

Students' Belief About Mathematics Through Metaphor

VILLA, Roselyn R. ⁽¹⁾

⁽¹⁾  0009-0008-6967-6515; Don Mariano Marcos Memorial State University, La Union, Philippines.
rvilla9575@student.dmmmsu.edu.ph

The authors are entirely responsible for the content of this article.

ABSTRACT

This study explored how junior high school students in Abra, Philippines, conceptualize mathematics through metaphors, revealing a developmental progression in their mathematical beliefs. Using a qualitative, phenomenological approach, researchers analyzed visual and written metaphors from 20 students in Grade 7 to 10. Students were prompted to draw and reflect on what mathematics meant to them, generating a wide array of metaphorical expressions. Analysis identified six thematic categories: mathematics as a journey, life, tool, value, history and tangible object. Grade 7 students often used playful and experiential metaphors such as games and adventures, indicating an identity-driven view of mathematics. Grade 8 students introduced abstract and functional metaphors like dream and calculator, reflecting transitional thinking. By Grade 9, students leaned toward concrete, object-based metaphors such as ruler and pyramid denoting applied understanding. Grade 10 students expressed more symbolic and reflective metaphors, like river, trophy and ancient Greek, suggesting deeper conceptual maturity and cultural awareness. The recurring metaphor of life across all grade levels signaled students' perception of mathematics as essential and ever-present. These metaphor choices highlight how age, experience, and cognitive development shape students' epistemological beliefs about mathematics. Findings suggest that metaphors are powerful cognitive tools, providing insight into learners' mathematical identities and experiences. Educators can use these insights to design more responsive, developmentally appropriate teaching strategies.

RESUMO

Este estudo explorou como alunos do ensino fundamental II em Abra, Filipinas, conceituam a matemática por meio de metáforas, revelando uma progressão no desenvolvimento de suas crenças matemáticas. Os pesquisadores empregaram uma abordagem qualitativa e fenomenológica, analisando metáforas visuais e escritas de 20 alunos do 7º ao 10º ano. Os alunos foram incentivados a desenhar e refletir sobre o significado da matemática para eles, gerando uma ampla gama de metáforas. A análise revelou seis categorias temáticas de metáforas: matemática como jornada, vida, ferramenta, valor, história e objeto tangível. Os alunos mais jovens (7º ano) usaram comumente metáforas lúdicas e experienciais, como jogo e aventura, indicando uma visão da matemática orientada pela identidade. Os alunos do 8º ano introduziram metáforas abstratas e funcionais, como sonho e calculadora, refletindo um pensamento de transição. No 9º ano, os alunos tenderam a usar metáforas concretas, baseadas em objetos, como régua e pirâmide, denotando uma compreensão aplicada. Os alunos do 10º ano expressaram metáforas mais simbólicas e reflexivas, como rio, troféu e Grécia Antiga, sugerindo maior maturidade conceitual e consciência cultural. A metáfora recorrente da vida em todos os níveis de escolaridade sinalizou a percepção dos alunos sobre a matemática como essencial e sempre presente. Essas escolhas de metáforas destacam como a idade, a experiência e o desenvolvimento cognitivo moldam as crenças epistemológicas dos alunos sobre matemática. Os resultados sugerem que as metáforas são ferramentas cognitivas poderosas, proporcionando insights sobre as identidades e experiências matemáticas dos aprendizes. Os educadores podem usar esses insights para fundamentar estratégias de ensino mais responsivas e adequadas ao desenvolvimento.

ARTICLE INFORMATION

Article process:

Submitted: 06/22/2025

Approved: 03/02/2026

Published: 03/05/2026



Keywords:

qualitative study, metaphor, epistemological beliefs, phenomenological approach

Keywords:

Introduction

To many students, mathematics is more than just numbers and formulas-it is an experience that can be exciting, mysterious, confusing or even intimidating (Brandt et al., 2022). Although mathematics is often regarded as a subject rooted in logic, precision and strict rules, students' emotions and beliefs about it can profoundly influence how they learn (Harefa, 2023). Traditional assessments may reveal little about what mathematics truly means to students (Albay & Eisma, 2025). To better understand their learning journeys, it is essential to focus on the beliefs and emotions that shape their experiences rather than solely on the scores they achieve (Ingram, 2021). One insightful way to uncover these deeper layers is by examining the metaphors students use to describe mathematics.

