EduVision: Journal of Innovations in Pedagogy and Educational Advancements
Volume 2, Issue 6, June 2026
brightmindpublishing.com
ISSN (E): 3061-6972

MATHEMATICAL MODELING AS A SCIENTIFIC BASIS FOR DEVELOPING ANALYTICAL THINKING IN ACADEMIC LYCEUM STUDENTS

Alijonov Sirojiddin Husan o'g'li
Fergana State Technical University Academic Lyceum No. 2

Abstract

This article investigates mathematical modeling as a scientifically grounded and pedagogically productive basis for developing analytical thinking in academic lyceum students. The study proceeds from the idea that mathematics education should not be limited to the memorization of formulas, the reproduction of standard algorithms, or the mechanical performance of symbolic transformations. In contemporary education, especially in academically oriented secondary institutions, mathematics must function as a method of inquiry that teaches students to identify a problem, distinguish essential variables, formulate assumptions, construct formal relations, transform a model, evaluate the result, and interpret conclusions in relation to the original situation. The article uses theoretical analysis, structural-functional modeling, comparative didactic interpretation, and methodological synthesis. It examines functions, equations, inequalities, optimization, probability, statistics, matrices, vectors, and graph-based representations as key mathematical instruments through which modeling competence can be formed. The results show that mathematical modeling develops analytical thinking through abstraction, formalization, structuralization, optimization, algorithmic reasoning, and reflective interpretation. The discussion emphasizes that modeling should not be treated as a decorative supplement to mathematics lessons but as a methodological core connecting algebra, geometry, calculus, probability, discrete mathematics, and STEM-oriented reasoning. The article concludes that systematic use of modeling tasks in academic lyceums can strengthen mathematical literacy, scientific worldview, independent problem solving, and readiness for higher education in technical, economic, engineering, and natural science fields.

Keywords: Mathematical modeling, analytical thinking, academic lyceum, function, optimization, probability, formalization, problem solving, mathematical literacy, STEM education.

EduVision: Journal of Innovations in Pedagogy and Educational Advancements
Volume 2, Issue 6, June 2026
brightmindpublishing.com
ISSN (E): 3061-6972

Introduction

Mathematics has historically been one of the most precise and universal languages of scientific thought, because it makes it possible to describe number, structure, change, uncertainty, space, relation, and order through formal signs and logically controlled operations. In the educational system of an academic lyceum, its importance becomes even more evident, since this stage prepares students for higher education, professional specialization, research-oriented learning, and participation in technologically intensive social life. Yet the effectiveness of mathematics education cannot be measured only by the number of solved exercises or the speed with which students apply memorized rules. A learner may know how to solve a quadratic equation, differentiate a polynomial, calculate an arithmetic mean, or use the formula for the area of a triangle, but still remain unable to formulate a real problem mathematically, explain why a method is appropriate, or evaluate whether the obtained result is meaningful. This contradiction reveals one of the central problems of modern mathematical education: the distance between formal mathematical knowledge and analytical use of that knowledge. Mathematical modeling offers a serious methodological response to this problem, because it requires the learner to pass from a real, verbal, technological, economic, physical, or social situation to a simplified mathematical structure and then return from that structure to interpretation and decision. In this sense, modeling is not merely an applied illustration of mathematics; it is a complete intellectual process that includes observation, abstraction, variable selection, assumption building, formalization, calculation, verification, and reflection [1]. The scientific relevance of this issue is connected with the growth of data-intensive technologies, engineering design, digital platforms, artificial intelligence, logistics, economics, environmental forecasting, and educational analytics, all of which rely on mathematical representations of real processes. Academic lyceum students encounter these realities not as distant scientific abstractions but as future university applicants and professionals who must learn to think in quantitative, structural, and evidence-based terms. Therefore, mathematical modeling should be introduced not only as a topic in applied mathematics but as a general didactic strategy for developing analytical thinking. Analytical thinking in this article is understood as the ability to decompose a complex situation into elements, determine relations among them, select relevant information, build a logical structure, apply appropriate mathematical tools, and justify a conclusion. This ability is close to

