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Enhancing Computational Thinking of Islamic Education Students through CT-Based Prompt Engineering: A Quasi-Experimental Study on AI Multimodal Media Design

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Abstract: This study evaluates the effectiveness of Prompt Engineering strategies based on Computational Thinking (CT) in enhancing the ability of Islamic Religious Education (PAI) students to design multimodal learning media (images, videos, and games) powered by Artificial Intelligence (AI). Using a quasi-experimental design involving 35 students, the research integrates the four pillars of CT decomposition, pattern recognition, abstraction, and algorithm design as logical foundations for composing AI instructions. The results show a significant increase in students' CT scores, from an average of 56.80 to 85.10, with an N-Gain Score of 0.65 (effective category). Students successfully produced educational image media (92%), interactive game logic (84%), and animated videos (78%) with high theological accuracy. The abstraction pillar was found to be the most crucial in minimizing AI "hallucinations" in sensitive religious content, while algorithm design enabled the creation of systematic game flows. This strategy successfully transformed students' roles from mere users to logical and critical instruction designers (Prompt Engineers). The study recommends integrating CT-Prompting into the PAI curriculum as a core competency to produce innovative and valid digital content in the era of artificial intelligence

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Introduction

Integration of Artificial Intelligence (AI) in higher education has triggered major transformations, especially through Generative Artificial Intelligence (Gen-AI), which is capable of producing new content such as text, images, or audio. In the digital era, the use of AI in learning is not just a technological trend(Hanifah et al., 2021), but an urgent need for instructional efficiency and personalization(Zaus et al., 2025). Global trends show a surge in research on AI applications for developing computational thinking (CT) skills that is, the ability

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pp. 329-339

to think logically and systematically to solve problems (Syafi et al., 2023)(Ginige et al., 2026). with a CAGR of 22.8% since 2019 (Al Husaeni et al., 2025; Phanichsiti et al., 2025a). In the field of Islamic Religious Education (PAI), AI is relied upon to designinteractive learning media that enhance student engagement and conceptual understanding(Kim et al., 2023). However, the effectiveness of AI tools largely depends on the quality of human instructions, technically known as Prompt Engineering (the crafting of specific instructions to generate optimal AI responses)(Sari & Munir, 2024).

For pre-service teacher students who may not be familiar with the term Computational Thinking (CT)(Hijón-Neira et al., 2023), this concept refers to a problem-solving method that uses systematic logic(Azmi & Ummah, 2021), similar to how a computer works, but carried out by the human brain (Susanti & Taufik, 2021). CT itself serves as a crucial "thinking foundation" in interacting with AI, as in this context, CT consists of four interconnected pillars: (1) Decomposition, which is the ability to break down broad material into smaller parts (e.g., breaking down a historical narrative into video scenes); (2) Pattern Recognition, the ability to identify similarities in instructions that yield the best outputs across various AI platforms; (3) Abstraction, the ability to focus on essential information (such as the core of a religious argument) and ignore irrelevant details to prevent AI "hallucinations"; and (4) Algorithm Design, the process of arranging step-by-step commands so that AI can produce final products such as images, videos, or educational game logic(del Olmo-Muñoz et al., 2023).

Several previous studies have examined the synergy between AI and thinking skills (Tian, 2025). reported that structured interaction with AI chatbots through algorithmic instructions stimulates students' systematic thinking. Similarly, (Wongla et al., 2025) found that learning platforms combining prompt engineering and gamification simultaneously improve problem-solving skills(Hijón-Neira et al., 2024). Research in language education also shows that AI can serve as cognitive scaffolding, helping students transform abstract ideas into digital products (Phanichsiti et al., 2025; Rachmayanti & Alatas, 2023) However, recent studies still indicate a lack of understanding regarding how procedural AI instructions with a CT approach influence the development of CT skills outside the realm of science. In the context of PAI students, research on designing complex AI-based multimodal learning media and the role of prompt engineering as a primary cognitive strategy is still limited (Weng et al., 2024) .

The scientific novelty of this study lies in the application of Prompt Engineering strategies based on the four pillars of CT to equip PAI students in producing multimodal learning media (images, videos, and educational games). Unlike previous studies that mainly focused on passive uses of AI for information retrieval, this research positions prompting as a structured cognitive activity to produce creative educational assets that remain theologically accurate. This emphasis is crucial because the PAI domain demands absolute precision concerning religious sources (Qur'an and Hadith). By applying CT logic to prompt construction, it is expected that errors in generative AI models such as invalid religious references or visuals misaligned with Islamic values can be minimized.

