p-ISSN: 2086-4280
e-ISSN: 2527-8827

Design Thinking Approach in the Development of E-Worksheets and AI Videos to Enhance Problem-Solving Skills of Senior High School Students

Mela Agustina[1], F.X. Didik Purwosetiyono[2*], Achmad Buchori[3], Ts. Dr. Sharifah Osman[4]

[1,2*,3]**Magister Mathematics Education, Universitas PGRI Semarang**
Jalan Lingga Raya No. 6, Dr. Cipto Semarang, Kota Semarang, Jawa Tengah, Indonesia
[1]*mela.agustina.ma@gmail.com*; [2*]*didikpurwo@upgris.ac.id*;
[3]*achmadbuchori@upgris.ac.id*
[4]**Faculty of Educational Sciences and Technology, Universiti Teknologi Malaysia**
81300 Johor bahru, Johor Darul Takzim, Malaysia
[4]*sharifah.o@utm.my*

Article received: 26-12-2025, revision: 17-01-2026, published: 31-01-2026

Abstrak

Penelitian ini bertujuan mengembangkan rancangan e-worksheet dan video AI melalui pendekatan design thinking untuk meningkatkan pemecahan masalah siswa SMA di Kota Pekalongan. Subjek penelitian terdiri atas 143 siswa dan 14 guru dari beberapa SMA berbeda yang terlibat pada tahap empathize dan define untuk mengidentifikasi profil permasalahan pembelajaran, yang menunjukkan bahwa pemecahan masalah kurang berkembang karena pembelajaran masih abstrak, berfokus pada hafalan, serta minim media interaktif sementara guru terkendala waktu bimbingan. Pada tahap ideate, melalui telaah literatur dan meta-analisis, dikembangkan gagasan E-TopWorksheets dengan Pendekatan Matematika Realistik berbantuan Mootion AI; hasil meta-analisis menunjukkan nilai p<0,001 dengan effect size 0,841 yang menandakan pengaruh signifikan dan kuat penggunaan media serupa terhadap peningkatan pemecahan masalah matematika yang berpotensi menjadi dasar pengembangan media dan memerlukan pengujian lanjutan. Disimpulkan bahwa pendekatan design thinking efektif sebagai kerangka kerja pengembangan prototype media yang kontekstual, adaptif, dan berkontribusi pada inovasi media pembelajaran yang relevan dengan tuntutan pembelajaran abad ke-21.

***Kata Kunci**: Design Thinking; E-Worksheets; Pemecahan Masalah Matematika; Video AI.*

Abstract

This study aims to develop a design for e-worksheets and AI-based videos using a Design Thinking approach to enhance the problem-solving skills of Senior High School (SMA) students in Pekalongan City. The research subjects consisted of 143 students and 14 teachers from various high schools who were involved in the empathize and define stages to identify learning problem profiles; findings indicated that problem-solving skills were underdeveloped due to abstract instruction focused on rote learning, a lack of interactive media, and teachers' constraints regarding guidance time. In the ideate stage, through literature review and meta-analysis, the concept of E-TopWorksheets using a Realistic Mathematics Education approach assisted by Mootion AI was developed. The meta-analysis results showed a p-value < 0.001 with an effect size of 0.841, indicating a significant and strong influence of similar media on improving mathematical problem-solving, which potentially serves as a basis for media development and requires further testing. It is concluded that the Design Thinking approach is effective as a framework for developing contextual and adaptive media prototypes, contributing to learning media innovation relevant to 21st-century learning demands.

Keywords: Design Thinking; E-Worksheets; Mathematical Problem Solving; AI Video.

I. INTRODUCTION

Mathematics studied at various levels is not merely about understanding concepts, but serves as a means to build logical and creative thinking methods to resolve daily problems (BSKAP, 2025). In the Society 5.0 era, education must align with technological advancements as a bridge between teachers and students to develop higher-order thinking skills, including problem-solving in mathematics learning. Problem-solving is one of the core competencies of the 21st century (Widana, 2021) and is a primary goal of mathematics instruction in the national curriculum (Muhtasyam & Novaliyosi, 2023). With good problem-solving skills, students will be more resilient in facing complex challenges in their daily lives (Munengsih et al., 2021).

According to BSKAP (2025), problem-solving stages include understanding the problem, designing a mathematical model, solving the model, or interpreting the obtained solution. Polya, in Liljedahl et al. (2016), also proposed four similar phases: Understanding the problem, devising a plan, carrying out the plan, and looking back. Mastery of these four phases helps students develop analysis, prediction, reasoning, evaluation, and reflection capabilities regarding their daily problems (Siswanto & Meiliasari, 2024).

However, results from various studies illustrate that the mathematical problem-solving skills of Indonesian students are still underdeveloped. PISA scores over the last 10 years show that students' mathematics achievement is below the average of other countries (Riyani & Hadi, 2023; Purnomo et al., 2025). Other research findings also place students' problem-solving abilities in the low category (Dwita Imannia et al., 2022; Syahril et al., 2021).