EduVision: Journal of Innovations in Pedagogy and Educational Advancements
Volume 2, Issue 6, June 2026
brightmindpublishing.com
ISSN (E): 3061-6972

what many international frameworks define as mathematical literacy: the capacity to formulate, employ, and interpret mathematics in a variety of contexts [2]. Traditional lessons often begin with a ready formula and end with a numerical answer. Modeling-based learning, by contrast, begins with a question: what is changing, what is constant, what depends on what, what can be neglected, what constraints exist, and what result would be reasonable? Such questions are valuable because they transform the student from a performer of procedures into a constructor of meaning. For example, the expression $y = ax + b$ is not simply a linear function; it can represent transport cost, temperature conversion, monthly savings, water consumption, or growth under a constant rate. The equation $x + y = 20$ is not merely a relation between two unknowns; it can represent resource distribution, time planning, mixture composition, or balance between alternatives. A probability value is not merely a fraction; it can represent risk, reliability, uncertainty, and the need for evidence-based decision making. Thus, modeling allows students to see that the same mathematical structure can represent many different phenomena, while one phenomenon may be represented by different models depending on purpose and assumptions. This multiplicity develops intellectual flexibility. The aim of this article is to analyze mathematical modeling as a scientific and pedagogical basis for developing analytical thinking in academic lyceum students. The object of the study is the process of teaching mathematics in academic lyceums, and the subject is the methodological potential of modeling tasks in strengthening abstraction, formalization, interpretation, and problem-solving competence. The scientific novelty of the article lies in treating modeling as an integrated educational mechanism connecting algebraic, geometric, probabilistic, statistical, discrete, and functional thinking rather than as a narrow set of word problems. The practical significance is that the proposed approach can be used by mathematics teachers when designing lessons, independent assignments, project-based learning activities, interdisciplinary STEM modules, and research-oriented tasks for students preparing for technical and scientific directions.

Materials and Methods

The methodological design of this article is based on theoretical analysis, structural-functional modeling, comparative interpretation of mathematical concepts, and didactic synthesis. Since the article is conceptual and methodological in nature, it does not claim to report a large-scale classroom experiment with statistical testing; instead,

EduVision: Journal of Innovations in Pedagogy and Educational Advancements
Volume 2, Issue 6, June 2026
brightmindpublishing.com
ISSN (E): 3061-6972

it constructs a scientific framework that may later serve as a basis for empirical research, diagnostic assessment, and experimental lesson design. The materials of the study consist of mathematical concepts that are typical for academic lyceum education and that possess strong modeling potential: functions, equations, systems of equations, inequalities, sequences, derivatives, elementary optimization, probability, descriptive statistics, vectors, matrices, geometric figures, coordinate methods, and graph structures. These concepts were selected because each of them forms a distinct cognitive instrument. A function teaches dependence and variation; an equation teaches balance, equivalence, and the search for unknown quantities; an inequality teaches comparison, limitation, and admissible range; a derivative teaches rate of change and local behavior; probability teaches thinking under uncertainty; statistics teaches data-based judgment; a vector teaches direction and magnitude; a matrix teaches organized representation of multiple relations; and a graph teaches network, connectivity, and path-based reasoning. The analysis was conducted by examining each mathematical instrument through three methodological dimensions: its formal structure, its modeling function, and its cognitive effect. Formal structure refers to the symbolic, logical, and operational content of the concept. Modeling function refers to the types of real or theoretical situations that can be represented by the concept. Cognitive effect refers to the thinking skill that is strengthened when students use the concept in problem construction and interpretation. For instance, if a student studies a quadratic function only as an expression of the form $y = ax^2 + bx + c$, the learning remains formal. If the same student uses a quadratic function to model the area of a rectangle with variable sides, the height of an object moving under gravity, or the revenue of a product depending on price, the function becomes an analytical tool. The central model proposed in this article may be written as $M = (P, V, A, C, F, S, R)$, where P denotes the initial problem situation, V denotes the set of variables, A denotes assumptions, C denotes constraints, F denotes the formal mathematical relation or system, S denotes the solution procedure, and R denotes interpretation of the obtained result. This expanded structure shows that a mathematical model is not identical with a formula. A formula without assumptions and interpretation is an incomplete model. If the assumptions are unrealistic, the model may be elegant but useless; if the constraints are ignored, the result may be impossible; if the solution is not interpreted, the calculation remains detached from meaning. The study also uses the modeling cycle described in international literature:

