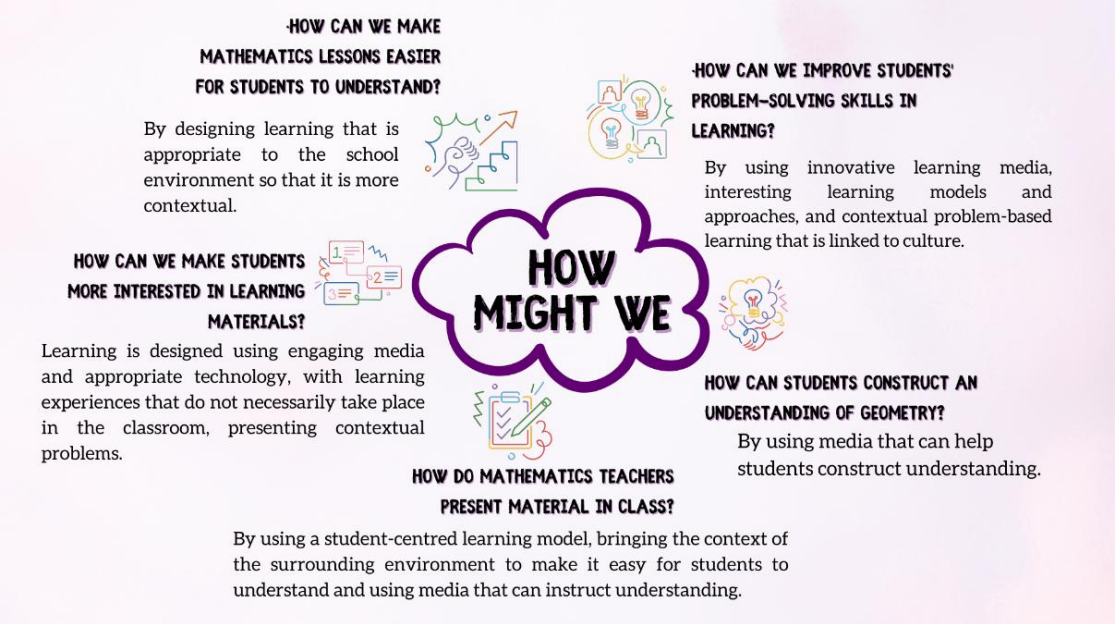


Picture 5. User Persona of Teachers

Researchers can better grasp the desired features that can address these issues by using user personas to determine user requirements and concerns (Purnomo et al., 2025).

b. How Might We

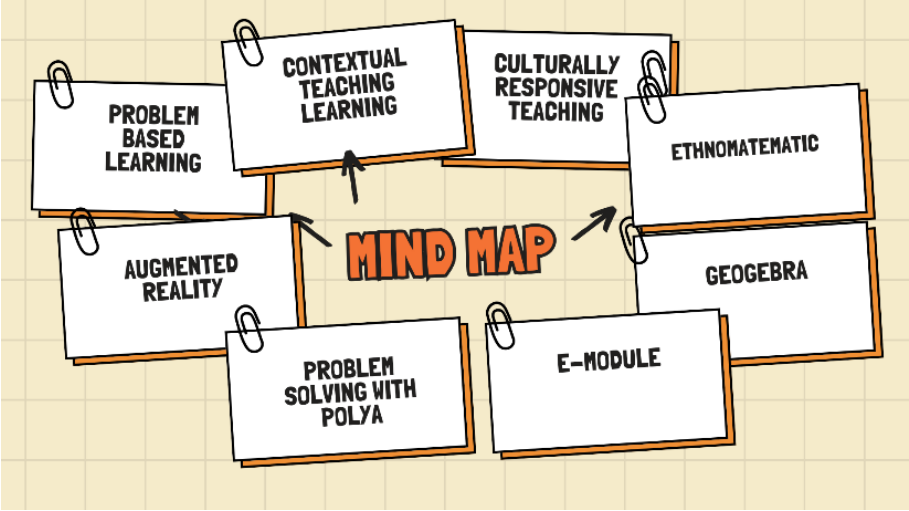
One technique for transforming statements into questions is called "How Might We" (HMW). The author's viewpoint on problem resolution is expanded through the usage of this technique. "How" stands for queries that result from user issues, and "might" offers potential responses to those queries. The results are as follows.



