Article

AIGC-Enabled Design of Interdisciplinary Project-Based Learning for Primary School Mathematics

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Abstract: The rapid development of generative artificial intelligence (AIGC) has created unprecedented opportunities for pedagogical innovation, particularly within the foundational domain of primary mathematics education. Traditional instructional methods often struggle to engage young learners and bridge the gap between abstract mathematical concepts and real-world applications. Guided by the comprehensive STEAM (Science, Technology, Engineering, Arts, and Mathematics) education framework, this study develops an innovative, AIGC-enabled interdisciplinary thematic learning model tailored specifically for primary mathematics. By utilizing interdisciplinary thematic learning as the core organizational approach and project-based learning (PBL) as the primary implementation strategy, this research seeks to transform conventional classroom dynamics. To rigorously examine the practical effectiveness and feasibility of the proposed model, a detailed teaching case was systematically designed, deployed, and evaluated in a real-world educational setting. Quantitative and qualitative analyses of the implementation results indicate that the AIGC-integrated model effectively promotes students' comprehensive cognitive competencies. Furthermore, it significantly enhances their practical problem-solving performance, facilitates deeper knowledge integration across multiple disciplines, and robustly supports the development of overall digital and mathematical literacy. These compelling findings demonstrate the profound educational value of integrating AIGC technologies into STEAM-oriented interdisciplinary PBL frameworks, offering a scalable and highly effective paradigm for modernizing primary mathematics curricula and preparing students for future technological landscapes.

Keywords: generative ai; mathematics education; steam education; interdisciplinary learning; project-based learning

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1. Introduction

AIGC is fostering transformative opportunities for instructional innovation, particularly in the realm of primary mathematics education. Despite its potential, traditional approaches to teaching mathematics often rely heavily on abstract concepts and symbol-focused methodologies, which can create significant barriers to students' deep comprehension and their ability to transfer knowledge to real-world contexts. These challenges are further compounded when interdisciplinary project-based learning (PBL) is introduced, as it frequently encounters difficulties in establishing meaningful contexts and providing adequate support for learners. To address these persistent issues, this study proposes an innovative instructional model that integrates AIGC with interdisciplinary thematic learning and PBL. By leveraging the capabilities of AIGC, the model aims to enhance the design of project-based activities, ensuring they are both contextually rich and pedagogically supportive. This integration seeks to foster a more engaging and effective learning environment, enabling students to develop critical competencies such as problem-solving, collaboration, and creative thinking. Ultimately, the study provides a practical framework for reimagining instructional practices in primary mathematics, offering insights into how emerging technologies can be harnessed to overcome traditional educational limitations and promote holistic student development [1].

2. Related Work

STEAM education represents a pedagogical approach that integrates science, technology, engineering, arts, and mathematics to foster interdisciplinary learning and problem-solving skills. This approach emphasizes the importance of combining scientific knowledge with humanistic literacy to support competency-based education. By encouraging students to engage with real-world problems, STEAM education promotes the development of critical thinking, creativity, and collaboration [2]. Similarly, interdisciplinary thematic learning focuses on organizing knowledge around central themes or practical challenges, enabling students to transfer knowledge across domains and develop a more holistic understanding of complex issues. This method leverages context-based inquiry to deepen learning and enhance the application of knowledge in diverse scenarios. Project-Based Learning (PBL), as a student-centered methodology, complements these approaches by involving learners in collaborative investigations and the execution of meaningful, authentic tasks. PBL encourages active participation, teamwork, and the application of theoretical concepts to practical situations, thereby reinforcing interdisciplinary connections. In parallel, Artificial Intelligence-Generated Content (AIGC) has emerged as a transformative educational technology. AIGC facilitates the creation of multimodal resources, the design of immersive learning environments, and the provision of personalized support tailored to individual learner needs. These capabilities align closely with the principles of STEAM education and inquiry-based learning, offering innovative tools to enhance educational outcomes. Despite the potential of these approaches, existing research often examines them in isolation, with limited efforts to integrate STEAM, interdisciplinary thematic learning, PBL, and AIGC into a unified instructional framework. This study addresses this gap by proposing a comprehensive model specifically designed to enhance primary mathematics education through the systematic integration of these methodologies.