EduVision: Journal of Innovations in Pedagogy and Educational Advancements
Volume 2, Issue 6, June 2026
brightmindpublishing.com
ISSN (E): 3061-6972

understanding the situation, simplifying it, mathematizing it, working mathematically, interpreting the result, validating it, and communicating the conclusion [3]. In educational practice, this cycle can be adapted to the age and preparation level of academic lyceum students. At the first level, students may work with closed modeling tasks in which the necessary quantities and formula are almost evident. At the second level, they may solve semi-open tasks where the context is given but variables, assumptions, and relations must be selected. At the third level, they may perform research modeling, compare alternative models, test limitations, and justify why one representation is more adequate than another. This gradual organization is methodologically important because students cannot immediately be expected to create complex models without preparatory experience. The article also applies the principle of multiple representation. A modeled situation should be expressed verbally, numerically, algebraically, graphically, and, when appropriate, algorithmically [4]. Such representational movement prevents one-sided understanding. A table may show values but hide general law; a graph may show trend but not exact calculation; a formula may show structure but appear abstract; a verbal explanation may be intuitive but imprecise. When students translate among these forms, they acquire deeper conceptual control. To illustrate the method, consider a simple but educationally rich modeling situation: a student wants to distribute weekly independent study time among mathematics, physics, and English. Let x1, x2, and x3 denote hours allocated to the three subjects, with the constraint $x1 + x2 + x3 = T$, where T is available time. If the learning effect in each subject is not linear because fatigue or diminishing returns appear after several hours, the model may use functions f1(x1), f2(x2), and f3(x3) with different coefficients expressing priority, difficulty, or examination importance. The objective function may be written as $Q = a1f1(x1) + a2f2(x2) + a3f3(x3)$, where Q represents an estimated learning result. Even if students do not solve this as a formal advanced optimization problem, they learn the logic of variables, constraints, criteria, and trade-offs. Similar tasks can be constructed for production cost, water use, route selection, examination statistics, geometric design, ecological monitoring, and financial planning. The research method therefore consists not in collecting isolated examples but in identifying the common cognitive structure that unites them. The reliability of the conceptual conclusions is supported by established works in problem solving, mathematical modeling, representation theory, and mathematical competence, including Polya's heuristic method, Blum and Leiss's

EduVision: Journal of Innovations in Pedagogy and Educational Advancements
Volume 2, Issue 6, June 2026
brightmindpublishing.com
ISSN (E): 3061-6972

modeling cycle, Lesh and Doerr's model-eliciting perspective, Niss's competence framework, and modern discussions of STEM-oriented mathematical literacy [5], [6], [7], [8]. These sources demonstrate that modeling is internationally recognized as a high-level form of mathematical activity. The limitation of the present article is that it does not present numerical data from a pedagogical experiment. However, this limitation is also a boundary of purpose: before measurement, it is necessary to clarify what should be measured, which competencies are targeted, and how modeling changes the structure of mathematical thinking. In this respect, the article provides a methodological foundation for future empirical research in academic lyceum mathematics education.