Picture 6. How Might We

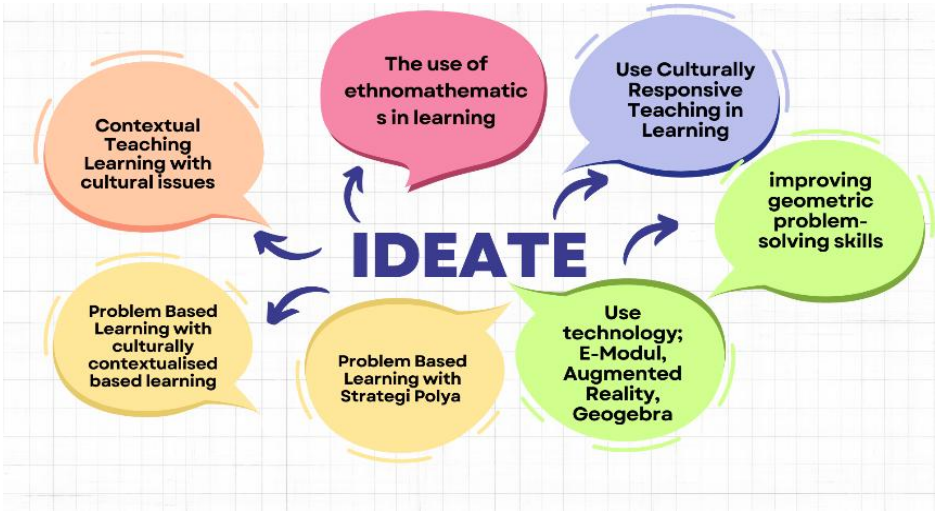
(3) Ideate Stage

Based on the identification achieved in the previous phase, brainstorming is done at this step to produce ideas that will show what users require. Following the brainstorming session, the chosen concepts are compiled into a mind map, which will then function as potential solutions that consumers may be presented with. The following are the results of the brainstorming session.



Picture 7. Brainstorming

The results of this brainstorming session are presented in a mind map that illustrates all user ideas as follows:



Picture 8. Ideate Stage

The following possible approaches to investigating learning innovations that are in line with user needs through design thinking are the outcome of this thought mapping:

1. Geometry Material: Geometry in junior high school, related to flat shapes and spatial shapes, is still difficult for students to understand. It is also in line with the results of the teachers' empathy survey, which found that geometry is still a difficult subject. Geometry as a spatial or axiomatic subject requires visualisation that can be handled better with the use of technology that is appropriate for its purpose (Kotu & Weldeyesus, 2022).
2. Mathematical problem-solving skills: Based on the empathy stage, students feel unable to solve problems.
3. The learning approach is expected to help students understand geometry material. The Culturally Responsive Teaching approach provides very appropriate support by integrating real-life problems that draw on the cultural context of the students' surroundings (Setiyani & Winanto, 2024). Cultural integration in learning makes the learning experience more meaningful for students, as the material taught is related to their experiences and culturally relevant in context (Larasati et al., 2025).
4. Problem-Based Learning (PBL) Model: One learning model that can enhance problem-solving skills is Problem-Based Learning (PBL). According to Wardani in Amsidi (2025), this model requires students to directly engage with contextual problems that encourage them to actively and collaboratively seek solutions. A study by Widana (2021) reinforces these findings by showing a significant improvement in students' mathematical problem-solving abilities after using the PBL model.
5. Contextual Teaching Learning (CTL) Model: One of the learning models that can enhance students' mathematical problem-solving abilities is the CTL learning model (Kistian et al., 2020). The learning process that applies the CTL model uses learning materials related to the students' surroundings (Widyastuti & Supardi, 2025).
6. Ethnomathematics: Ethnomathematics is the integration of mathematics and culture as an effort to introduce culture and mathematics simultaneously (Mahlina et al., 2025). Many cultural objects in the NTT region, especially in the Sumba area, can be used as learning materials, such as grave stones, traditional houses, and Mamuli objects.

7. Media:
   a. E-Modules; a highly effective medium that can be used in specific areas, are easy for teachers to create and are accessible to students without the need for hard copies. Students can save them on their mobile phones.
   b. GeoGebra; an application that can be installed on a laptop without requiring an internet connection. It makes it easier to use. GeoGebra is considered capable of providing concrete visualisations of geometric transformation concepts, thereby significantly enhancing students' understanding (Mariana et al., 2025). The use of GeoGebra will facilitate students in learning similarity concepts because the application allows for the visualisation of various two-dimensional shapes (Najma Ulya & Hasanuddin Hasanuddin, 2025).
   c. Augmented Reality; AR-based media has the potential to strengthen the connection between learning experiences and complex conceptual representations through interactive visualisation (Cut Najwa Aulia et al., 2025). The application of Augmented Reality (AR) in mathematics learning can create a more enjoyable and interactive learning atmosphere, making mathematics learning more comfortable and pleasant for students (Rahman, 2025).