3. Methodology

3.1. Theoretical Foundations

Constructivist theory underscores the importance of learners actively constructing their own understanding through engagement with meaningful tasks and experiences. This approach aligns with the principles of multimodal learning theory, which advocates for the integration of diverse representational forms—such as visual, auditory, and kinesthetic modalities—to enhance comprehension and retention. By leveraging these theoretical frameworks, Artificial Intelligence-Generated Content (AIGC) can facilitate a more dynamic and interactive learning environment. Specifically, AIGC enables the creation of contextualized multimodal resources that cater to diverse learning preferences, thereby fostering deeper conceptual understanding. Furthermore, it supports collaborative inquiry by enabling students to engage in shared problem-solving activities, promoting critical thinking and teamwork. AIGC also enhances knowledge transfer by providing adaptive learning pathways that connect abstract mathematical concepts to real-world applications [3]. Lastly, it contributes to the development of interdisciplinary competencies by integrating mathematics with other domains, such as science and technology, preparing students for complex, interconnected challenges.

3.2. Model Construction

Guided by the STEAM framework, this study integrates interdisciplinary thematic learning and project-based learning (PBL) methodologies, with artificial intelligence-generated content (AIGC) serving as a pivotal technological enabler. The proposed instructional model for primary mathematics is meticulously designed to align with the PBL process, ensuring a structured and dynamic approach to learning. The model is built upon three interdependent core elements: teacher guidance, student participation, and

AIGC support [4]. Teacher guidance plays a critical role in scaffolding the learning process, providing students with clear objectives, structured activities, and continuous feedback to foster engagement and understanding. Student participation is emphasized as an active and collaborative process, encouraging learners to engage in problem-solving, critical thinking, and creative exploration within authentic, real-world contexts. AIGC support enhances the learning experience by offering multimodal resources, such as interactive simulations, adaptive learning tools, and personalized content recommendations, which cater to diverse learning needs and preferences. The integration of these elements facilitates interdisciplinary inquiry, enabling students to construct knowledge through meaningful exploration and application. Furthermore, the model aims to cultivate students' comprehensive competencies, including mathematical reasoning, communication skills, and digital literacy, thereby preparing them for future academic and professional challenges in an increasingly interconnected and technology-driven world (As shown in Figure 1).

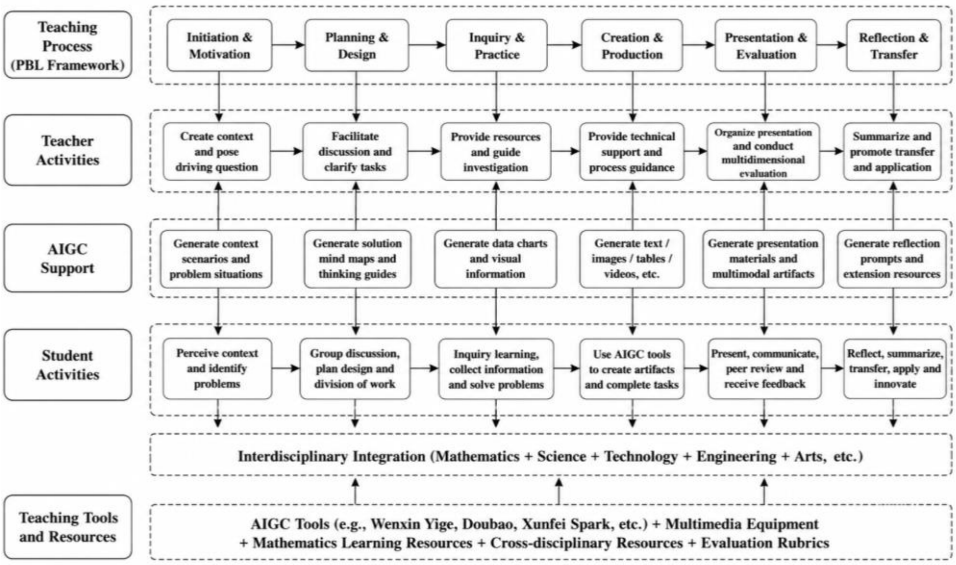

Figure 1. Teaching Model of Interdisciplinary Theme-Based Mathematics Learning in Primary School Empowered by AIGC.