Results

The theoretical analysis indicates that mathematical modeling develops analytical thinking through six major mechanisms: abstraction, structuralization, formalization, transformation, optimization, and interpretation. First, abstraction forms the student's ability to distinguish essential properties from secondary features. In ordinary school problems, the essential quantities are usually already selected by the textbook author. In modeling tasks, students must decide what is relevant. If they model the cost of organizing a scientific event, they may consider printing, room preparation, certificates, electronic publication, transport, design, communication, and technical equipment. If the purpose is a rough estimate, some components may be grouped; if the purpose is detailed budgeting, each component must be separated. This teaches that abstraction is not arbitrary simplification but purposeful reduction of complexity. Second, structuralization helps students organize information into a system. A real situation is often presented as a narrative, but mathematical thinking requires arrangement. Data can be placed into a table, relations can be represented by a diagram, dependencies can be shown through a graph, and multiple conditions can be written as a system. For example, route planning among several educational institutions may be represented through graph theory: institutions become vertices, roads become edges, and distances or travel times become weights. The problem then becomes the search for an optimal path or a comparison of alternative routes [9]. Even if students use only elementary reasoning, they learn that complex networks can be represented by mathematical structures. Third, formalization develops symbolic precision. When a student writes $C(x) = ax + b$ for cost, he or she expresses a fixed

EduVision: Journal of Innovations in Pedagogy and Educational Advancements
Volume 2, Issue 6, June 2026
brightmindpublishing.com
ISSN (E): 3061-6972

cost b and a variable cost ax. When a student writes P(A union B) = P(A) + P(B) - P(A intersection B), he or she expresses the logic of overlapping events. When a student writes a system of equations, he or she transforms several verbal conditions into a compact structure. This ability is one of the central outcomes of mathematical education because symbols make complex reasoning economical and exact. Fourth, transformation develops procedural and logical skill. After a model has been formalized, students must work within the mathematical system: solve equations, simplify expressions, compare functions, differentiate, compute probabilities, estimate parameters, or use an algorithm. However, in modeling, transformation is not blind calculation. Each operation must remain connected with the meaning of the variables. For instance, if x represents a number of students, fractional or negative results must be interpreted carefully. If t represents time, $t < 0$ may be mathematically possible in an equation but practically irrelevant in a future-planning problem. Fifth, optimization develops purposeful reasoning under constraints. Many real problems do not ask merely for a value; they ask for the best value, the minimum cost, the maximum efficiency, the shortest path, the safest probability threshold, or the most balanced distribution. Optimization tasks teach students to think about goals, limitations, and trade-offs. A classic example is maximizing the area of a rectangle with fixed perimeter. At a superficial level, it is a geometry exercise. At a deeper level, it teaches that among many possible configurations satisfying the same constraint, one may be optimal. The same principle appears in resource distribution, construction planning, schedule design, and engineering calculation. In calculus-based contexts, the derivative provides a powerful tool for optimization, since local extrema are found by analyzing critical points and the behavior of the function [10]. Nevertheless, optimization thinking can begin before formal calculus through graphs, inequalities, tables, and comparative reasoning. Sixth, interpretation develops reflective mathematical culture. A model is not complete when the answer is calculated. The answer must be returned to the original context. If a calculation gives 18.7 seats, a student must understand that 19 seats are required, not because of a formal rounding rule alone but because a fraction of a seat is practically impossible. If a probability value is 0.92, the student must interpret whether this level is sufficient for the decision being made. If a model predicts growth without limit, students must ask whether the assumption of unlimited growth is realistic. This interpretive stage prevents formalism and encourages scientific caution. The results also show that modeling

EduVision: Journal of Innovations in Pedagogy and Educational Advancements
Volume 2, Issue 6, June 2026
brightmindpublishing.com
ISSN (E): 3061-6972