Observations in several high schools in Pekalongan City indicate that students frequently experience difficulties in understanding concepts, selecting important information, determining the problem, choosing solution strategies, and lack precision in calculations. Many students are unable to solve problems without teacher guidance and demonstrate a lack of self-confidence when facing questions different from given examples. This is due to weak mastery of basic, conceptual, and procedural knowledge, which impacts the difficulty in completing complex tasks requiring high-level mathematical reasoning (Žakelj et al., 2025). They also tend to fail in transforming contextual problems into symbolic representations, such as understanding variables, formulating equations, or using equal signs correctly (Musyarofah et al., 2025). Barriers in mathematical representation, including the transition from visual/contextual to symbolic representation, are also primary factors in low non-routine problem-solving performance (Fatqurhohman & Susetyo, 2022).

Various efforts have been made to overcome these issues. Prior research indicates that the use of worksheets can improve mathematics learning outcomes (Iffah, 2021), and e-worksheets based on Liveworksheets are valid, practical, and effective in developing students' problem-solving skills (Sarman et al., 2023). On the other hand, the use of mathematics

p-ISSN: 2086-4280
e-ISSN: 2527-8827

learning videos has also proven to have a positive influence on students' problem-solving (Salsabila & Pradipta, 2021). Well-crafted animated videos can enhance students' concept understanding and problem-solving (Nasution & Lailia, 2023). However, the majority of these studies still utilize worksheets and videos separately. There is a paucity of research integrating both into a single learning system specifically designed to support problem-solving stages sequentially and holistically.

Furthermore, e-worksheets used in schools are often difficult to integrate with other media, whereas the utilization of multimedia and hypermedia could more optimally encourage student learning achievement (Hamid & Saprudin, 2016). Interviews with mathematics teachers in Pekalongan City high schools also indicate that most teachers have not developed worksheets independently and still rely on conventional videos or videos taken from YouTube, which are often inconsistent with student characteristics.

Meanwhile, developments in Artificial Intelligence (AI) technology offer new opportunities in media development. AI-based video storytelling can be an effective alternative as it is capable of generating high-quality educational content with more efficient time and resources (Leiker et al., 2023). The integration of e-worksheets and AI-generated storytelling videos has the potential to create a learning experience that is not only meaningful and enjoyable but also capable of strengthening the stages of mathematical problem-solving.

To ensure this media development aligns with user needs and characteristics, a user-centered approach is required. Design Thinking is an approach offering effective and adaptive strategies in developing products to face educational challenges and strengthen 21st-century skills (Purnomo et al., 2025). Therefore, this study utilizes the Design Thinking approach to develop e-worksheets and AI videos to enhance the problem-solving skills of high school students. Through this Design Thinking framework, the design of e-worksheets and AI videos is expected to be not merely digital, but truly aligned with students' learning difficulties at each problem-solving stage and realistically implementable by teachers.

Based on the description above, this research focuses on: (1) identifying the profile of mathematics learning problems among high school students in Pekalongan City; (2) exploring and developing alternative solutions through literature review and relevant research studies (including appropriate meta-analysis); and (3) designing a prototype of e-worksheets and AI videos. This research is expected to contribute to the innovation of learning media development that is adaptive, contextual, and consistent with 21st-century learning demands.

II. METHOD

The research method in this study employs a qualitative research approach integrating the Design Thinking framework and meta-analysis as strategies for idea development and testing. This approach was selected because it is creative, iterative, and user-centered, allowing researchers to understand student and

teacher needs deeply while seeking relevant solutions and sustainable learning (Riverdale & IDEO, 2011). Design Thinking is positioned as the development process framework, while meta-analysis is utilized to assess the strength of empirical support for the generated solution ideas.

Design Thinking is a problem-solving approach starting from community or user needs as the primary consideration, encouraging collaboration, idea exploration, prototyping, and solution testing through a continuous learning cycle (Putri et al., 2024). The stages of the Design Thinking approach are as follows in Figure 1.

Figure 1. Stages of Design Thinking.

According to (Putri et al., 2024), the Design Thinking approach consists of five stages: 1) Empathize: The stage to identify user needs and experiences regarding a product by increasing sensitivity to the environment, forming insights, and fostering open-mindedness in product developers or innovators; 2) Define: Where innovators determine the core problem or primary user needs to be addressed by the product; 3) Ideate: The stage of exploring various alternative ideas to design a product aligned with user needs and characteristics; 4) Prototype: Where design ideas are realized in the form of a trial product; and 5) Testing: The stage where the designed product is tested directly in trials involving users.

These stages serve as the operational framework in designing and testing the developed AI-based e-worksheets and videos.

The subjects of this study were high school mathematics students and teachers in Pekalongan City, comprising 143 student respondents and 14 teacher respondents. Subject selection considered school representation in both the central and peripheral areas of Pekalongan City to obtain a diverse overview of needs. The primary data collection instruments were observation sheets, student and teacher needs questionnaires, and interview guidelines structured based on problem-solving ability indicators and learning media needs. All instruments were validated by mathematics education and instructional technology experts to assess content suitability, item clarity, and readability. Secondary data were obtained from various relevant research results used as material for meta-analysis.

The data collection procedure began with instrument construction and validation, questionnaire distribution to students and teachers, classroom learning observations, and interviews for in-depth information regarding real obstacles and needs in the field. The implementation of Design Thinking in this research followed the flow below: 1) Empathize Stage: Conducted through observation, questionnaires, and interviews to map learning experiences, problem-solving difficulties, and learning media usage in Pekalongan City high schools; 2) Define Stage: Conducted by analyzing the data to formulate the main problem profile and structuring problem statements in the form of "What if" or "How might we" questions; 3) Ideate Stage: Conducted by generating

p-ISSN: 2086-4280
e-ISSN: 2527-8827

various solution alternatives in the form of e-worksheet and AI video designs, which were then enriched and conceptually tested using literature review and meta-analysis results; and 4) Prototype and Test Stages: Executed iteratively. Based on selected ideas, an initial prototype of the e-worksheet and AI video was compiled, then reviewed and revised based on expert validator input. The revised prototype was subsequently tested on a limited basis in the test stage through initial trials and the collection of student and teacher feedback.