3.2.1. Instructional Process Layer

This layer adheres to the structured methodology of Problem-Based Learning (PBL), which is widely recognized for its systematic approach to fostering critical thinking and problem-solving skills. The instructional process is divided into six distinct stages, each serving a specific purpose in guiding learners from the initial identification of a problem to the generation of meaningful outcomes and their subsequent refinement. The initiation stage involves identifying and understanding the problem, setting the foundation for the learning process. In the planning stage, learners outline strategies and allocate resources to address the problem effectively. The inquiry stage emphasizes exploration and research, encouraging learners to gather relevant information and analyze it critically [2]. During the creation stage, learners synthesize their findings to develop solutions or products. The presentation stage focuses on communicating these outcomes effectively to an audience, fostering skills in articulation and dissemination. Finally, the reflection stage allows learners to evaluate their process and outcomes, identifying areas for improvement and consolidating their learning experience. This comprehensive framework ensures a coherent and iterative process that promotes both individual and collaborative learning.

3.2.2. Teacher Activity Layer

Teachers play a guiding and supportive role throughout the learning process, transitioning from traditional methods of direct knowledge transmission to a more dynamic role of facilitating and orchestrating learning experiences. This involves creating an environment where students feel encouraged to engage in discussions, critically analyze information, and collaborate with peers. Teachers provide essential resources tailored to the needs of the learners, ensuring that the materials are accessible and relevant to the subject matter. Additionally, they offer technical assistance to help students navigate any challenges related to tools or platforms used in the learning process. Beyond these practical roles, teachers also organize reflective activities, enabling students to evaluate their learning outcomes and identify areas for improvement. By adopting this multifaceted approach, teachers empower students to take greater ownership of their educational journey, fostering a more interactive and participatory learning environment [5].

3.2.3. AIGC Support Layer

As a key component of the model, the Artificial Intelligence Generated Content (AIGC) support layer plays a pivotal role in enhancing multimodal functionalities across various stages of application. This layer is designed to provide comprehensive support by integrating advanced capabilities such as text generation, image synthesis, data visualization, and interactive assistance. These functionalities collectively contribute to creating enriched learning environments that cater to diverse user needs [6]. For instance, text generation can facilitate the creation of tailored educational materials, while image synthesis can enhance visual learning by producing contextually relevant graphics. Data visualization, on the other hand, enables the transformation of complex datasets into intuitive visual formats, aiding in better comprehension and decision-making processes. Furthermore, the interactive assistance feature ensures a dynamic and responsive user experience, allowing for real-time engagement and problem-solving. By supporting both the procedural aspects and the final outcomes, the AIGC layer serves as a cornerstone in advancing the overall efficacy and adaptability of the model.

3.2.4. Student Activity Layer

Student activities are organized around project tasks that encompass a variety of interconnected processes, including problem exploration, collaborative engagement, inquiry-based learning, the creation of tangible or digital artifacts, and reflective practices. These activities are designed to foster active participation, enabling students to construct knowledge through hands-on experiences and critical thinking. Problem exploration encourages learners to identify and analyze complex issues, laying the groundwork for deeper understanding [7]. Collaboration allows students to work in teams, promoting the exchange of diverse perspectives and the development of interpersonal skills. Inquiry-based learning emphasizes the importance of questioning and investigation, guiding students to seek evidence and draw conclusions. Artifact creation involves the production of meaningful outputs that demonstrate applied knowledge, while reflection provides an opportunity for students to evaluate their learning processes and outcomes. Together, these elements create a dynamic and authentic educational environment.

3.2.5. Interdisciplinary Integration

Interdisciplinary integration serves as a foundational principle within the educational model, emphasizing the seamless connection of mathematics with science, technology, engineering, and the arts. This approach fosters a holistic learning environment where students are encouraged to transcend traditional subject boundaries, enabling them to synthesize knowledge from multiple domains. By bridging these disciplines, learners are better equipped to tackle complex, real-world challenges that require multifaceted solutions. For instance, mathematical concepts can be applied to engineering projects to optimize structural designs, while scientific principles may inform technological innovations. Similarly, the integration of the arts introduces creativity and critical thinking into problem-solving processes, enriching the overall learning experience. This interconnected framework not only enhances cognitive flexibility but also prepares students for the demands of an increasingly interdisciplinary and innovation-driven global landscape. Such an approach underscores the importance of cultivating adaptable, well-rounded individuals capable of addressing diverse societal needs [8].

3.2.6. Tools and Resources

The implementation of the model is supported by advanced tools and resources that facilitate its practical application and enhance its overall effectiveness. AIGC tools, which encompass artificial intelligence-generated content platforms, play a pivotal role in streamlining processes and providing innovative solutions for problem-based learning (PBL). These tools enable learners to access dynamic and interactive content, fostering deeper engagement and understanding. Additionally, digital media serves as a critical component, offering diverse formats such as videos, simulations, and interactive modules that cater to various learning styles and preferences. Interdisciplinary learning resources further enrich the PBL experience by integrating knowledge from multiple domains, encouraging holistic thinking and collaborative problem-solving. Together, these elements ensure that the model is not only feasible but also adaptable to evolving educational needs, thereby promoting sustainable and impactful learning outcomes [9].