transforms the meaning of mathematical concepts. A linear function becomes a model of constant change; a quadratic function becomes a model of accelerated change, area variation, or parabolic motion; an exponential function becomes a model of compound growth or decay; a logarithmic function becomes a model of inverse growth or scale compression; a system of equations becomes a model of simultaneous conditions; a matrix becomes a model of structured data or transformation; a probability distribution becomes a model of uncertainty; and a graph becomes a model of relationships. In this way, students begin to perceive mathematics not as a sequence of isolated chapters but as a system of instruments for describing the world. The analysis further reveals three levels of modeling competence suitable for academic lyceum instruction. The first level is reproductive modeling. Here students apply a given formula to a contextual task, such as calculating distance from speed and time or area from dimensions. This level is necessary but insufficient because the model is already supplied. The second level is constructive modeling. Here students select variables, build a relation, and solve it. For example, they may construct a linear model of printing cost depending on the number of pages and copies. The third level is research modeling. Here students compare different assumptions, test model adequacy, and discuss limitations. For example, when modeling population growth, they may compare linear and exponential models and explain why one may fit short-term data while the other may become unrealistic in the long term. The transition from the first to the third level is the real development of analytical thinking. Another result concerns the role of errors. In standard exercises, an error is often viewed only as an incorrect answer. In modeling, an error may indicate an incorrect assumption, a missing variable, an unsuitable function, an excessive simplification, or a wrong interpretation. This makes error analysis an educationally valuable process. Students learn to revise models, not merely erase mistakes. Such practice is close to scientific research, where hypotheses are tested, rejected, improved, and compared. Finally, the analysis shows that mathematical modeling has interdisciplinary value. In physics, it describes motion, force, energy, and oscillation. In economics, it describes cost, revenue, demand, and optimization. In architecture and engineering, it describes measurement, load, material use, proportion, and spatial planning. In computer science, it underlies algorithms, data structures, networks, and simulation. In social research, it supports statistics, forecasting, and decision analysis. Therefore,

EduVision: Journal of Innovations in Pedagogy and Educational Advancements
Volume 2, Issue 6, June 2026
brightmindpublishing.com
ISSN (E): 3061-6972

modeling-based mathematics education in academic lyceums can prepare students not only for examinations but for scientific and professional reasoning in a broad sense.

Discussion

The results require a deeper discussion of how mathematical modeling should be understood and organized in academic lyceum education. The first point concerns the relationship between theoretical rigor and applied context. It is sometimes assumed that applied tasks make mathematics easier, more superficial, or less rigorous. This assumption is incorrect when modeling is organized properly. Genuine modeling does not reduce mathematical exactness; it increases the need for it. A student who applies a linear function to a process must understand that the model assumes a constant rate of change. A student who uses a quadratic model must understand the meaning of curvature, vertex, and domain. A student who applies probability must distinguish independence from dependence, mutually exclusive events from overlapping events, theoretical probability from empirical frequency, and sample data from population characteristics. Context does not cancel definitions; it tests whether definitions are understood. Therefore, modeling should not be used as decoration after theory but as a method through which theory becomes necessary. The second point concerns classroom organization. A modeling-based lesson cannot be reduced to the teacher writing a formula and students substituting numbers. It requires a sequence of questions: what is the problem, which quantities are known, which are unknown, which assumptions are acceptable, which mathematical structure is suitable, what constraints exist, what method can be applied, what does the answer mean, and how can the model be improved? These questions should gradually become part of the student's internal thinking. In early stages, the teacher may provide guiding prompts. Later, students should formulate such questions independently. This is why modeling is closely connected with heuristic teaching. Polya's classical stages of understanding the problem, devising a plan, carrying out the plan, and looking back remain extremely relevant [5]. Modeling extends these stages by emphasizing simplification, mathematization, validation, and communication. The third point concerns assessment. If education values modeling competence, assessment must measure more than final numerical answers. A good modeling response should be evaluated according to several criteria: clarity of problem understanding, appropriateness of variables, reasonableness of assumptions, correctness of mathematical formulation,