Metaphors are not merely figures of speech; they are cognitive tools that help us make sense of abstract ideas. Winter and Soshimi (2020) define metaphor as the process of understanding and discussing one concept in terms of another. When a student describes mathematics as "a puzzle," this is not just a casual remark-it reflects a meaningful belief about the nature of learning mathematics (Gadanidis et al., 2024, Albay & Aquino, 2024). Such metaphors suggest that each new problem is an engaging challenge, inviting curiosity, persistence, and playful problem-solving (Adeshola, 2024). When faced with difficulties, students who view mathematics through this lens are less likely to see setbacks as failures and more likely to interpret them as temporary obstacles on the path to understanding (Lutovac, 2020; Schukailow, 2020). This mindset fosters resilience and supports a belief in continuous growth.

Students often develop their mathematical metaphors based on how they perceive mathematicians and their teachers (Haser et al., 2024). In some cases, students describe mathematicians in exaggerated or imaginative terms-such as "creatures" or "monsters" - which reflect their emotional reactions to the subject and their perceptions of its difficulty or accessibility (Hatisaru and Murphy, 2019; Akpalu et al., 2025). These metaphors also reveal who students believe mathematics is for and how welcoming the field feels to them (Russell, 2025). Furthermore, students' perceptions of mathematics usefulness and complexity significantly influence how they conceptualize and describe it (Heinz et al., 2024, Albay et al., 2024). As Men et al. (2024) observe, students' beliefs are central to the metaphors they use, shaping both how they talk about mathematics and but also how they engage with it.

Understanding students' perceptions of mathematics is crucial for enhancing both pedagogical strategies and learning outcomes (Shone, 2023). One particularly illuminating lens through which these perceptions can be explored is metaphor (Demirbilek and Korkmaz, 2021; Bernstein, 2020). Students frequently use metaphorical language to articulate their emotional and cognitive relationships with mathematics, offering insights into their conceptual understanding, epistemological beliefs, and personal experiences with the subject.

Metaphors provide a powerful means of accessing students' inner cognitive frameworks. For instance, Atkins et al., (2020) emphasized that students' beliefs about mathematics strongly influence their engagement and achievement, while Gibbs Jr. and Siman (2021) demonstrated that metaphorical thinking can reveal underlying attitudes and cognitive orientations. Hill et al. (2020) found that students who perceive mathematics as a "fun adventure" or a "challenging puzzle" tend to exhibit greater motivation and improved academic performance. Similarly, Afifah et al. (2019) showed how pre-service teachers employed metaphors to connect mathematics to practical, real-life applications, reinforcing its perceived value and relevance.

Recent studies have also highlighted the diversity of students' metaphorical perceptions. Danisman et al. (2024), examining secondary school students' responses to modern "new generation" mathematics questions, identified a wide range of metaphors-from "complicated" and "troublesome" to "motivating" and "comprehensive"-underscoring varied emotional and intellectual responses to contemporary assessments. Teke (2023) compared metaphors used by prospective mathematics teachers with those from non-education majors, revealing differences linked to academic trajectory: education students favored concrete, experiential metaphors, while others leaned toward abstract representations.

The influence of teacher identity and instructional roles has also emerged as a key theme. Katrinci et al. (2021) reported that pre-service teachers frequently described mathematics as a "tool" or "puzzle" and depicted themselves as "guides" or "lighthouses," illustrating a sense of responsibility in facilitating student understanding. Kaphesi (2014) found that university students often characterized mathematics learning as "climbing a mountain" or "building a house", emphasizing perseverance and structured support. Additionally, Walfurqan (2020) observed that students with higher mathematical proficiency tend to conceptual mastery.