4. Application

4.1. Teaching Case

4.1.1. Case Design

Basic Project Information.

Project Title: AI-Assisted Creation of Mathematical Stories [10]. This title highlights the integration of mathematical learning with creative expression and appropriate digital support, emphasizing that students use intelligent tools as aids for thinking, organizing, and presenting mathematical ideas rather than as substitutes for independent reasoning.

Target Grade: Grade 2. The project is designed in accordance with the cognitive characteristics, language development level, and mathematical learning needs of lower primary students, with particular attention to concrete situations, intuitive representation, and guided participation [4].

Duration: 3 class sessions [1]. The instructional sequence is arranged progressively across three lessons, including task introduction and problem discovery, story design and multimodal production, and presentation, evaluation, and reflection, so that students can complete the learning cycle in an orderly manner.

Subjects Integrated: Mathematics (primary), Chinese, Information Technology, and Art. Mathematics serves as the central disciplinary foundation, while Chinese supports narrative organization and oral and written expression, information technology supports digital production and tool use, and art contributes visual design and aesthetic presentation.

Technical Support: AIGC tools. Such tools are used in a limited and guided manner to assist with idea generation, image-text organization, and presentation design, while teachers maintain clear instructional supervision to ensure age-appropriate use, accuracy of mathematical content, and alignment with learning objectives [11].

Curriculum, Learner, and Textbook Analysis.

This project, situated within the "Comprehensive and Practical Activities" domain of primary mathematics, focuses on core content such as number sense and basic operations, guiding Grade 2 students to identify and solve quantitative problems in real-life contexts. It integrates Chinese, art, and information technology to support interdisciplinary learning, while fostering mathematical expression, aesthetic awareness, and key competencies, including reasoning, application, and creativity. Students possess foundational knowledge, such as number recognition within 10,000 and basic operations, and generally show strong interest in storytelling, drawing, and collaborative activities. However, they may experience difficulties in representing abstract quantitative relationships, organizing problem situations clearly, and connecting mathematical language with visual and verbal expression. In addition, most students have limited experience in contextualized and multimodal expression, especially when using AIGC tools in a purposeful and regulated way. As a comprehensive practical activity, the project reorganizes "numbers and operations" content into holistic, context-based tasks with open-ended outcomes, promoting the transition from isolated knowledge acquisition to integrated application. It also helps students gradually form awareness of problem posing, problem analysis, and solution communication, thereby laying a foundation for subsequent interdisciplinary learning and more advanced mathematical understanding.

Project Objectives.

1. To integrate and apply core knowledge of numbers and operations in presenting real-life mathematical problems and solution processes, enabling students to connect textbook knowledge with familiar situations and to express quantitative relationships in a complete and understandable manner [12];
2. To enhance students' abilities in multimodal creation, AIGC tool usage, and collaborative inquiry, so that they can participate in planning, discussing, revising, and presenting learning products through appropriate division of labor and guided digital practice;

To promote interdisciplinary competence and develop initial mathematical modeling and problem-solving abilities, encouraging students to move from observing everyday phenomena to identifying mathematical information, constructing simple problem situations, and selecting suitable methods of representation;

To increase students' interest in mathematics by highlighting its relevance and practical value, helping them experience mathematics as meaningful, expressive, and closely connected with daily life, communication, and creative activity.

Driving Questions.

Essential Question: How can quantitative relationships in real life be understood and expressed? This question directs students to observe daily situations carefully, identify key numerical information, and consider how quantities change, compare, combine, or separate within meaningful contexts.

Driving Question: How can we use AIGC to create an engaging mathematical story that accurately represents mathematical relationships and problems? This question emphasizes that digital tools should support, rather than replace, students' mathematical thinking, and that the final story must remain accurate in logic, clear in structure, and appropriate in expression [13] (As shown in Table 1).

Table 1. Design of Driving Questions.

Stage	Question Chain
Initiation	What is happening in the picture? What mathematical information can be identified? How can it be transformed into a story problem?
Planning	What mathematical problem should be embedded? How can it be represented in a story?
Inquiry	What relationships exist among the quantities? How can the problem be solved and explained?
Creation	Does the generated image accurately represent the mathematical situation?
Presentation	Can others understand the mathematical reasoning?
Reflection	How can the story be improved or transferred to new contexts?

