



International Journal of Technology, AI and STEM Education

<https://ijtase.minduraresearch.com/journal/index>

ISSN (ONLINE): 3116-3718

Volume 1 Issue 3 - 2026

Specific Aspects of Critical Thinking Skills Improved Through Mathematical Modeling Among College Students

Jonalie U. De La Cruz
Apayao State

Date Submitted:

March 7, 2026

Date Accepted:

May 15, 2026

Date Published:

June 30, 2026

ABSTRACT: This study examined the specific aspects of critical thinking skills improved through mathematical modeling among college students at Apayao State College during the School Year 2025–2026. The research utilized a quantitative descriptive research design involving 36 first-year Bachelor of Secondary Education students enrolled in Mathematics in the Modern World. Data were gathered using an adapted Critical Thinking Skills Questionnaire (CTSQ) and analyzed using weighted mean and rank. The findings revealed that mathematical modeling significantly enhanced several aspects of critical thinking skills among students. The highest-rated aspect was the opportunity to consider different viewpoints and improve problem-solving skills, followed by logical reasoning during collaborative problem-solving activities. Reflective thinking, communication skills, and decision-making abilities were also improved through mathematical modeling activities. The findings suggest that mathematical modeling promotes active learning, analytical thinking, collaboration, and reflective judgment among college students. The study concludes that mathematical modeling is an effective instructional approach for developing higher-order thinking skills necessary for academic success and real-life problem-solving.

Keywords: mathematical modeling, critical thinking skills, problem-solving, logical reasoning, reflective thinking, college students



INTRODUCTION

The development of critical thinking skills has become one of the major goals of modern education due to the increasing demands of the 21st-century learning environment. Educational institutions are expected to produce learners who are capable of analyzing situations, solving problems, making sound decisions, and communicating ideas effectively. Critical thinking is considered an essential skill that enables students to become independent learners and responsible decision-makers in academic and real-life situations. In mathematics education, critical thinking skills are necessary because students are expected to interpret information, evaluate solutions, and apply logical reasoning to solve complex problems.

Mathematical modeling has emerged as an effective instructional strategy that allows students to connect mathematical concepts to real-life experiences. Mathematical modeling refers to the process of representing real-world situations using mathematical concepts, equations, diagrams, and logical relationships to analyze and solve problems. Through mathematical modeling activities, learners engage in the exploration, analysis, interpretation, and evaluation of situations that require critical and analytical thinking.

Several studies have emphasized that mathematical modeling strengthens higher-order thinking skills because students are exposed to authentic and contextualized learning experiences. Blum and Borromeo Ferri (2009) explained that mathematical modeling encourages learners to think critically by allowing them to analyze assumptions, evaluate data, and formulate logical conclusions. Similarly, English (2016) emphasized that modeling activities improve problem-solving skills and analytical reasoning because students actively participate in inquiry-based learning. Niss and Blum (2020) further stated that mathematical modeling supports meaningful learning by allowing students to apply mathematics to real-world contexts.

Constructivist learning theory supports the use of mathematical modeling in mathematics instruction. According to Piaget (1954) and Vygotsky (1978), learners construct knowledge through active participation, collaboration, and interaction with meaningful experiences. Lave and Wenger (1991) also emphasized that learning occurs effectively through situated and collaborative experiences. Mathematical modeling activities provide opportunities for learners to work collaboratively, communicate ideas, and reflect on their reasoning processes. As students engage in collaborative problem-solving tasks, they develop communication, reasoning, and reflective thinking skills.

Recent studies also highlighted the importance of mathematical modeling in developing students' competencies in mathematics education. Cevikbas et al. (2022) explained that mathematical modeling enhances students' modeling competencies, analytical reasoning, and critical thinking abilities. Likewise, Jung and Magiera (2023) emphasized that mathematical modeling and problem-posing activities encourage learners to examine social and real-world issues critically.