Connections between mathematics and real-world contexts further reinforce the value of metaphorical analysis. Barete and Taja-on (2023), in their exploration of the course "Mathematics in the Modern World," found that students employed metaphors such as "tool," "map," or "bridge" to articulate how mathematics relates to daily life. Presto and Menorca (2023), investigating students' experiences with precalculus during remote learning, noted metaphorical framings like "maze," reflecting challenges in planning and problem-solving. Likewise, the EURASIA Journal (2022) documented highly polarized student reactions to dynamic classroom environments with metaphors ranging from "roller coaster" to "storm," illustrating the emotional complexity of mathematics learning in innovative settings.

The reviewed literature reveals several limitations. Small, context-specific sample sizes hinder generalizability, as most studies focus on single groups (e.g., preservice teachers, secondary students) without accounting for diverse educational backgrounds, cultural contexts, or mathematical abilities. Furthermore, while metaphors successfully uncover

beliefs, there is a lack of research on the cognitive processes and long-term academic outcomes linked to metaphor formation. Longitudinal data are often missing, preventing analysis of how metaphorical conceptions evolve over time. Finally, limited triangulation with other data sources in qualitative studies may impact the validity of interpretation.

Historically, gaining insight into students' true beliefs and perceptions about mathematics has been challenging due to a lack of effective tools. To address this, recent studies, including Savas et al. (2024) and Teke (2023) have effectively employed metaphor analysis. This powerful approach acts as a crucial lens, moving past superficial attitudes to unveil the intricate cognitive and affective experiences of students, capturing nuanced understandings that conventional surveys often fail to capture.

Moreover, Presto and Menorca's (2023) phenomenological approach thoughtfully explores the overlooked aspects of metacognition and emotion through student self-reflection and problem-solving strategies. However, their work primarily focuses on learning processes rather than metaphorical frameworks. Despite these valuable contributions, several critical gaps persist in the existing research. Specifically, none of the reviewed studies thoroughly investigated the longitudinal development of students' metaphorical conceptions, triangulate findings with quantitative data, or examined cross-cultural differences in metaphor use. These areas represent significant opportunities for future research.

This study aims to contribute to this emerging field by focusing specifically on the metaphors students use when describing mathematics. These metaphorical expressions—such as mathematics being a “puzzle,” “journey,” “game,” or “tool—offer revealing insights into students' lived experiences, emotional responses, and epistemological beliefs. Rather than evaluating correctness. This study interprets the language students use to express what mathematics means to them, how they relate to it, and how it reflects their broader views on learning and knowledge.

To guide this inquiry, the research addresses the all-encompassing question: How do students' metaphorical representations of mathematics reflect their personal experiences, perception and epistemological beliefs? To answer this question, the study is structured around four specific research objectives: (1) To identify the metaphors students use to describe mathematics and interpret their underlying meanings. (2) To categorize these metaphors into thematic groups (e.g., math as a puzzle, a lifestyle, a time or a food). (3) To examine how students' metaphors, reflect their epistemological views (e.g., mathematics as rigid rules vs. creative exploration). (4). To explore how age, grade level or prior mathematics experience influences metaphor choice.

Methodology

In order to investigate how students, perceive and understand mathematics through metaphor, this study used a descriptive qualitative approach.

The primary research instrument used in this qualitative descriptive study was a structured student response sheet designed to elicit both metaphorical and reflective insights into students' beliefs about mathematics. The instrument was divided into four parts to guide participants through a thoughtful exploration of their mathematical perceptions:

Part 1: Student Information – This section collected basic demographic data, including code name, grade level, and age.

Part 2: Consent Note – A brief consent form ensured ethical compliance and informed assent from participants.

Part 3: Drawing Prompt – Students were asked to create a visual representation of what mathematics is like for them. This open-ended drawing activity served as a metaphor elicitation technique, encouraging students to express their beliefs creatively.

Part 4: Written Reflection – Following the drawing, students were prompted to explain the meaning behind their illustration and describe their personal experiences and attitudes toward mathematics in their own words.

To enhance interpretation and identify deeper themes, an AI- assisted text analysis tool was used as a supporting aid. The tool which had been validated and reviewed by experts prior to use, assisted the researchers in clustering similar responses, highlighting keywords, and clarifying vague or complex narrative data. This automated support was not a substitute for researcher interpretation but serve to augment manual coding and ensure consistency in theme identification.