Assessment Design.

This project adopts a process-oriented evaluation approach combining teacher and peer assessment. Criteria include mathematical accuracy, logical coherence, clarity of expression, creativity, technology use, and collaboration [5, 12]. Teacher assessment is based on a comprehensive rubric, while peer assessment focuses on presentation and creativity. At the same time, evaluation is embedded throughout the learning process rather than limited to the final display stage. Teachers observe students' participation in discussion, task completion, revision behavior, and use of mathematical language, while peers provide accessible feedback on whether the story is interesting, understandable, and well presented. Feedback and discussion are incorporated to support reflection and improvement, ensuring a comprehensive evaluation of both learning processes and outcomes. This design helps students recognize strengths and weaknesses in a timely manner, promotes self-adjustment, and reinforces the educational value of assessment as guidance for learning (As shown in Table 2, 3).

Table 2. Student Peer Evaluation Form.

Evaluation Criteria	Excellent	Fair	Needs Improvement
Clarity of Mathematical Problems	□	□	□
Accuracy of Quantitative Relationships	□	□	□
Engaging Storyline	□	□	□
Appropriate Match Between Text and Images	□	□	□
Completeness and Clarity of Expression	□	□	□

Table 3. Teacher Comprehensive Evaluation Rubric.

Evaluation Dimension	Indicators	Excellent (4)	Good (3)	Satisfactory (2)	Developing (1)
Mathematical Quality	Accuracy of Quantitative Relationships	□	□	□	□
Logical Coherence	Consistency Between Problem and Story	□	□	□	□
Expressive Quality	Clarity of Text and Image Expression	□	□	□	□
Creativity	Originality of Context and Design	□	□	□	□
Use of Technology	Appropriate Use of AIGC	□	□	□	□
Collaboration	Effective Group Collaboration	□	□	□	□
	Total Score:	/24			

Project Outcomes.

Individual Outcomes: learning worksheets and reflective journals [11]. These materials document each student's understanding of mathematical situations, problem-solving process, participation in group work, and reflections on the use of digital tools, thereby providing evidence of both cognitive development and learning habits.

Group Outcomes: mathematical comic strips. As collaborative products, these comic strips are expected to present complete story situations, accurate quantitative relationships, and clear solution paths, while also demonstrating coordinated visual design, language expression, and division of labor within the group.

Presentation Formats: digital multimodal artifacts (e.g., text--image compositions) and notes [2, 5]. These formats allow students to combine words, numbers, images, and oral explanation in a structured way, making mathematical meaning more visible and supporting classroom sharing, evaluation, and subsequent revision.

4.1.2. Case Implementation

Guided by the proposed AIGC-enabled interdisciplinary PBL model, the teaching process is organized into six coherent and progressively connected stages. These stages are designed to support students' movement from contextual observation to problem identification, from collaborative inquiry to artifact production, and from presentation to reflective transfer. In this implementation, AIGC functions as a supportive instructional tool for scenario generation, language assistance, and visual representation, while teachers maintain responsibility for pedagogical guidance, task regulation, and evaluation. The overall process emphasizes the integration of mathematical understanding, language expression, visual communication, and cooperative learning within an authentic project-based framework.

Initiation (Context Perception and Problem Generation).

Teachers use AIGC to generate real-life visual scenarios, such as a stationery shop, that encourage students to identify mathematical information and quantitative relationships embedded in familiar contexts. Through guided discussion, students examine what is happening in the scenario, what mathematical problems can be identified, and how these problems can be represented in a coherent story. This process gradually leads to the central driving question: How can we use AIGC to create an engaging mathematical story that accurately represents mathematical relationships and problems? At this stage, students are also encouraged to observe details, distinguish relevant from irrelevant information, and connect everyday experiences with formal mathematical thinking [2, 9]. They then generate context-related problems, learn basic prompt construction strategies, and form collaborative groups with clear initial roles, thereby establishing a foundation for subsequent inquiry and creative work.

Planning (Task Structuring and Design).

Students design story contexts by addressing questions such as: What mathematical problem should be embedded in the story? and How can quantitative relationships be represented through characters and events? During this stage, they clarify task objectives, determine the sequence of story development, and consider how mathematical meaning can remain explicit while the narrative remains understandable and engaging. AIGC supports idea generation and language refinement, while teachers guide project planning, structured expression, and the alignment between mathematical content and narrative form. Students may also discuss division of labor, expected outputs, and criteria for quality, which helps improve task organization and strengthens their awareness of both disciplinary accuracy and communicative effectiveness.