Meta-analysis in this study was utilized to assess the potential effectiveness of solution ideas generated in the *ideate* stage. Studies sampled for the meta-analysis were selected based on thematic relevance (mathematical problem solving, e-worksheets, digital storytelling videos), statistical data completeness, recency, and research design quality. From each study, relevant effect size data regarding the improvement of problem-solving abilities or other learning indicators were extracted. Effect size data were then analyzed using JASP software version 0.95.4.0, with a significance criterion of $p < 0.05$ as the basis for determining the acceptability of the effect size estimation model. The meta-analysis results were used to strengthen or filter ideas in the *ideate* stage and serve as the argumentative basis for the potential effectiveness of the developed product.

Qualitative data analysis techniques in this study were conducted interactively through three steps: data reduction, data display, and verification. This included selection, focusing, simplification, and organization of observation, questionnaire, and interview data according to the focus on problem-solving needs and media development. These were then described in descriptive forms, tables, and thematic matrices to facilitate pattern identification and conclusion drawing, and verified repeatedly by comparing findings across sources and process stages. Data validity was maintained through source triangulation (students, teachers, and learning documents), technique triangulation (observation, questionnaire, and interview), and limited member checking with several teachers to confirm the researcher's interpretation against field experiences. Meanwhile, the combination of interactive qualitative analysis and quantitative meta-analysis provided a more holistic picture of real classroom needs and the strength of empirical evidence supporting the developed e-worksheet and AI video design.

III. RESULT AND DISCUSSION

This research was conducted based on the Design Thinking framework. The results and discussion are presented as follows:

A. Profile of Mathematics Learning Problems of High School Students in Pekalongan City

The profile of mathematics learning problems was obtained from the *empathize* and *define* stages of the Design Thinking framework. In the *empathize* stage, researchers drafted observation sheets, questionnaires, and interview guidelines, which were then validated by experts and revised. After instrument revision, questionnaires were administered to students and teachers, followed by in-

depth interviews and classroom observations.

Table 1.
Student Respondents

School	Number of Students	Percentage (%)
SMAN 1 Pekalongan	50	34,97
SMAN 2 Pekalongan	50	34,97
SMAN 4 Pekalongan	43	30,07
Total	143	100

From 143 high school students in Pekalongan City, it was found that 21% of students really like mathematics, 37.8% like studying it, and 41.3% have neutral feelings toward mathematics. Furthermore, 90.8% of students felt it was possible to experience, and did experience, difficulties in learning mathematics, while only 9.1% did not experience difficulties. Additionally, 66.7% of students found it difficult to understand questions, 63% struggled to understand concept material, and 57.4% had difficulty analyzing problems. Similarly, 60.1% of students struggled to visualize scenarios in questions. Mathematics topics considered difficult or requiring assistance were System of Linear Inequalities in Two Variables (SPtLDV) at 35%, Quadratic Functions at 37.1%, and Trigonometry at 32%.

Table 2.
Mathematics Teacher Respondents

School	Number of Teachers	Percentage (%)
SMAN 1 Pekalongan	3	21,43
SMAN 2 Pekalongan	3	21,43
SMAN 4 Pekalongan	4	28,57
SMA Islam Pekalongan	1	7,14
SMA Hasyim Asy'ari Pekalongan	1	7,14
SMA Sains Cahaya Al-Qur'an	1	7,14
SMA Al Irsyad Pekalongan	1	7,14
Total	14	100

Consistent with students, the 14 mathematics teachers in Pekalongan City stated that topics difficult for students to understand were SPtLDV (40%), Quadratic Functions (53.1%), and Trigonometry (33%). Teachers also experienced difficulty in preparing learning media. Whereas a study indicated an improvement in students' mathematical problem-solving after the implementation of interactive media learning (Habuke et al., 2022). Based on the questionnaire results, the problem analysis is presented via the empathy map in Figure 2 and 3.

Figure 2. Student Empathy Map.

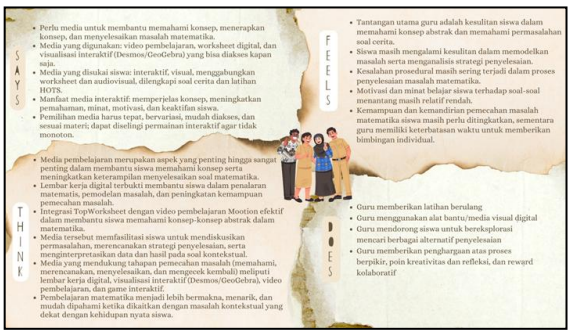

Figure 3. Teacher Empathy Map.