The study involved a total of 20 junior high school students from Abra, with five participants randomly selected from each grade level (Grades 7, 8, 9, and 10). This simple random sampling ensured balanced representation across developmental stages in early secondary education. Participants varied in age and gender, contributing to a diverse range of perspectives. Their voluntary participation provided insights into how beliefs and metaphorical understandings of mathematics may evolve as students' progress through junior high school.

Data collection took place in a classroom setting over one session. Students completed the response sheet individually to ensure independent thought and minimize peer influence. Instructions were clearly explained, and the researcher was available to answer procedural questions without guiding content. All completed sheets were collected and anonymized to protect confidentiality.

Ethical approval was obtained from the school principal, and all participants gave written assent to participate. Anonymity and confidentiality were strictly maintained throughout the study.

Data were analyzed using phenomenological thematic analysis, focusing on identifying recurring metaphorical themes and the underlying beliefs about mathematics they reflected. Student drawings and written reflections were coded inductively to capture patterns of meaning. Emergent themes were grouped into broader categories representing students' cognitive, emotional, and experiential associations with mathematics (e.g., math as a challenge, a tool, a journey, etc.). Triangulation of visual and textual data helped ensure validity and depth of interpretation. Representative metaphors and quotes were selected to illustrate key findings in the results section.

To enhance clarity and accessibility of the findings, the results are presented in table form, categorizing student generated metaphors by grade level and thematic grouping. This tabular format allows for clear comparison across developmental stages and highlights shifts in metaphor use as students progress through junior high school. Representative quotes and illustrations accompany the table to contextualize and deepen the interpretation of key themes.

Results and Discussion

This section presents the metaphors students used to describe mathematics that offer insights into their perceptions and experiences with the subject. The results are organized according to the study's research questions: identifying common metaphors, grouping them into thematic categories, linking them to students' epistemological views, and examining how factors like age and prior experience influence metaphor choice. These findings reveal both positive and negative views of mathematics, reflecting its complex role in students' academic and personal lives.

Table 1.

Metaphors Used by Students to Describe Mathematics and Their Interpretation

Grade Level	Metaphors	Interpretation
Grade 7	game, adventure	Math is fun, engaging and exploratory- perceive as a challenge or dynamic activity.
	lifestyle, life	Math is seen as essential and integrated into daily existence-perceive as constant or foundational.
Grade 8	dream	Suggest abstraction, idealism or confusion- may reflect both aspiration and elusiveness
	life	Reinforces the perception of math as integral and ever present in life
Grade 9	calculator, building, time	Math is practical, structured and useful – tools and concepts for measuring and organizing reality.
	pizza, clock, cube, ruler, pyramid	Math is tangible and relevant – relates to real-world objects, time and measurement; may indicate structure and usefulness
Grade 10	river	Suggests flow, complexity and continuity in mathematical processes.
	life	Continues the theme of math as foundational to living
	money, trophy	Math has value and bring rewards – could symbolize achievement and economic importance.
	ancient Greek	Implies math's historical roots, intellectual tradition and cultural depth.

Table 1 reveals a rich variety of metaphors that students across Grades 7 to 10 use to represent mathematics, each offering insight into their emotional and cognitive relationship with the subject.

In Grade 7, students often perceive mathematics as a game or adventure, highlighting its playful and dynamic aspects. Metaphors like lifestyle and life further suggest that even at this younger age, students recognize mathematics' fundamental and constant presence in their daily experiences. This perception aligns with findings by Hill, Kern, and van Driel (2020) and Adeshole (2024), who observed that when students frame mathematics as a playful or exploratory activity, they tend to demonstrate increased motivation, curiosity, and resilience in the face of challenges. Similarly, Gadanidis et al. (2024) highlighted that viewing mathematics as a "puzzle" or "game" promotes an attitude of persistence and enjoyment, encouraging students to engage actively with problems and embrace mistakes as part of the learning process.