Inquiry (Problem Solving and Knowledge Construction).

Students collaboratively investigate questions such as: What relationships exist among the quantities?, How can the problem be solved?, and Why does this solution work? In this stage, group members compare possible solution paths, explain their reasoning to one another, and test whether their interpretations are mathematically valid and contextually appropriate. AIGC assists with explanation and clarification of problem situations, supporting conceptual understanding and knowledge construction in a more accessible manner. Teachers further encourage students to justify each step, use precise mathematical language, and connect concrete situations with abstract relationships. As a result, inquiry becomes not only a process of obtaining answers, but also a process of deepening understanding, correcting misconceptions, and building shared knowledge through dialogue and evidence-based reasoning [1].

Creation (Multimodal Artifact Development).

Students refine prompts and evaluate whether the generated images accurately represent the mathematical situation and support the intended story. They then integrate text and visuals to create mathematical comic artifacts, achieving multimodal expression and interdisciplinary integration. In this process, students must repeatedly compare the generated content with the original mathematical relationships to ensure consistency, clarity, and educational value. They may revise wording, adjust visual details, and reorganize narrative sequences so that the final artifact communicates both the story and the mathematical logic effectively. This stage highlights the productive use of AIGC as a creative aid rather than a substitute for student thinking, because students remain responsible for judgment, selection, revision, and the final coherence of the multimodal product.

Presentation (Sharing and Evaluation).

Groups present their artifacts and explain the underlying mathematical reasoning. Peer and teacher evaluation focuses on questions such as: Can the mathematical relationships be clearly understood? and Does the story accurately represent the problem situation? In addition, presentation provides students with an opportunity to articulate design choices, respond to questions, and reflect publicly on how mathematical ideas were transformed into narrative and visual forms. Evaluation is therefore not limited to the correctness of the answer, but also considers clarity of explanation, appropriateness of representation, and the degree of collaboration demonstrated during the project. Through this process, students strengthen communication skills, develop evaluative awareness, and gain feedback that can inform later revision and improvement.

Reflection (Consolidation and Transfer).

Students reflect on questions such as: What have I learned?, How did AIGC support my learning?, and How can this approach be applied to new situations? They then revise or extend their work using new scenarios, promoting knowledge transfer. Reflection in this stage serves to consolidate mathematical concepts, summarize effective problem-solving strategies, and examine the strengths and limitations of AIGC support in the learning process. Students are encouraged to identify how their understanding changed over time, what difficulties they encountered, and how collaboration contributed to the final outcome. By connecting the completed project with future tasks and unfamiliar contexts, this stage helps transform isolated learning experiences into transferable competence, thereby reinforcing both disciplinary learning and broader interdisciplinary application (As shown in Figure 2, 3).

AI-Assisted Math Story Task Sheet
Group Name: ____
My Role: ☐ Problem Designer ☐ Story Writer ☐ Image Creator ☐ Presenter

1. Explore & Identify the Problem
What do we observe?
What questions can we ask?
What do we already know?
What problem will we solve?

2. Plan & Design the Story
Theme:
Story Outline:
Characters:
Math Problem:
Quantitative Relationships:

3. Investigate & Solve
Describe your solution process:
Try different methods (if any):
Final Answer:

4. Generate with AI
Prompt:
AI Output (Image/Text):
Revision: ☐ Yes ☐ No
What was improved?

5. Present & Evaluate
Our work (attach or describe):
Peer Feedback (brief):

6. Reflect & Extend
What did we learn?
How did AI help?
What would we improve next time?

Group Collaboration (Optional) ☐ Clear task division ☐ Active participation ☐ Effective communication ☐ Problem-solving effort
What went well in our teamwork? ____ What can we improve? ____

Figure 2. Learning Task Sheet.