In the Philippine educational setting, curriculum reforms emphasize learner-centered instruction and the development of higher-order thinking skills. The Department of Education (2023) continuously encourages the integration of contextualized and inquiry-based learning approaches to



improve students' mathematical understanding and critical thinking skills. Vistro-Yu et al. (2025) further noted that problem-posing and contextualized mathematical activities improve learners' engagement and reasoning abilities in Philippine mathematics classrooms. Despite these efforts, many college students still struggle to demonstrate strong analytical reasoning and decision-making skills in mathematics.

Although several studies explored the relationship between mathematical modeling and academic performance, limited studies specifically examined the aspects of critical thinking skills improved through mathematical modeling among college students. Hence, this study was conducted to identify the specific critical thinking skills enhanced through mathematical modeling activities.

METHODOLOGY

This study utilized a quantitative descriptive research design to determine the specific aspects of critical thinking skills improved through mathematical modeling. Descriptive research design was considered appropriate because it focused on describing and analyzing the students' perceptions regarding the enhancement of their critical thinking skills after exposure to mathematical modeling activities. According to Creswell and Creswell (2018), descriptive research is appropriate for identifying trends, perceptions, and relationships among variables within a specific population.

The study was conducted at Apayao State College located in San Isidro Sur, Luna, Apayao. The institution offers various degree programs and promotes innovative and learner-centered instructional approaches.

The respondents of the study were the 36 first-year Bachelor of Secondary Education students enrolled in Mathematics in the Modern World during the School Year 2025–2026. The respondents consisted of 9 male students and 27 female students.

The study utilized an adapted Critical Thinking Skills Questionnaire (CTSQ) based on the California Critical Thinking Skills Test (CCTST). The instrument measured different aspects of critical thinking skills, including problem-solving, logical reasoning, communication, reflective thinking, and decision-making. The questionnaire used a five-point Likert scale ranging from 1 (Strongly Disagree) to 5 (Strongly Agree).

The researcher secured permission from the appropriate school authorities before conducting the study. After obtaining approval, the researcher administered the mathematical modeling intervention to the respondents during their mathematics classes. Following the intervention, the adapted Critical Thinking Skills Questionnaire was administered to gather data regarding the students' perceptions of the critical thinking skills improved through mathematical modeling.

The collected responses were tallied, encoded, and organized for statistical analysis. Ethical considerations such as voluntary participation, confidentiality, and proper handling of data were strictly observed throughout the study.



Weighted mean and rank were utilized to determine the specific aspects of critical thinking skills improved through mathematical modeling.

RESULTS

Table 1

Specific Aspects of Critical Thinking Skills Improved Through Mathematical Modeling

Aspects	Mean Rank	
Mathematical modeling provides opportunities for me to consider different viewpoints and improve my problem-solving skills.	4.6	1
I enjoy solving problems in group settings by applying logical reasoning.	4.3	2
I tend to question my own reasoning to make sure I am not overlooking important factors.	4.2	3
Using mathematical modeling helped me improve my ability to communicate and justify my ideas logically.	4.1	4
I seek to understand the underlying causes of problems before proposing solutions.	4.0	5

The findings revealed that the statement “Mathematical modeling provides opportunities for me to consider different viewpoints and improve my problem-solving skills” obtained the highest mean of 4.6 and ranked first. This indicates that students strongly agreed that mathematical modeling improved their problem-solving skills and encouraged them to examine situations from different perspectives. This finding supports the study of Blum and Borromeo Ferri (2009), who emphasized that mathematical modeling promotes analytical thinking and problem-solving through real-world applications.

The statement “I enjoy solving problems in group settings by applying logical reasoning” ranked second with a mean of 4.3, indicating that mathematical modeling strengthened students’ logical reasoning abilities through collaborative learning experiences. This result aligns with the constructivist perspective of Vygotsky (1978), which highlights the importance of social interaction and collaboration in developing higher-order thinking skills.



The statement “I tend to question my own reasoning to make sure I am not overlooking important factors” obtained a mean of 4.2 and ranked third, suggesting improvement in reflective thinking skills. This finding is consistent with Facione (1990), who identified self-regulation and reflective judgment as important components of critical thinking.