From this, researchers have identified various alternative solutions that may be implemented to improve problem-solving skills, based on student needs, teacher needs, scientific and technological developments, and future demands, while taking into account the facilities available in the school environment, as follows:

1. Designing E-Modules with CTL-based Ethnomathematics learning
2. Developing CTL and PBL learning activities with a CRT approach based on Augmented Reality
3. Integrating CTL with a CRT approach assisted by GeoGebra

(4) Meta Analysis

This meta-analysis's objective is to examine the idea of solutions related to the influence of the Contextual Teaching Learning (CTL) model, Problem-Based Learning (PBL) integrated with Culturally Responsive Teaching (CRT), and GeoGebra or Augmented Reality media on improving problem-solving skills. Effect size calculations are necessary to determine whether the use of the CTL and PBL models integrated with CRT using the selected media supports the proposed solutions for users. Six chosen articles were subjected to analysis, coded, and the effect size was computed using the relevant formula. Following a meta-analysis of the effect size results, the following conclusions were reached:

Table 3. Effect Size (ES) and Standard Error (SE) from Article Data

No	Research	Treatment	N	l	ES	SE
1	Azmi & Gaol (2025)	CTL	20	17	0.850	0.080
2	Hamidah et al (2024)	CTL	22	17	0.773	0.089
3	Hayati et al (2024)	PBL + CRT	24	21	0.875	0.068
4	Sugiyono et al (2024)	PBL + CRT	13	12	0.923	0.074
5	Sari (2023)	GeoGebra	36	33	0.917	0.046
6	Eviota & Liangco (2020)	Augmented Reality	30	27	0.900	0.005

The data was processed using JASP 0.19.3 analysis software. The results are as follows:

Table 4. Pooled Effect Size Test

Estimate	Standard Error	z	p
0.889	0.026	34.235	< 0.001

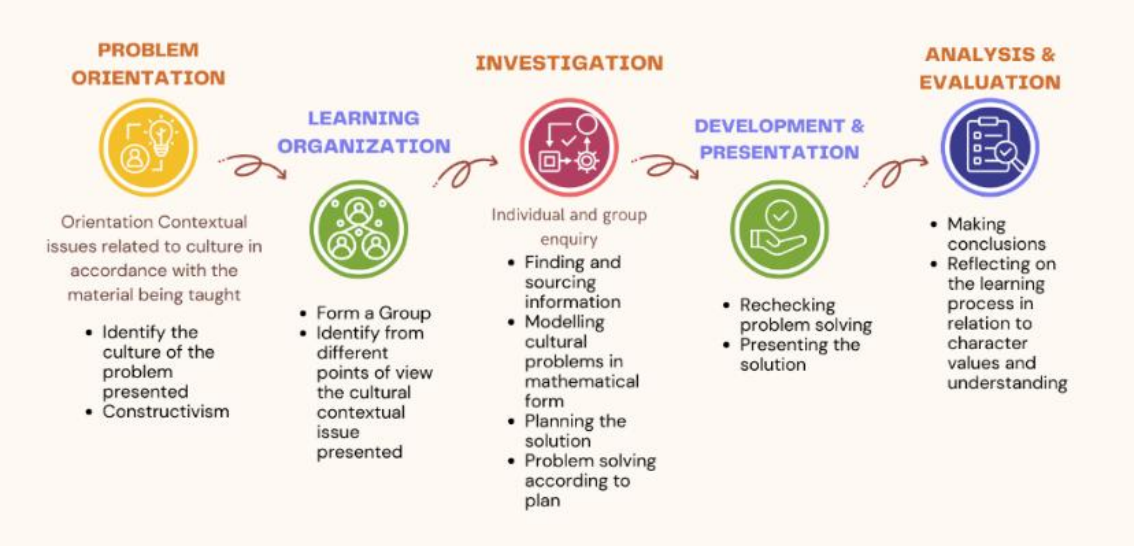
Table 5. Meta-Analytic Estimates

		95% CI		95% PI	
	Estimate	**Lower**	**Upper**	**Lower**	**Upper**
Effect Size	0.889	0.838	0.939	0.838	0.939

Based on Table 4, the p-value obtained is <0.001, which is smaller than the alpha value (0.05), indicating that all models and media have a significant effect. In Cohen's classification, a value of 0.80 is considered to have a large impact. Therefore, the results indicate that integrating CTL and PBL with CRT can enhance problem-solving skills. Additionally, the results for GeoGebra and Augmented Reality media also show a large effect, exceeding 0.8. Thus, media can be selected based on students' needs and interests. Meanwhile, in Tables 4 and 5, the average effect size (estimated summary effect size) for the CTL and PBL models integrated with CRT and the use of Augmented Reality media on problem-solving ability is 0.900, from Table 3, classified as a large effect in Cohen's classification, with a standard error of 0.026. These results indicate that the proposed solution for users is well supported by previous research, yielding a significant impact on mathematical problem-solving ability.