April 2026 Vol. 11 No. 2
E-ISSN: 2656-1417
P-ISSN: 2503-0602
pp. 329-339

Based on this background, the main problem identified is the low ability of PAI students to design systematic AI instructions for various media formats. As a result, the learning media produced are often of low quality, content errors are common, and logical reasoning is lacking. Based on previous findings and needs, the hypothesis of this study is that the application of CT-based Prompt Engineering strategies can significantly enhance PAI students' computational thinking skills while optimizing their ability to produce diverse AI-based learning media.

The integration of Artificial Intelligence (AI) in higher education has triggered major transformations, especially through Generative AI (Gen-AI). In the field of Islamic Religious Education (PAI), AI is relied upon to design interactive learning media. However, its effectiveness depends heavily on Prompt Engineering. For PAI students, Computational Thinking (CT) serves as a crucial thinking foundation in interacting with AI. Despite the growing interest in AI literacy, no study has empirically tested CT-based prompting in religious education contexts, where the accuracy of sacred texts and theological integrity are paramount.

This research aims to fill this gap by providing a dual contribution to the field. Theoretically, this study introduces the CT-Prompting model as a new conceptual framework for understanding how cognitive logic can be transformed into systematic AI instructions. Practically, it demonstrates a scalable method for PAI students to produce validated multimodal learning media (images, videos, and games) that are not only technologically advanced but also religiously sound. Furthermore, this study addresses the challenge of 'AI hallucination' the tendency of AI to produce factually incorrect information by positioning the abstraction pillar of CT as a theological filter to ensure religious accountability.

Research Method

This study employed a quantitative approach with a quasi-experimental one-group pretest-posttest design. The main focus was to evaluate the cognitive transformation of Islamic Religious Education (PAI) students through Prompt Engineering strategies in designing AI-based multimodal learning media. This design allowed the researchers to compare the students' computational thinking abilities before and after the intervention, which consisted of systematic prompt engineering strategy training.

April 2026 Vol. 11 No. 2
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pp. 329-339

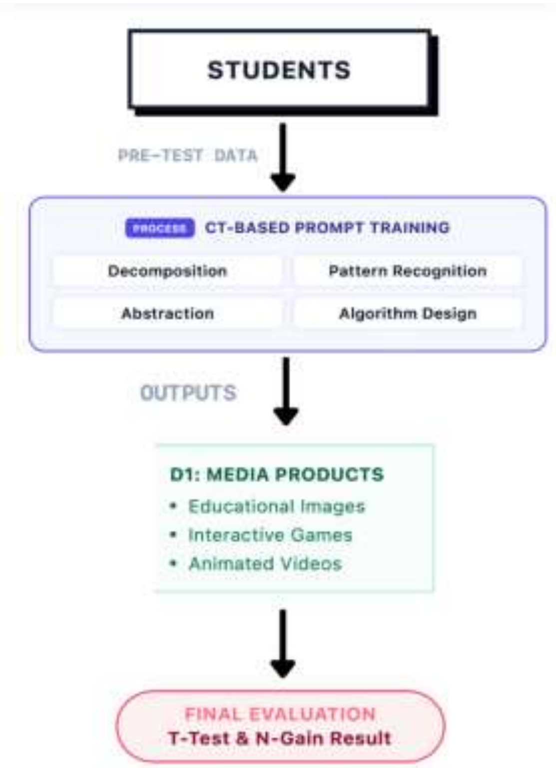

Figure 1. Research Data Flow Diagram (DFD)

The research was conducted through a quantitative approach using a quasi-experimental one-group pretest-posttest design involving 35 students from the Islamic Religious Education (PAI) Study Program. Participants were selected via purposive sampling, focusing on those with basic digital literacy but no prior formal training in Computational Thinking (CT). The selection of PAI students was strategic, as the field demands high precision in processing sacred texts and religious arguments, requiring students to bridge theological disciplines with systematic technological logic to ensure religious content accuracy. (Dinata et al., 2025)

The intervention consisted of an intensive, project-based training cycle integrating the four CT pillars into multimodal media production. During this process, students applied Decomposition by breaking down complex PAI topics into manageable sub-tasks like scriptwriting and visual asset creation; Pattern Recognition to identify effective prompt structures across diverse AI platforms; Abstraction to filter essential information and provide strict constraints that minimize AI 'hallucinations' or content deviations; and Algorithm Design to construct logical prompt chains, such as 'If-Then' branching for interactive educational games.