Meanwhile, the statement “Using mathematical modeling helped me improve my ability to communicate and justify my ideas logically” ranked fourth with a mean of 4.1, indicating that students developed better communication and reasoning skills during mathematical modeling activities. This supports the findings of Stillman and Brown (2019), who explained that mathematical modeling enhances students’ communication and collaborative competencies.

Lastly, the statement “I seek to understand the underlying causes of problems before proposing solutions” ranked fifth with a mean of 4.0, indicating improvement in students’ decision-making and analytical thinking skills. This finding agrees with Zhang and Cai (2021), who emphasized that mathematical modeling and problem-posing activities develop learners’ analytical reasoning and evidence-based decision-making abilities.

Overall, the findings suggest that mathematical modeling effectively enhanced several aspects of critical thinking skills among college students. The results further support the studies of Cevikbas et al. (2022) and Niss and Blum (2020), which emphasized that mathematical modeling develops higher-order thinking skills, reasoning abilities, and real-world problem-solving competencies among learners.

DISCUSSION

The results of the study demonstrated that mathematical modeling significantly improved students’ critical thinking skills, particularly in problem-solving and logical reasoning. Students perceived that mathematical modeling activities provided opportunities to analyze problems from different perspectives and apply logical reasoning in collaborative settings.

The improvement in problem-solving skills supports the findings of Facione (1990), who emphasized that critical thinking involves interpretation, analysis, evaluation, and inference. Mathematical modeling activities require students to identify variables, formulate assumptions, analyze data, and evaluate possible solutions, thereby strengthening these cognitive processes.

The findings also support the constructivist learning theory of Piaget (1954) and Vygotsky (1978), which explains that learners actively construct knowledge through meaningful experiences and social interaction. Through collaborative mathematical modeling activities, students were able to exchange ideas, justify reasoning, and evaluate solutions together. This collaborative environment contributed to the enhancement of logical reasoning and communication skills.

Furthermore, the improvement in reflective thinking suggests that mathematical modeling encourages students to examine and evaluate their own reasoning processes. Reflective thinking is an important component of critical thinking because it allows learners to assess the validity of their decisions and identify areas for improvement.



The study also revealed improvement in communication skills, particularly in students' ability to explain and justify mathematical ideas logically. This finding is consistent with the study of Stillman and Brown (2019), which highlighted that mathematical modeling develops communication and collaborative skills because students engage in discussion, explanation, and presentation of ideas. Brown and Stillman (2017) further explained that mathematical modeling helps learners connect mathematics with real-life experiences, thereby improving conceptual understanding and communication abilities.

Additionally, the improvement in decision-making skills indicates that mathematical modeling helps students understand the underlying causes of problems before making conclusions. This finding supports inquiry-based learning approaches that encourage learners to investigate situations critically and formulate evidence-based solutions. Zhang and Cai (2021) emphasized that problem-posing and modeling activities enhance learners' reasoning and decision-making abilities through analytical investigation.

Moreover, Kaiser and Blum (2007) explained that mathematical modeling develops learners' capacity to analyze real-world situations critically and apply mathematical thinking to practical problems. Borroneo Ferri (2018) also emphasized that mathematical modeling supports meaningful and reflective learning experiences that improve higher-order thinking skills among students.

Overall, the findings imply that mathematical modeling is an effective instructional approach for developing higher-order thinking skills among college students.

CONCLUSION

Based on the findings of the study, mathematical modeling significantly improved several aspects of critical thinking skills among college students. The most improved aspect was problem-solving skills, followed by logical reasoning, reflective thinking, communication skills, and decision-making abilities. The findings indicate that mathematical modeling provides meaningful and collaborative learning experiences that enhance students' analytical and reflective thinking.

The study further concludes that mathematical modeling supports constructivist and inquiry-based learning by encouraging active participation, collaboration, and contextualized learning. Through mathematical modeling activities, students become more capable of analyzing situations, evaluating information, communicating ideas logically, and making sound decisions.