EduVision: Journal of Innovations in Pedagogy and Educational Advancements
Volume 2, Issue 6, June 2026
brightmindpublishing.com
ISSN (E): 3061-6972

accuracy of solution, adequacy of interpretation, and awareness of limitations. For example, two students may solve the same contextual problem using different assumptions. If both assumptions are explicitly stated and logically defended, both solutions may be educationally valuable even if their numerical results differ. This does not make assessment arbitrary; it makes assessment more intellectually honest. Mathematics is exact, but modeling includes judgment. The fourth point concerns curriculum design. Modeling should accompany major mathematical topics from the beginning of academic lyceum study. Linear functions can be connected with proportional planning, tariffs, salaries, and constant-rate motion. Quadratic functions can be connected with area optimization, projectile motion, and revenue models. Systems of equations can be connected with mixtures, resource allocation, and balance problems. Inequalities can be connected with admissible ranges, safety thresholds, and budget limitations. Derivatives can be connected with growth, velocity, marginal analysis, and optimization. Probability can be connected with risk, reliability, quality control, and forecasting. Statistics can be connected with survey data, examination results, variation, and evidence-based comparison. Geometry and trigonometry can be connected with measurement, design, construction, navigation, and spatial reasoning. Discrete mathematics can be connected with routes, networks, coding, and algorithmic processes. Such integration prevents students from thinking that applications are occasional additions. The fifth point concerns digital tools. Spreadsheets, dynamic geometry environments, graphing calculators, computer algebra systems, and simple programming languages can greatly support modeling. They allow students to test parameters, visualize functions, simulate random events, process data, and compare alternative scenarios. However, technology should not replace conceptual understanding. A graph produced by software is useful only if the student understands axes, scale, domain, intercepts, slope, maximum, minimum, and asymptotic behavior. A spreadsheet formula is useful only if the student understands the relation it expresses. A simulation is useful only if the student understands randomness and sample size. Thus, digital tools must function as extensions of mathematical reasoning, not as black boxes. The sixth point concerns the role of language. Mathematical modeling requires students to move between natural language and symbolic language. Many errors occur not because students cannot calculate, but because they misunderstand the wording of a problem, fail to identify a condition, or cannot translate a verbal relation into a formula. Therefore, mathematics

EduVision: Journal of Innovations in Pedagogy and Educational Advancements
Volume 2, Issue 6, June 2026
brightmindpublishing.com
ISSN (E): 3061-6972

teachers should pay attention to precise language: terms such as at least, at most, not less than, proportional to, depends on, rate of change, average, total, difference, ratio, probability, and constraint must be interpreted rigorously. This is especially important in multilingual educational environments where students may encounter mathematical literature in Uzbek, Russian, and English. The seventh point concerns motivation and professional orientation. Academic lyceum students are often preparing for entrance examinations and specialized university programs. Modeling helps them see the professional value of mathematics. A future engineer needs modeling to analyze structures, loads, materials, and systems. A future economist needs modeling to analyze cost, demand, risk, and optimization. A future programmer needs modeling to understand algorithms, networks, data, and complexity. A future teacher needs modeling to explain concepts meaningfully. A future researcher needs modeling to formulate hypotheses and interpret evidence. Therefore, modeling increases not only mathematical achievement but also career-oriented awareness. The eighth point concerns scientific worldview. Modeling teaches two complementary intellectual attitudes: confidence in rational analysis and caution about assumptions. Students learn that mathematics can clarify complex phenomena, but they also learn that a model is not reality itself. Every model simplifies. Every result depends on assumptions. Every interpretation requires context. This intellectual balance is essential in the modern world, where statistical claims, forecasts, digital indicators, rankings, and algorithmic decisions influence public and professional life. A mathematically educated person should not blindly accept numbers; he or she should ask how they were obtained, what model produced them, what data were used, what limitations exist, and what conclusion is justified. In this sense, mathematical modeling contributes not only to academic success but also to responsible citizenship and critical information culture.