From the Student and Teacher Empathy Maps above, it was found: 1) Students perceive mathematics as difficult when explanations are too fast, concepts are too abstract, there is excessive formula

p-ISSN: 2086-4280
e-ISSN: 2527-8827

memorization, and questions differ from examples, causing them to feel left behind and struggle to connect concepts with solutions; 2) Students need clear and staged learning, supported by interactive media, audiovisuals, contextual examples, an enjoyable atmosphere, games, and collaborative spaces; 3) When facing difficulties, students tend to review material, ask friends or teachers, search digital learning resources, or even give up when questions differ from examples; thus, they require instruction with clear solution steps and interactive media facilitating understanding and problem-solving; 4) Teachers need interactive, user-friendly, and adaptive learning media in the form of videos, digital worksheets, and interactive visuals that can be accessed independently, as these are believed to assist in visualizing abstract concepts and improving understanding, reasoning, and problem-solving skills. This aligns with Cahyani et al. (2024), stating that teaching materials or media adjusted to the high school cognitive level, such as interactive multimedia, Edpuzzle interactive media, and GeoGebra, can visualize abstract concepts into reality for student understanding; 5) According to Wathoni (2024), the use of concrete media in mathematics learning is highly necessary to meaningfully improve understanding of abstract concepts; and 6) The topic of System of Linear Inequalities in Two Variables is considered difficult by both teachers and students. Research by Siregar et al. (2024) found that 75% of students struggled to understand the material, 43% struggled in solving, and 29% lacked precision. In this topic, student difficulties typically occur when transforming problems into SPtLDV and determining the solution region (Utami & Hidayanto, 2022).

Problems from the *empathize* results were identified and clarified in the *define* stage. Problems were formulated specifically yet openly to encourage the emergence of various creative solutions (Putri et al., 2024). Each problem identified in the empathy stage is addressed through a clear and well-defined approach (Purnomo et al., 2025). The perspective techniques used in this process include the Point of View (POV) technique and the "How Might We" framework. In POV, the researcher attempts to explore needs and emerging problems to understand what users desire to obtain the best resolution for the found problems (Nurlailiyah et al., 2025).

Figure 4. Student POV.

Figure 5. Teacher POV.

"How Might We" is used to transform statements into questions. In this stage, as many ideas as possible are sought by

creating questions and answers based on user problems. Through this technique, it is expected that the researcher can be more directed and focused in determining solutions for the formulated problems.

The results of the "How Might We" stage, representing the profile of mathematics learning and problem-solving issues of high school students in Pekalongan City, are as follows:

a) How might we help students understand abstract mathematical concepts in a real, visual, and joyful way? By presenting concepts through AI-generated storytelling videos based on real-world contexts and interactive visuals, so abstract concepts are represented in concrete forms close to students' experiences.
b) How might we design staged and interactive learning so students are more confident? By developing tiered E-Worksheets equipped with adaptive instructions and immediate feedback, allowing students to build understanding gradually and independently.
c) How might we reduce fear and anxiety towards mathematics? By creating enjoyable, non-monotonous learning with minimal rote memorization, through interactive media that encourages exploration, trial, and error as part of the learning process.
d) How might we provide interactive media that is easy for teachers to use to visualize abstract concepts? By designing digital learning media that is practical, ready-to-use, and structured, integrating visuals, animations, and contextual examples without technically burdening the teacher.
e) How might we help teachers guide students independently despite limited time? By providing e-worksheets that function as scaffolding, so students can learn and solve problems independently with staged guidance.
f) How might we shift learning from rote memorization to meaningful problem solving? By integrating e-worksheets and audiovisual media based on contextual problems, guiding students to understand concepts, plan strategies, and reflect on solutions.

B. Exploration and Development of Alternative Solutions through Design Thinking and Meta-Analysis

The exploration and development of alternative solutions through design thinking and meta-analysis were conducted in the *ideate* stage. From the "How Might We" results, researchers explored various alternative ideas functioning as solutions for a problem or need (Putri et al., 2024). Brainstorming was conducted to generate ideas answering user needs from the previous stage (see Figure 6).

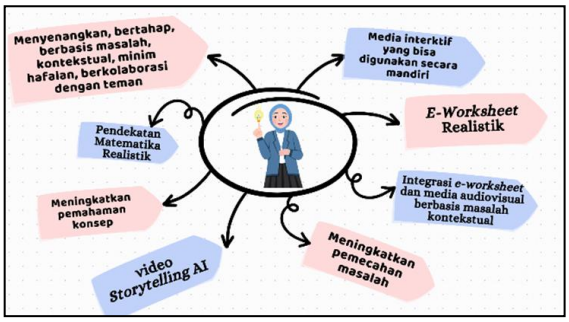

Figure 6. Brainstorming Results.

These ideas were then organized into a mind map, which would later function as features for the developed media. Below is the mind map from the brainstorming

p-ISSN: 2086-4280
e-ISSN: 2527-8827

results representing the entire concept (see Figure 7).

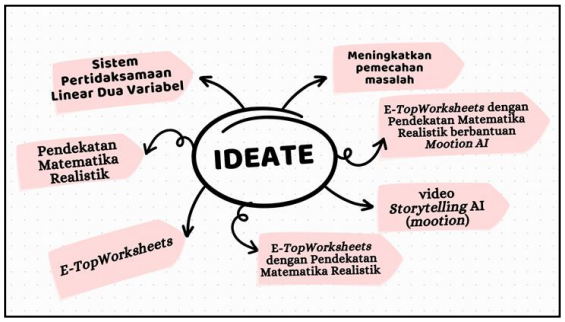

Figure 7. Mind Mapping of Ideate Stage.