(5) Prototype Stage

From the Ideate stage, the CTL and PBL models were obtained and integrated with CRT using Augmented Reality media. The design challenge identified was to develop an integrated CTL and PBL learning design using the CRT approach with Augmented Reality media through a Forum Group Discussion involving 15 participants, consisting of six lecturers specialising in mathematics education and nine postgraduate students. The PBL learning design integrated with CRT using Augmented Reality media resulted in the following prototype model: (1) the syntax in the PBL model was adapted by taking contextual problems based on local culture; (2) Augmented Reality media was adapted to the field of geometry found in cultural objects; (3) the learning design was used for geometry learning; (4) the student worksheet media presented problem-solving steps; (5) presenting geometry problems related to problem-solving. The steps of CTL and PBL activities integrated with CRT aim to develop culture-based learning that can help students construct their understanding of geometry. The CTL and PBL learning steps are integrated with CRT.



Picture 9. CTL and PBL learning steps are integrated with CRT

Meanwhile, Augmented Reality media is presented in student activity sheets by presenting cultural objects such as Mamuli, traditional houses, and Sumba grave stones, accompanied by geometric images that correspond to the artistic objects used as learning objects. Here is an example illustration.

(a) (b)

Picture 10. (a) Use of Mamuli objects in geometric transformation, (b) identifying geometry in traditional houses

The approach to local culture is expected to facilitate students in constructing conceptual understanding, thereby improving their mathematical problem-solving abilities, starting with cultural objects that they create in real life using Augmented Reality.

(6) Test Stage

Prototype testing was carried out using seven steps: (1) preparation of learning instruments and assessment instruments, (2) validation of learning and assessment instruments, (3) preparation of learning media, (4) validation by experts related to learning media, (5) implementation of learning activities, (6) problem-solving ability

tests with problem-solving indicators according to the questions presented, (7) a questionnaire on participant reflection, (8) analysis of problem-solving ability results. This prototype testing was conducted at least twice, with each iteration evaluated considering its strengths, weaknesses, and effectiveness in learning.

The integration of the PBL learning model with the GeoGebra application has a significant impact on students' mathematical abilities (including problem solving) with a substantial effect size (Anzani & Juandi, 2022). Meanwhile, research on augmented reality-based media, such as Augmented Reality in the classroom, shows indications of improvement, although the results are not always statistically significant (Musyarrofah, 2024). Research on the Contextual Teaching and Learning (CTL) learning model shows its effectiveness in improving mathematical problem-solving skills (Salsabila & Mardhiyana, 2025). Thus, the integration of CTL and PBL with the CRT approach and GeoGebra or AR media is in line with previous empirical evidence: contextual learning models plus visual-interactive media have been proven to improve problem-solving skills. Here, we need to adjust to the local cultural context and the use of appropriate media, which have been relatively little explored together in previous studies.

The integration of CTL and PBL based on CRT provides concrete direction for adapting learning to social, cultural, and local resource realities. In the context of specific regions (rural, remote, indigenous, or border areas), this approach has several direct impacts: It makes mathematics contextual and meaningful by using real-life problems from students' daily lives, such as farming, weaving, hunting, trading at the market, or measuring land as a source of problems (problem sets) in PBL. The CTL approach ensures that students see the direct relevance between mathematical concepts (e.g., area, perimeter, symmetry, patterns) and their local context. CRT guides teachers to ensure that the context comes from the students' own culture, not from unfamiliar examples.

Conclusions and Suggestions

In light of the findings of the learning innovation exploration that has been conducted and aims to improve problem-solving skills through the Design Thinking method, The processes of empathy, definition, and ideation yielded the following learning innovation solutions: (1) designing E -Module based on Ethnomathematics (2) developing CTL and PBL learning activities using the CRT approach based on Augmented Reality (3) integrating CTL with the CRT approach using GeoGebra media. Additionally, the meta-analysis results from the ideate phase yielded a p-value of < 0.001, which is smaller than the alpha value (0.05). It indicates a significant effect of 0.900 from the integrated CTL and PBL CRT model, the use of Augmented Reality, and GeoGebra media in enhancing problem-solving skills. The application of the Design Thinking method in innovating effective learning models can significantly improve students' mathematical problem-solving skills.

The following recommendations can be used as guides for the Design Thinking stages that follow, specifically the prototyping and testing stages, in light of the study findings: (1) For researchers interested in the effectiveness of implementing the CTL and PBL integrated CRT model with Augmented Reality, this study can serve as a reference; (2) The development of CTL and PBL learning activities integrated with CRT and Augmented Reality should be conducted while considering school conditions, facilities, and the capabilities of teachers and students; (3) This study is limited to

schools in the special region of West Sumba, NTT, with only three schools selected, so it may not apply to other special regions in different areas. Therefore, further testing of this innovative learning approach, combining the models, strategies, and media, is needed on a larger and more diverse sample. By implementing these recommendations, future research can make a significant contribution to enhancing interactive learning media and the integration of CTL and PBL models with CRT and Augmented Reality.

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