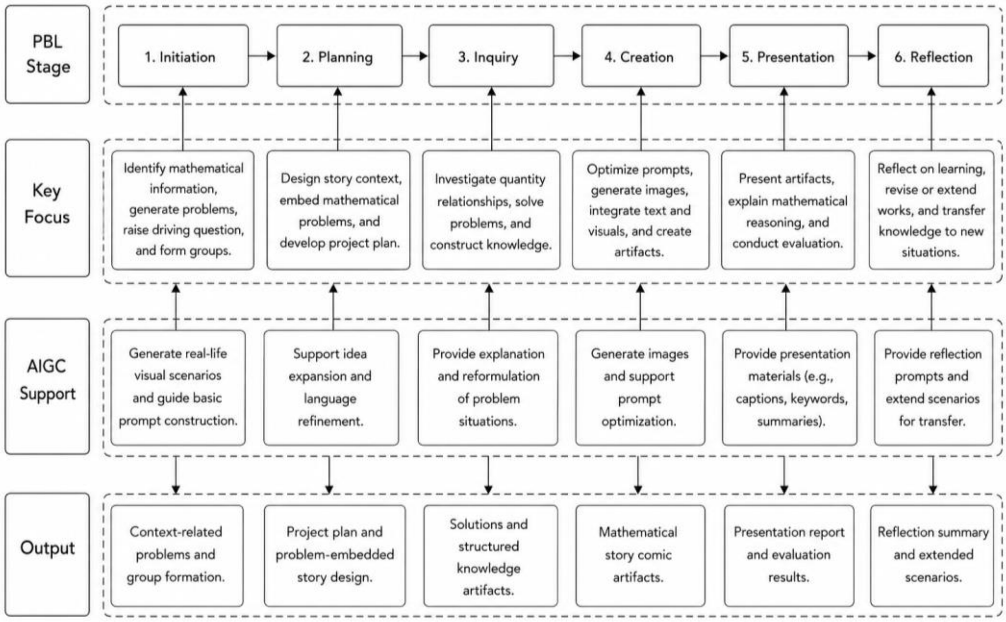

Figure 3. Teaching Flowchart.

4.2. Effectiveness Evaluation

To evaluate the effectiveness of the proposed AIGC-enabled interdisciplinary thematic learning model, a comprehensive comparison of students' performance before and after the implementation of the project was conducted. This evaluation spanned multiple dimensions, including learning engagement, interest in the subject matter, understanding and solving of problems, integration of knowledge across disciplines, collaborative communication, and the ability to independently manage learning tasks. The findings revealed significant improvements in students' cognitive and collaborative abilities. Specifically, the model enhanced students' capacity to comprehend and address complex problems, integrate knowledge from various domains, and communicate effectively within group settings. Additionally, students demonstrated a marked increase in active participation during lessons, transitioning from a reliance on teacher-led instruction to a more self-directed approach to learning. This shift underscores the development of critical thinking and inquiry-based skills, which are essential for fostering long-term academic growth. The integration of AIGC-generated multimodal resources played a pivotal role in this transformation. These resources provided students with enriched contextual understanding of mathematical problems and facilitated the exploration of diverse solution strategies. By presenting information in varied formats, such as visual, textual, and interactive elements, the resources catered to different learning preferences and enhanced overall comprehension. Consequently, the use of these tools not only improved students' academic performance but also contributed to a more engaging and dynamic learning environment, promoting sustained interest and deeper intellectual engagement (Table 4)[14].

Table 4. Comparison of Student Performance Before and After the Implementation of AIGC-Enhanced Interdisciplinary Thematic Learning in Primary School Mathematics. (Case of the Study Class)

Evaluation Dimension	Before Implementation	After Implementation
Learning Engagement	Teacher-led; moderate participation	Active participation; increased engagement
Learning Interest	Limited; textbook-dependent	Enhanced via authentic, multimodal tasks

Problem Understanding	Teacher-dependent; superficial	AIGC-supported; deeper understanding
Problem-Solving Ability	Single approach; experience-based	Multiple strategies; iterative optimization
Knowledge Integration	Fragmented; weak transfer	Cross-disciplinary integration
Collaboration and Communication	Superficial interaction	Frequent, effective collaboration
Use of Learning Resources	Textbook-based; limited	Diverse AIGC-generated resources
Learning Autonomy	Low; instruction-dependent	Increased autonomy; task-driven
Learning Outcomes	Uniform; low creativity	Diverse; creative and personalized
Overall Performance	Basic attainment	Multi-dimensional improvement

5. Conclusion

This study developed and implemented an AIGC-enabled interdisciplinary learning model for primary mathematics and examined its instructional value in classroom practice. The results indicate that the model contributed to noticeable improvements in several important dimensions of student learning, including problem comprehension, problem-solving performance, knowledge connection across subject areas, collaborative participation, and independent learning capacity. In addition, students demonstrated a clearer transition from relatively passive reception of information to more active inquiry, exploration, and meaning construction during the learning process (As shown in Table 4).