To ensure rigorous measurement, the study utilized the Computational Thinking Scale (CTS), which demonstrated high internal consistency with a Cronbach's Alpha of 0.84, while the theological validity of the final products was evaluated by a panel of five experts focusing on source accuracy, visual alignment, and contextual clarity. Data were analyzed using descriptive statistics to overview achievement scores, paired sample t-tests to determine the

April 2026 Vol. 11 No. 2
E-ISSN: 2656-1417
P-ISSN: 2503-0602
pp. 329-339

significance of improvement, and Normalized Gain (N-Gain) scores to assess intervention effectiveness. This quantitative analysis was further enriched by qualitative evaluations of student prompt drafts to describe the cognitive shift from random instructions to structured, logical prompt engineering.

Result and Discussion

Quantitative data revealed a substantial increase in students' systematic thinking competencies across all aspects. The comparison of average scores obtained from the Computational Thinking Scale (CTS) instrument before (pre-test) and after (post-test) the training is presented in detail in Table 1.

Table 1. Description of CT Score Improvement Based on Four Main Pillars

Computational Thinking Pillars	Pre-test (Avg ± SD)	Post-test (Avg ± SD)	Improvement	Interpretation	Cohen's d
Decomposition	52.4 ± 4.2	82.6 ± 3.8	57.6%	Effective	1.82
Pattern Recognition	58.1 ± 3.5	85.3 ± 3.1	46.8%	Effective	1.75
Abstraction	55.2 ± 4.8	88.7 ± 2.9	60.7%	High +1	2.15
Algorithm Design	61.5 ± 5.1	83.8 ± 4.2	36.2%	Effective	1.34

Statistically, the paired sample t-test yielded a value of $t(34) = 15.24$ with a probability of $p < 0.001$. This indicates that the improvement in students' abilities did not occur by chance, but was a direct result of the CT-based prompt engineering training intervention. The highest increase was observed in the Abstraction aspect (60.7%), indicating that students became highly skilled in filtering crucial information and providing appropriate constraints to the AI to prevent content deviation.

The effectiveness of the training was confirmed by the N-Gain Score of 0.65 which falls into the medium-to-high (effective) category. This demonstrates that the strategy was able to accelerate PAI students' technological understanding in a relatively short period.

This study did not stop at the theoretical level but also measured students' tangible success in producing media assets. This achievement was assessed from two perspectives: the validity of the religious (PAI) content and the aesthetic/functional quality of the media.

Tabel 2. Success Rate of Multimodal Media Production Using AI Prompting

Media Type	AI Platforms	Success Rate (%)	Key Performance Indicators
Educational Images	DALL-E	92%	Visual accuracy of Islamic content & aesthetics.
Animated Videos	VEO.3	78%	Narrative consistency & audio-visual synchronization.
Games/Quizzes	ChatGPT	84%	Branching logic accuracy & interactivity.

April 2026 Vol. 11 No. 2
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P-ISSN: 2503-0602
pp. 329-339

Although animated videos presented a higher level of technical difficulty (as indicated by a 78% achievement rate), the majority of students were still able to meet the minimum standards for learning media feasibility.

Discussion

The findings indicate a profound shift in thinking processes. Abstraction and decomposition served as the main drivers of creativity. Students successfully produced high-quality media: Educational Images (92%), Interactive Games (84%), and Animated Videos (78%).

The qualitative transformation in students' logic is most evident when comparing their prompt construction before and after the Computational Thinking (CT) intervention. Initially, students tended to provide vague and simplistic instructions, such as 'Make an image about zakat' or 'Make a video about Islamic history,' which often resulted in low-quality or inaccurate AI outputs. However, following the training, students demonstrated advanced cognitive shifts by applying specific CT pillars to their instructions.

For educational images, students utilized abstraction and decomposition to specify technical parameters like flat design styles and 16:9 ratios while filtering sensitive visual details to maintain solemnity. In video production, students moved from broad requests to structured scene-based narratives, effectively decomposing long historical accounts into manageable segments with distinct visual and audio descriptions. Furthermore, for interactive games, students successfully applied algorithm design by treating natural language as procedural logic—specifically using 'If-Then' statements to manage points and feedback based on valid religious references.

This shift from random instruction to structured prompt engineering positions students as logical designers capable of producing high-quality, theologically sound multimodal assets.