Therefore, mathematical modeling may be considered an effective instructional strategy for promoting critical thinking skills in mathematics education.



International Journal of Technology, AI and STEM Education

<https://ijtase.minduraresearch.com/journal/index>

ISSN (ONLINE): 3116-3718

Volume 1 Issue 3 - 2026

REFERENCES

Blum, W., & Borromeo Ferri, R. (2009). Mathematical modelling: Can it be taught and learnt? *Journal of Mathematical Modelling and Application*, 1(1), 45–58.
https://www.researchgate.net/publication/279478754_Mathematical_Modelling_Can_It_Be-Taught_And_Learnt

Borromeo Ferri, R. (2018). *Learning how to teach mathematical modeling in school and teacher education*. Springer. <https://doi.org/10.1007/978-3-319-68072-9>

Brown, J., & Stillman, G. (2017). Developing the roots of modelling conceptions: “Mathematical modelling is the life of the world.” *International Journal of Mathematical Education in Science and Technology*, 48(3), 353–373. <https://doi.org/10.1080/0020739X.2016.1245875>

Cevikbas, M., Kaiser, G., & Schukajlow, S. (2022). A systematic literature review of the current discussion on mathematical modelling competencies: State-of-the-art developments in conceptualizing, measuring, and fostering. *Educational Studies in Mathematics*, 109(2), 205–236. <https://doi.org/10.1007/s10649-021-10104-6>

Creswell, J. W., & Creswell, J. D. (2018). *Research design: Qualitative, quantitative, and mixed methods approaches* (5th ed.). Sage Publications.

Department of Education. (2023). *MATATAG curriculum guide: Mathematics*. Department of Education. <https://www.deped.gov.ph/matatagcurriculumk147/>

English, L. D. (2016). Advancing mathematics education through modelling and problem posing. *ZDM Mathematics Education*, 48(6), 725–737. <https://doi.org/10.1007/s11858-016-0796-1>

Facione, P. A. (1990). *Critical thinking: A statement of expert consensus for purposes of educational assessment and instruction*. California Academic Press.

Jung, H., & Magiera, M. T. (2023). Connecting mathematical modeling and social justice through problem posing. *Mathematical Thinking and Learning*, 25(2), 232–251. <https://doi.org/10.1080/10986065.2021.1966713>

Kaiser, G., & Blum, W. (2007). The teaching and learning of mathematical modelling. In F. K. Lester Jr. (Ed.), *Second handbook of research on mathematics teaching and learning* (pp. 461–494). Information Age Publishing.



International Journal of Technology, AI and STEM Education

<https://ijtase.minduraresearch.com/journal/index>

ISSN (ONLINE): 3116-3718

Volume 1 Issue 3 - 2026

Lave, J., & Wenger, E. (1991). *Situated learning: Legitimate peripheral participation*. Cambridge University Press.

Niss, M., & Blum, W. (2020). *The learning and teaching of mathematical modelling*. Routledge. <https://doi.org/10.4324/9781315189314>

Piaget, J. (1954). *The construction of reality in the child*. Basic Books.

Stillman, G., & Brown, J. (2019). Research and development of mathematical modeling competencies. In G. A. Stillman, W. Blum, & G. Kaiser (Eds.), *Mathematical modeling education and sense-making* (pp. 1–18). Springer.

Vistro-Yu, C. P., Hao, L. C., & Sua, M. H. (2025). The struggle is real: Finding opportunities for problem posing in the Philippine school mathematics curriculum. *International Journal of Educational Research Open*, 4(2). <https://doi.org/10.1177/27527263251340036>

Vygotsky, L. S. (1978). *Mind in society: The development of higher psychological processes*. Harvard University Press.

Zhang, H., & Cai, J. (2021). Teaching mathematics through problem posing: Insights from an analysis of teaching cases. *ZDM Mathematics Education*, 53(4), 961–973. <https://doi.org/10.1007/s11858-021-01260-3>