The mind map results revealed alternative solutions aligned with user needs through the Design Thinking framework, as follows:

1) Topic: System of Linear Inequalities in Two Variables (SPtLDV): According to both students and teachers, SPtLDV is considered a difficult topic to understand.
2) Problem Solving: Based on the empathize stage, students and teachers stated that problem-solving skills of Pekalongan City high school students still need development.
3) Learning Approach: Realistic Mathematics Education (RME) can provide more meaningful learning experiences. Additionally, RME can connect mathematical concepts that are abstract in class with real situations experienced by students (Handayani, 2023)
4) Media

a) E-Topworksheets

E-TopWorksheets is a web-based learning platform allowing teachers to create e-worksheets either from scratch or by converting printed worksheets (PDF, images) into online versions, enabling online completion by students with a primary feature of auto-grading. E-TopWorksheets contains not only questions but also staged instructions and activities guiding students to learn independently, build concept understanding, and is proven to improve problem-solving (Sarman et al., 2023).

b) Mootion AI

Mootion is an AI-based platform allowing users to automatically transform text, scripts, images, or audio into educational videos or visual stories, complete with animation, voice, and narration. Utilizing Mootion AI provides a solution for students' needs in visualizing abstract mathematical concepts (Julianingsih & Krisnawati, 2020), while assisting teachers in presenting learning media that is practical to create without reducing material presentation quality.

Therefore, the researcher identified an alternative solution to improve high school students' problem-solving skills: utilizing the Design Thinking approach to develop E-TopWorksheets with a Realistic Mathematics Education (RME) approach assisted by Mootion AI on SPtLDV material.

To strengthen the alternative solution obtained from the literature review, a meta-analysis of relevant research was conducted to assess empirical support for the use of such learning media. Effect size calculation was used to determine the strength of the learning media's influence by analyzing seven selected articles meeting the criteria. The effect size results of each study were processed using meta-analysis procedures to obtain a comprehensive picture of the extent to which the media supports the proposed solution.

Tabel 3.
Effect Size (ES) and Standard Error (SE) Data from Relevant Previous Studies

Author	T	N	I	ES	SE
Fitriana, Aida, et al. (2023)	E-LKS 1	42	31	0,7381	0,0678
Wedyastuti, Rini (2023)	E-LKS 2	36	35	0,9722	0,0274
Julianingsih, D., et al. (2020)	Video digital *story telling*	27	19	0,7037	0,0879
Jayantika, I. G. A. N. T., et al. (2024)	RME 1	36	31	0,8611	0,0576
Budiyanto, Aris (2024)	RME 2	39	33	0,8462	0,0578
Syaifudin (2023)	LKS + RME	28	23	0,8214	0,0724
Shahabiah, S. (2024)	Video + RME	21	18	0,8571	0,0764

Based on the collected data, the research continued with meta-analysis using JASP analysis software version 0.95.4.0. The results are as follows:

Table 4.
Heterogeneity Test and Pooled Effect Results

	Test	p
Heterogeneity	$Q_e(6) = 20.37$	.002
Pooled effect	Z = 22.74	< .001

Table 5.
Pooled Effect Estimation Results

		95% CI		95% PI	
	Estimate	Lower	Upper	Lower	Upper
Pooled effect	0.844	0.772	0.917	0.679	1.010

Based on Table 4, the p-value < 0.001, which is smaller than the alpha value of 0.05, indicates a significant influence of E-TopWorksheets with a realistic mathematics approach assisted by Mootion AI in improving high school students' problem-solving skills. Furthermore, in Table 4 and 5, the pooled effect for E-TopWorksheets based on a realistic mathematics approach assisted by Mootion AI to improve high school student problem-solving is 0.844, categorized as a large effect according to Cohen's classification. This indicates that the proposed solution is supported by previous research, showing a significant influence on student problem-solving. Although the meta-analysis shows a positive effect tendency, further empirical testing through field studies is necessary.

C. Product Prototype

After the alternative solution was selected, the design idea was realized in the form of a prototype as a tangible product testable according to user needs, through an iterative trial process requiring the innovator's readiness to face failure until the expected solution is truly achieved (Putri et al., 2024). When designing idea testing, several factors must be considered, including curriculum, infrastructure, funding, school environment, human resources, energy, and time constraints.

The identified design challenge was to develop E-TopWorksheets with a realistic mathematics approach assisted by Mootion AI to improve problem-solving, determined through Focus Group Discussions (FGD) involving 25 participants, consisting of six mathematics education experts and 19 postgraduate students.

The design of the E-TopWorksheets with a realistic mathematics approach assisted by Mootion AI subsequently produced the following prototype model: 1) E-TopWorksheets designed systematically for

p-ISSN: 2086-4280
e-ISSN: 2527-8827

SPtLDV material, starting with an initial section containing a cover with logo, title, material, education level, supporting images, student identity, and author identity; followed by a preface, table of contents, learning objective flow, learning instructions, supporting information, work steps, bibliography, and author biography as main device components; and 2) In the core section, the E-TopWorksheets contain four learning activities: Activity 1 presents contextual problems visualized through Mootion AI-based video, while Activity 2, Activity 3, and Activity 4 focus on concept deepening, graphical representation, solution set determination, and SPtLDV application in various daily life situations. All activities are structured with realistic mathematics approach steps and a series of questions to develop student problem-solving sequentially from context introduction to problem resolution.

The prototype visualization is shown in the Figure 8.