Moving to Grade 8, the metaphor of dream emerges, introducing a more abstract or even elusive quality to mathematics. This could signal a transitional phase where the subject might appear idealized or, at times confusing. This metaphorical ambiguity reflects findings by Presto and Menorca (2023) and Danisman et al. (2024), who observed that students in middle school often use abstract or uncertain metaphors when encountering complex mathematical content. Conversely, calculator, building and time underscore students' growing awareness of mathematics' practicality and inherent structure. These representations are consistent with studies by Kaphesi (2014) and Afifah et al. (2019), who found that students at this stage begin to view mathematics as a tool for logical reasoning, problem-solving, and future planning. Together, these metaphorical choices reflect a cognitive and emotional shift as students begin to reconcile mathematics abstract nature with its functional value in everyday life.

By Grade 9 students' metaphors become notably more concrete and relatable, with term such as pizza, clock, cube, ruler and pyramid. This shift indicates a developing familiarity with mathematical objects and their tangible real-world applications. Such metaphorical choices align with the findings of Barete and Taja (2023), who noted that students at this stage often draw connections between mathematics and their lived experiences, emphasizing its practical relevance. Moreover, this trend reflects what Heinz et al. (2024) identified as the impact of perceived usefulness on students' cognitive framing of mathematics indicating that as learners recognize the subject's functional value they begin to articulate it through relatable utilitarian metaphors

Finally, in Grade 10, the metaphors evolved toward the symbolic and reflective. River, money, trophy and ancient Greek suggested that older students are beginning to recognize mathematics' complexity, its value as a tool for success and its profound intellectual and historical significance. This finding is consistent with Russell (2025) and Walfurqan (2022),

who noted that older or more academically advanced students often view mathematics as both a utilitarian tool and a representation of broader cognitive and historical value. Similarly, Katrinci et al. (2021) found that pre-service teachers and senior students frequently express metaphors tied to identify formation and philosophical reflection, describing themselves as “guides”, and mathematics as a “journey” or “legacy.”

Overall, this progression from Grade 7 to 10 highlights a clear developmental trajectory in students’ mathematical understanding—from playful to abstract, concrete to symbolic which supports the broader claim made by Savas et al. (2024) and Demirbilek & Korkmaz (2021) that metaphor analysis is a powerful lens for tracking how students’ mathematical beliefs and experiences evolve across age and academic exposure.

Table 2.
Categorize Metaphors into Thematic Groups

Theme	Metaphors	Implied Meaning
Math as a Journey/Adventure	game, adventure, river	Dynamic, nonlinear, requires effort and progression
Math as Life/Existence	life, lifestyle, dream, time	Math is central, continuous, abstract yet vital
Math as a Tool/Structure	calculator, ruler, cube, building, clock	Math is logical, instrumental, and used for construction and understanding
Math as a Symbol of Value	money, trophy	Math leads to success, achievement, and reward
Math as History/Intellect	ancient Greek	Deep, foundational, and linked to intellectual heritage
Math as Food/Concrete Object	pizza, pyramid	Familiar, tangible, maybe enjoyable or layered

Table 2 served to categorize the metaphors students used to describe mathematics into distinct thematic groups, offering valuable insight into their perceptions and emotional connections with the subject.

Math as a Journey/Adventure

The metaphors game, adventure and river collectively suggested that students perceived mathematics as a dynamic, nonlinear experience that requires effort and progression.

Game implied an element of play, challenges, rules, and the possibility of winning or losing. It indicates that mathematics can be engaging and stimulating, involving strategic thinking and problem-solving. Adventure further emphasizes the exploratory and unpredictable nature of the subject. It suggests that learning mathematics involves venturing into new territories, encountering obstacles, and discovering solutions, fostering a sense of excitement and discovery. River brings in the idea of continuous flow movement. It suggests

that mathematics is ever-evolving, with interconnected concepts that flow from one to another, requiring students to navigate and adapt to its currents as they progress. This theme highlights that mathematics is not a static body of knowledge but an active and unfolding process. These interpretations are strongly supported by Men et al. (2024), who found that metaphorical thinking interventions helped students approach mathematical reasoning more reflectively and dynamically that echoing the spirit of adventure and discovery.