Conclusion

The article concludes that mathematical modeling is a powerful scientific and pedagogical basis for developing analytical thinking in academic lyceum students. Its value lies in the fact that it unites the most important components of mathematical activity: abstraction, formalization, logical transformation, calculation, optimization, interpretation, validation, and communication. A student who learns through modeling does not merely apply formulas; he or she learns to construct relations

EduVision: Journal of Innovations in Pedagogy and Educational Advancements
Volume 2, Issue 6, June 2026
brightmindpublishing.com
ISSN (E): 3061-6972

between reality and mathematical structure. This changes the educational meaning of mathematics. Instead of appearing as a closed system of rules, mathematics becomes a method for investigating problems, comparing alternatives, evaluating evidence, and making reasoned decisions. The proposed structure M = (P, V, A, C, F, S, R) demonstrates that a complete model includes the initial problem, variables, assumptions, constraints, formal relations, solution procedure, and interpretation. This structure may be used by teachers when designing tasks and by students when organizing their reasoning. The study shows that different branches of mathematics contribute different but complementary forms of analytical competence. Algebra develops symbolic transformation and equivalence thinking; geometry develops spatial imagination and measurement culture; functions develop understanding of dependence and change; calculus develops local analysis and optimization; probability develops reasoning under uncertainty; statistics develops data interpretation; matrices and vectors develop structured representation; graph theory develops network thinking; and discrete mathematics develops algorithmic reasoning. When these components are integrated through modeling, students gain a more holistic understanding of mathematics. The practical implication is that academic lyceums should systematically include modeling tasks in lessons, homework, projects, and assessment. These tasks should progress from reproductive to constructive and research levels. Teachers should require students not only to solve but also to explain assumptions, justify variables, interpret results, and evaluate limitations. Digital tools may be used effectively, but only when they support conceptual understanding rather than replace it. The main pedagogical conclusion is that modeling-based mathematics education forms students who are better prepared for higher education, scientific research, technical professions, and evidence-based decision making. Such students can analyze complex situations, select essential information, build formal structures, test solutions, and communicate conclusions. Therefore, mathematical modeling should be regarded as one of the core methodological directions for improving the quality and scientific orientation of mathematics education in academic lyceums.

References

1. Giordano, F. R., Fox, W. P., & Horton, S. B. A First Course in Mathematical Modeling. Boston: Brooks/Cole, 2014.

EduVision: Journal of Innovations in Pedagogy and Educational Advancements
Volume 2, Issue 6, June 2026
brightmindpublishing.com
ISSN (E): 3061-6972

2. OECD. PISA 2022 Assessment and Analytical Framework. Paris: OECD Publishing, 2023.
3. Blum, W., & Leiss, D. How Do Students and Teachers Deal with Mathematical Modelling Problems? In: Haines, C. et al. Mathematical Modelling: Education, Engineering and Economics. Chichester: Horwood Publishing, 2007.
4. Duval, R. A Cognitive Analysis of Problems of Comprehension in a Learning of Mathematics. Educational Studies in Mathematics, 61, 2006, pp. 103-131.
5. Polya, G. How to Solve It: A New Aspect of Mathematical Method. Princeton: Princeton University Press, 2004.
6. Lesh, R., & Doerr, H. M. Beyond Constructivism: Models and Modeling Perspectives on Mathematics Problem Solving, Learning, and Teaching. Mahwah: Lawrence Erlbaum Associates, 2003.
7. Niss, M., & Hojgaard, T. Mathematical Competencies Revisited. Cham: Springer, 2019.
8. English, L. D. STEM Education K-12: Perspectives on Integration. International Journal of STEM Education, 3(1), 2016.
9. Rosen, K. H. Discrete Mathematics and Its Applications. New York: McGraw-Hill, 2019.
10. Stewart, J. Calculus: Early Transcendentals. Boston: Cengage Learning, 2020.
11. Bender, E. A. An Introduction to Mathematical Modeling. New York: Dover Publications, 2000.
12. Tall, D. How Humans Learn to Think Mathematically: Exploring the Three Worlds of Mathematics. Cambridge: Cambridge University Press, 2013.
13. Schoenfeld, A. H. Mathematical Problem Solving. Orlando: Academic Press, 1985.
14. Devlin, K. Introduction to Mathematical Thinking. Stanford: Keith Devlin, 2012.
15. Gravemeijer, K., Stephan, M., Julie, C., Lin, F. L., & Ohtani, M. What Mathematics Education May Prepare Students for the Society of the Future? International Journal of Science and Mathematics Education, 15, 2017, pp. 105-123.