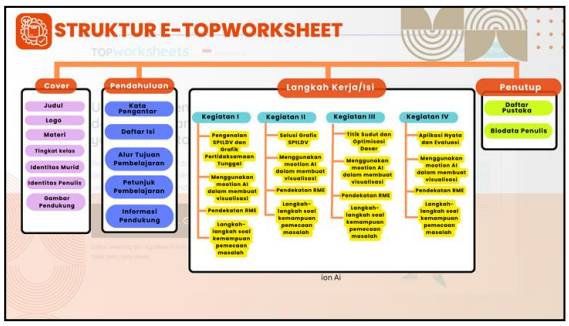

Figure 8. Product Prototype.

Through this design, it is expected to bridge abstract mathematical concepts into more concrete forms, support independent learning, and improve high school students' problem-solving skills.

After the prototype was validated by experts and revised, the prototype trial plan was implemented using four methods: (1) problem-solving tests based on the Understanding by Design (UbD) framework; (2) learning observation; (3) media expert validation sheets for E-TopWorksheets with realistic mathematics approach assisted by Mootion AI; and (4) student response questionnaires. The prototype trial was conducted in two stages and evaluated based on advantages, effectiveness in increasing student engagement, and potential to improve student problem-solving. Observation data helped capture student interactions and behavioral responses, while expert feedback ensured media design alignment with pedagogical goals. Questionnaire results provided direct insight into student learning experiences.

IV. CONCLUSION

This study found that through the *empathize* and *define* stages of the Design Thinking framework, it was identified that mathematics problem-solving skills of high school students in Pekalongan City were underdeveloped because learning tended to be abstract, focused on rote memorization, and teachers had limited time and interactive media to guide students gradually. Based on this understanding of the problem, in the *ideate* stage and through literature review as well as meta-analysis, the idea of using E-TopWorksheets with a realistic mathematics approach assisted by Mootion AI was developed as an alternative solution. The meta-analysis results showed a p-value < 0.001 with an effect size of 0.841, indicating that E-TopWorksheets with a realistic mathematics approach assisted by Mootion AI have a significant

and substantial effect in improving student problem-solving, thereby strengthening the basis for the media prototype design in this study.

This research has limitations as it only involved the high school student population in Pekalongan City and has not yet examined long-term learning retention. Additionally, claims of effectiveness presented in this study are based on theoretical meta-analysis results of the developed solution concept; thus, these findings remain conceptual and require further specific product testing through field trials. It is suggested that future researchers develop E-TopWorksheets with a realistic mathematics approach assisted by Mootion AI up to the limited trial and quasi-experiment stages so that their effectiveness on high school students' mathematical problem-solving can be measured more comprehensively. Further research also needs to expand materials, levels, and school contexts to test practicality, acceptance, and opportunities for theory development related to the integration of Design Thinking, Realistic Mathematics Education, and AI technology in learning.

REFERENCES

BSKAP. (2025). *Panduan Mata Pelajaran Matematika Fase A – Fase F dan Fase F Tingkat Lanjut*. 314. https://repositori.kemendikdasmen.go.id/33608/

Budiyanto, A. (2024). Peningkatan Hasil Belajar Matematika Pada Materi Turunan Fungsi Aljabar Dengan Penerapan Pendekatan Pendidikan Matematika Realistik Indonesia (PMRI). *Indonesian Journal of Innovation Science and Knowledge*, *1*(1), 551-561.

Cahyani, A., Meiliasari, M., Rahayu, W., & Hidajat, F. A. (2024). Studi Literatur: Pemilihan Media Pembelajaran Matematika untuk Siswa Sekolah Menengah Atas. *Jurnal Riset Pendidikan Matematika Jakarta*, *6*(1), 70–80. https://doi.org/10.21009/jrpmj.v6i1.290238

Dwita Imannia, Jumroh, & Destiniar. (2022). Kemampuan Pemecahan Masalah Matematis Siswa Pada Materi Program Linear. *Inomatika*, *4*(1), 19–30. https://doi.org/10.35438/inomatika.v4i1.279

Fatqurhohman, & Susetyo, A. M. (2022). Transisi Representasi Simbolik-Pictorial dalam Menyelesaikan Masalah Matematika Transition of Symbolic-Pictorial Representation in Solving Mathematics Problems. *Edumatica: Jurnal Pendidikan Matematika*, *12*(01), 22–29. https://doi.org/10.22437/edumatica.v12i01.15291

Fitriana, A., & Juwana, I. D. P. (2023). Implementasi Pembelajaran Berdiferensiasi Berbantuan E-LKPD Untuk Meningkatkan Hasil Belajar Matematika Siswa. *Widyadari*, *24*(2), 276-285.