To facilitate understanding of the distribution of improvements, the results of this study are also presented in the form of a bar chart. This visualization highlights that the pillars of Abstraction and Decomposition serve as the main drivers of creativity among PAI students in the AI era.

Jurnal Teknologi Pendidikan:
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https://e-journal.undikma.ac.id/index.php/jtp/index

April 2026 Vol. 11 No. 2
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P-ISSN: 2503-0602
pp. 329-339

Figure 2. Highlights that the pillars of Abstraction and Decomposition

The implementation of the CT-Prompting strategy across various media formats demonstrates a significant shift in how students manage complex digital tasks through structured logic. In the creation of educational images, students utilize the abstraction pillar to visualize abstract concepts like faith or manners by identifying appropriate symbols that maintain religious boundaries and ensure theological validity. For animated videos, the decomposition pillar is applied to break down lengthy narratives into systematic components, including scriptwriting, scene-by-scene visual descriptions, and audio instructions, which prevents AI from generating disjointed or overlapping content. Furthermore, in developing interactive games, students employ algorithm design to treat natural language as a form of 'code,' allowing them to construct complex branching quiz logic and manage educational flows without traditional programming, a process that exemplifies learning by doing through technical execution..

The integration of Computational Thinking in prompt engineering instruction has a deeper impact than mere technical proficiency. Students now possess full agency over technology. They no longer accept AI-generated outputs at face value; rather, they are able to critically evaluate (debug) inaccurate AI results. This transformation is crucial for future PAI educators to remain critical, logical, and to maintain the authenticity of digital religious content amid the flood of AI-generated information.

The ultimate contribution of this research is the formulation of the CT-Prompting Model. This model represents how computational logic transforms natural language

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P-ISSN: 2503-0602
pp. 329-339

instructions into high-quality educational outputs. The relationship between these variables can be expressed in the following conceptual formula:

$$(D + P + A + AD) \times Prompt \rightarrow Outcome$$

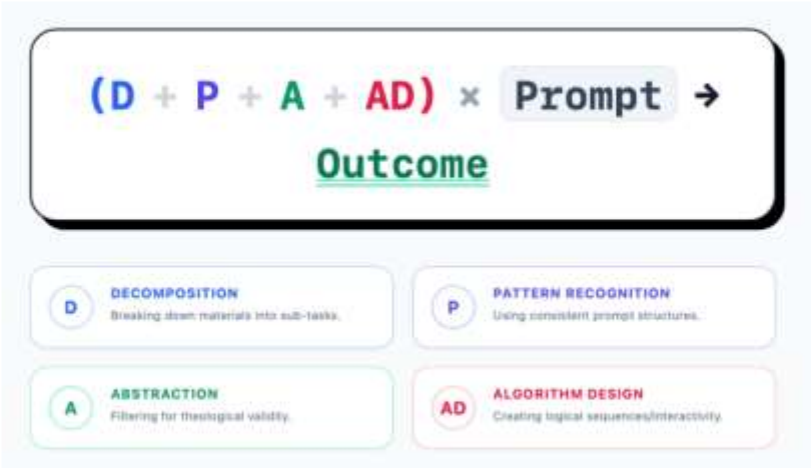

Figure 3. The CT-Prompting Model Framework

The framework proposed in this study establishes the CT-Prompting Model as a theoretical foundation for transforming computational logic into high-quality educational outputs. This model begins with the Cognitive Input, integrating the four pillars of Computational Thinking (CT) where each element plays a vital role: without Decomposition (D), learning materials become too complex for AI to process effectively; without Pattern Recognition (P), prompts lack the necessary consistency; without Abstraction (A), content risks theological inaccuracy or 'hallucination'; and without Algorithm Design (AD), the resulting media lacks essential interactivity.

This CT logic functions as a cognitive process that is then amplified by the Prompt Multiplier, where technical Prompt Engineering serves as the direct vessel for execution. The final Outcome is not merely a media asset, but a validated multimodal product that is both technologically advanced and religiously sound. Ultimately, this model provides a scalable framework for educators to navigate the challenges of AI-generated content while ensuring that human agency and theological integrity remain at the center of technological integration.

Conclusion

In conclusion, CT-based Prompt Engineering significantly improves PAI students' systematic thinking, transforming them into critical instruction designers. However, this study is limited by its one-group design and small sample size (N=35), which may affect generalizability. Future research should involve larger cohorts and control groups. We recommend that Islamic Higher Education Institutions integrate AI literacy and CT into their educational technology curricula to ensure future teachers remain the final verifiers (Human-in-the-loop) of digital religious content.

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