The findings further suggest that AIGC can provide substantial support for interdisciplinary mathematics learning when it is used appropriately. In particular, AIGC-supported multimodal resources helped create richer and more concrete learning situations, broadened the forms through which students could access and express knowledge, and strengthened the connection between mathematical concepts and authentic tasks. These features appear to support the development of comprehensive competencies by encouraging students to observe, analyze, communicate, and apply ideas in more integrated ways.

At the same time, the study indicates that AIGC should be positioned as a supportive instructional tool rather than as a substitute for students' own reasoning and participation. The effectiveness of interdisciplinary learning still depends on the design of authentic, task-driven contexts that require students to think, discuss, test ideas, and reflect on outcomes. Collaborative interaction and structured reflection were also shown to play an essential role in consolidating understanding and promoting deeper learning.

This study has several limitations, including a relatively small sample and a primary reliance on qualitative analysis. Future research should therefore include larger samples, adopt mixed-method approaches, and further investigate how the model can be refined and adapted across different grade levels, learner characteristics, and instructional settings.

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References

1. J. Bradbeer, "Barriers to interdisciplinarity: Disciplinary discourses and student learning," *Journal of Geography in Higher Education*, vol. 23, no. 3, pp. 381-396, 1999.
2. K. Beddoes and K. Bartlett, "Assessing interdisciplinary learning and knowledge: A state-of-the-art review and heuristic," *Journal of Engineering Education*, vol. 115, no. 2, p. e70062, 2026.

3. S. Mejias, N. Thompson, R. M. Sedas, M. Rosin, E. Soep, K. Peppler, et al., "The trouble with STEAM and why we use it anyway," *Science Education*, vol. 105, no. 2, pp. 209-231, 2021.
4. D. S. Fleming, *A Teacher's Guide to Project-Based Learning*. Blue Ridge Summit, PA: Scarecrow Education, 2000.
5. H. Yoon, J. Hwang, K. Lee, K. H. Roh, and O. N. Kwon, "Students' use of generative artificial intelligence for proving mathematical statements," *ZDM-Mathematics Education*, vol. 56, no. 7, p. 1531, 2024.
6. S. H. Xuan, A. T. Nguyen, T. Nguyen, L. Nguyen, H. Nguyen, N. Pham, et al., "Evaluating the impact of generative AI in mathematics education: A comparative study in Vietnamese high schools," *Human Behavior and Emerging Technologies*, vol. 2025, no. 1, p. 8886206, 2025.
7. L. A. Awang, F. D. Yusop, and M. Danaee, "Current practices and future direction of artificial intelligence in mathematics education: A systematic review," *International Electronic Journal of Mathematics Education*, vol. 20, no. 2, p. em0823, 2025.
8. C. Walkington, "The implications of generative artificial intelligence for mathematics education," *School Science and Mathematics*, 2025.
9. M. L. Bernardi, R. Capone, E. Faggiano, and H. Rocha, "Generative AI in mathematics education: pre-service teachers' knowledge and implications for their professional development," *International Journal of Mathematical Education in Science and Technology*, vol. 56, no. 8, pp. 1513-1530, 2025.
10. N. Rane, "Enhancing mathematical capabilities through ChatGPT and similar generative artificial intelligence: Roles and challenges in solving mathematical problems," SSRN 4603237, 2023.
11. T. Pelton and L. F. Pelton, "Using generative AI in mathematics education: critical discussions and practical strategies for preservice teachers, teachers, and teacher educators," in *Society for Information Technology & Teacher Education International Conference*, Mar. 2024, pp. 1800-1805. Association for the Advancement of Computing in Education (AACE).
12. I. Rizos, E. Foykas, and S. V. Georgakopoulos, "Enhancing Mathematics Education for Students with Special Educational Needs through Generative AI: A Case Study in Greece," *Contemporary Educational Technology*, vol. 16, no. 4, 2024.
13. B. Liu, W. Zhang, and F. Wang, "Can Generative Artificial Intelligence Effectively Enhance Students' Mathematics Learning Outcomes?—A Meta-Analysis of Empirical Studies from 2023 to 2025," *Education Sciences*, vol. 16, no. 1, p. 140, 2026.
14. J. Liu, D. Sun, J. Sun, J. Wang, and P. L. H. Yu, "Designing a generative AI enabled learning environment for mathematics word problem solving in primary schools: Learning performance, attitudes and interaction," *Computers and Education: Artificial Intelligence*, vol. 9, p. 100438, 2025.