Habuke, F., Hulukati, E., & Pauweni, K. A. . (2022). Meningkatkan Kemampuan Pemecahan Masalah Matematika Siswa Melalui Media Pembelajaran Interaktif Articulate Storyline Pada

Materi Peluang. *Euler : Jurnal Ilmiah Matematika, Sains Dan Teknologi*, *10*(1), 103–110. https://doi.org/10.34312/euler.v10i1.14496

Hamid, I., & Saprudin, S. (2016). Penggunaan Hypermedia Pada Mata Kuliah Kalkulus Ii Untuk Meningkatkan Hasil Belajar Dan Kemampuan Berpikir Kritis Mahasiswa Program Studi Pendidikan Matematika Fkip Unkhair. *Delta-Pi: Jurnal Matematika Dan Pendidikan Matematika*, *1*(2), 75–80. https://doi.org/10.33387/dpi.v1i2.90

Handayani, N. N. L. (2023). Determination of Realistic Mathematics Education on Problem Solving with Numeracy Literacy Covariables. *Jurnal Pendidikan Dan Pengajaran*, *56*(2), 299–309. https://doi.org/10.23887/jpp.v56i2.63288

Iffah, J. D. N. (2021). Pengaruh Penggunaan Media Worksheet terhadap Hasil Belajar Siswa Sekolah Menengah. *Mosharafa: Jurnal Pendidikan Matematika*, *10*(1), 107–116. https://doi.org/10.31980/mosharafa.v10i1.645

Jayantika, I. G. A. N. T., Kesumawati, N. W. A., & Septiani, N. M. A. (2024). Peningkatan Kemampuan Pemecahan Masalah Siswa Melalui Implementasi Pendekatan PMRI Berbasis Diskusi Kelompok. *SAP (Susunan Artikel Pendidikan)*, *9*(2), 192-201.

Julianingsih, D., & Krisnawati, E. (2020). Efektivitas Video Digital Storytelling terhadap Hasil Belajar Siswa Kelas X Materi Trigonometri. *Journal of Medives : Journal of Mathematics Education IKIP Veteran Semarang*, *4*(1), 129. https://doi.org/10.31331/medivesveteran.v4i1.975

Leiker, D., Gyllen, A. R., Eldesouky, I., & Cukurova, M. (2023). Generative AI for Learning: Investigating the Potential of Learning Videos with Synthetic Virtual Instructors. *Communications in Computer and Information Science*, *1831 CCIS*(November), 523–529. https://doi.org/10.1007/978-3-031-36336-8_81

Liljedahl, P., Santos-trigo, M., & Malaspina, Uldarico Bruder, R. (2016). *Problem Solving in Mathematics Education*. https://doi.org/10.1007/978-3-319-40730-2

Muhtasyam, A., & Novaliyosi. (2023). Systematic literature review: Kemampuan pemecahan masalah matematis dan model pembelajarannya di satuan pendidikan. *Histogram : Jurnal Pendidikan Matematika*, *7*(2), 34–45. https://doi.org/10.31100/histogram.v7i2.2995

Munengsih, Safitri, P. T., & Sukmawati, R. (2021). Analisis Kemampuan Pemecahan Masalah Matematis Siswa SMP Pada. *Jurnal Imajiner, 3*(4), 312–321. https://doi.org/10.26877/imajiner.v3i4.7267

Musyarofah, G. A., Merlina, A., & Ratnaningsih, N. (2025). Analisis Kesulitan Siswa Menerjemahkan Soal Cerita Ke dalam Model Matematika pada Materi Aljabar. *Jurnal Ilmuan Pendidikan, Matematika Dan*

Kebumian, *1*(1), 55–67. https://journal.arimsi.or.id/index.php/Aljabar/article/view/520

Nasution, M., & Lailia, H. (2023). Animated Video Media: Improved Conceptual Understanding And Solving Mathematical ProblemS. *AKSIOMA: Jurnal Program Studi Pendidikan Matematika*, *12*(1), 1344–1358. https://doi.org/10.24127/ajpm.v12i1.6892

Nurlailiyah, L., Nugroho, A. A., & Harun, L. (2025). Eksplorasi Pembelajaran yang Berpihak pada Siswa Menggunakan Design Thinking untuk Meningkatkan Kemampuan Pemecahan Masalah pada Bangun Ruang Sisi Lengkung. *Teorema: Teori Dan Riset Matematika*, *10*(01), 73–82. https://jurnal.unigal.ac.id/teorema/article/view/18178

Purnomo, D. J., Dwijayanti, I., & Nugroho, A. A. (2025). Enhancing Trigonometric Critical Thinking Through Innovative Learning: A Design Thinking Approach. *AL-ISHLAH: Jurnal Pendidikan*, *17*(2), 2402–2414. https://doi.org/10.35445/alishlah.v17i2.6891

Putri, F. E., Zelvia, M. F., Kumala, N. R. A. C., Khusaini, K., Djarot, V., Yeni, C., Suharni, & Rengganis. (2024). Modul PPG Prajabatan Untuk Dosen, Design Thinking: Berinovasi dalam Dunia dengan Kompleksitas yang Dinamis. *Journal of Innovation and Teacher Professionalism*, *2*(1), 66.

Riverdale, & IDEO. (2011). *Design Thinking for Educators*. *April*. https://f.hubspotusercontent30.net/hubfs/6474038/Design%20for%20Learning/IDEO_DTEdu_v2_toolkit+workbook.pdf

Riyani, P., & Hadi, M. S. (2023). Upaya Meningkatkan Kemampuan Pemecahan Masalah Siswa dalam Pembelajaran Matematika dengan Pendekatan Keterampilan Proses. *Jurnal Riset Pembelajaran Matematika Sekolah,* 7(1). https://doi.org/10.21009/jrpms.071.02

Salsabila, A., & Pradipta, T. R. (2021). Mathematical Problem Solving Ability: The Impact of Mathematics Learning Videos on an E-Learning Platform. *Jurnal Pendidikan Matematika*, *12*(1), 83. https://doi.org/10.24042/ajpm.v12i1.8708

Sarman, A. A., Suastika, I. K., & Murniasih, T. R. (2023). Pengembangan E-LKPD untuk Meningkatkan Kemampuan Pemecahan Masalah Matematis Peserta Didik pada Materi Bangun Ruang Sisi Lengkung. *Jurnal Tadris Matematika*, *6*(1), 49–66. https://doi.org/10.21274/jtm.2023.6.1.49-66

Shahabiah, S., & Dewi, I. (2024). Upaya Meningkatkan Kemampuan Pemecahan Masalah Matematis Peserta Didik SMP Kelas VII Melalui Pendekatan Pembelajaran Matematika Realistik Dengan Menggunakan Media Audio Visual. *SAKOLA: Journal of Sains Cooperative Learning and Law*, *1*(2), 578-592.

Siregar, B. H., Sinaga, S. M., Andini, P., Masita, N., & Fadilla, N. (2024). *Analisis Kesalahan Siswa dalam Menyelesaikan Soal Hots Materi Sistem Pertidaksamaan Linear Dua Variabel :*

Perspektif Teori Kastolan. *4*, 798–807. https://doi.org/10.53299/jagomipa.v4i4.926

Siswanto, E., & Meiliasari, M. (2024). Kemampuan Pemecahan Masalah pada Pembelajaran Matematika: Systematic Literature Review. *Jurnal Riset Pembelajaran Matematika Sekolah*, *8*(1), 45–59. https://doi.org/10.21009/jrpms.081.06

Syahril, R. F., Maimunah, M., & Roza, Y. (2021). Analisis Kemampuan Pemecahan Masalah Matematis Siswa SMA Kelas XI SMAN 1 Bangkinang Kota Ditinjau dari Gaya Belajar. *Edumatica : Jurnal Pendidikan Matematika*, *11*(03), 78–90. https://doi.org/10.22437/edumatica.v11i03.15320

Syaifudin, A. (2023). *Penerapan Lembar Kerja Peserta Didik (LKPD) Berbasis Scientific Approach Untuk Meningkatkan Keterampilan Proses Sains Dan Hasil Belajar Siswa Kelas XI MAN 1 Lampung Timur Pada Materi Sistem Pernapasan Manusia* (Doctoral dissertation, IAIN Metro).

Utami, L. W., & Hidayanto, E. (2022). *Kesulitan Peserta Didik dalam Menyelesaikan Soal Program Linear pada Pembelajaran Daring*. *11*, 257–268. https://doi.org/10.31980/mosharafa.v11i2.704

Wathoni, N. (2024). Penggunaan Media Konkret Dalam Pembelajaran Konsep Matematika Abstrak. *Jurnal Ilmiah Ipa Dan Matematika*, *3*(2), 106–112. https://doi.org/10.61116/jiim.v2i4.484

Wedyastuti, R. (2023). Upaya meningkatkan hasil belajar polinomial menggunakan media interaktif live worksheet. *Ideguru: Jurnal Karya Ilmiah Guru*, *8*(2), 171-178.

Widana, I. W. (2021). Realistic Mathematics Education (RME) untuk Meningkatkan Kemampuan Pemecahan Masalah Matematis Siswa di Indonesia. *Jurnal Elemen*, *7*(2), 450–462. https://doi.org/10.29408/jel.v7i2.3744

Žakelj, A., Štemberger, T., & Klančar, A. (2025). An Empirical Study on Basic and Conceptual Knowledge, Procedural Knowledge and Problem Solving among Primary School Students. *International Journal of Instruction*, *18*(4), 627–650. https://doi.org/10.29333/iji.2025.18434a

AUTHOR'S BIOGRAPHY

Mela Agustina, S.Pd.

Born in Ngawi, August 15, 1989. She is a teaching staff member at SMA Negeri 4 Pekalongan. She received her Bachelor's degree (S1) in Mathematics Education from Universitas Negeri Yogyakarta, Sleman, in 2011. Currently, she is a Master's (S2) student at Universitas PGRI Semarang.

Dr. FX Didik Purwosetiyono, S.Pd., M.Pd.

Born in Grobogan, December 21, 1984. He is a permanent lecturer at Universitas PGRI Semarang. He earned his Bachelor's degree (S1) in Mathematics Education from Universitas PGRI Semarang in 2006; his Master's degree (S2) in Mathematics Education from Universitas Negeri Semarang in 2010; and his Doctoral degree

(S3) in Mathematics Education from Universitas Negeri Malang in 2021.

Prof. Dr. Achmad Buchori, S.Pd., M.Pd.

Born in Grobogan, April 10, 1981. He is a Professor of Mathematics Education at Universitas PGRI Semarang. He completed his Bachelor's degree (S1) in Mathematics Education at Universitas PGRI Semarang in 2004; his Master's degree (S2) in Mathematics Education at Universitas Negeri Semarang in 2008; and his Doctoral degree (S3) in Instructional Technology at Universitas Negeri Malang in 2017.

Ts. Dr. Sharifah Osman

Professor in Engineering Education at Universiti Teknologi Malaysia. She holds a Bachelor of Science (Honours) in Chemistry from Universiti Kebangsaan Malaysia; a Postgraduate Diploma of Education (Chemistry) from Maktab Perguruan Batu Pahat, Johor; and a Doctor of Philosophy in Engineering Education from Universiti Teknologi Malaysia.