Likewise, Ingram and Meaney (2021) describe how students navigate identity stories around mathematics aligning with the notion of math as a flowing river which is a personal and evolving journey. Furthermore, Walfurqan (2022) highlights students' strategic and exploratory approaches to algebra problem-solving consistent with the metaphors of game and adventure, further affirming this theme of mathematics as an active and unfolding experience.

Math as Life/Existence

Metaphors such as life, lifestyle, dream and time convey the profound idea that mathematics is central, continuous, abstract yet vital to existence.

Life and lifestyle position mathematics as an inherent and fundamental part of reality, interwoven with daily experiences and personal routines. This implies that student see mathematics not just an academic subject but as an indispensable aspect of how the world functions and how they navigate it. Dream introduces an abstract, perhaps even idealized or aspirational quality. It might suggest that mathematics holds a certain allure or mystery, representing something to be pursued or understood on a deeper, less tangible level. Conversely, it could also imply that mathematics can sometimes feel elusive or challenging to grasp, much like a dream.

Time underlines mathematics' foundational and inescapable nature. It suggests that mathematical principles are constant and govern the very structure of existence, much like time itself. This theme points to students recognizing the omnipresence and enduring relevance of mathematical concepts. This thematic framing aligns with findings from Chan and Reynolds (2022), who revealed that students viewed mathematics as intimately connected to their lived experiences, reinforcing the notion of math as a lifestyle. Similarly, Shone et al. (2023) highlighted how students' self-efficacy in math was tied to their sense of purpose and future success, validating the metaphor of dream as both a motivator and a reflection of personal aspiration.

Wang (2024) further supports this theme by illustrating how formative assessment and a sense of belonging can reduce anxiety in math learning emphasizing the constant, time like influence mathematics exerts on student's development. Together, these insights affirm that students perceive mathematics not just as subject but as an omnipresent and deeply meaningful element of life itself.

Math as a Tool/Structure

The metaphors calculator, ruler, cube, building and clock indicate that students view mathematics as logical, instrumental, and essential for construction and understanding.

Calculator and ruler directly represented mathematics as a practical instrument used for computation, measurement and precision. Highlighting its utility in solving concrete problems and achieving accurate results. Cube and building emphasized mathematics' inherent structural and foundational qualities. These metaphors suggested that mathematics provided the blueprints and principles upon which complex systems, ideas, and even physical structures were built, implying an understanding of mathematics as a stable, predictable, and logical framework. Furthermore, clock reinforced the idea of structure, measurement and consistent operation, pointing to the mathematics as a system that ordered and organized, allowing for predictability and analysis.

Collectively, these metaphors conveyed that mathematics was a reliable and powerful instrument for both practical and application and for comprehending the underlying order of the world. This interpretation is supported by Gadanidis et al. (2024), who describe how computer programming puzzles offer structured pathways for mathematical thinking, resonating with the calculator and building metaphors. Verschaffel et al. (2020) further validate this perspective by highlighting how word problems demand structured application of mathematical principles, aligning with the utility and framework aspects of the metaphors. Additionally, Khadpe et al. (2020) show how conceptual metaphors influence perceptions of human-AI collaboration, affirming that metaphors like clock and calculator shape how people conceptualize math as orderly, instrumental and deeply integrated into logical systems. Together, these findings reinforce the idea of mathematics as a powerful and structured tool for both understanding and constructing the world.

Math as a Symbol of Value

The metaphors money and trophy signify that mathematics is perceived as something that leads to success, achievement and reward.

Money directly linked mathematics to tangible value, economic prosperity, and the ability to attain resources. This reflected a belief that mathematical proficiency was a key to financial gain or general well-being in society. Similarly, trophy symbolized accomplishment, recognition, and the fruits of effort. It suggested that excelling in mathematics was a pathway to personal pride, tribute, and a sense of triumph. This theme highlighted the aspirational aspect of learning mathematics, where the subject was seen as a means to achieve desirable outcomes and recognition.

This aspirational perspective is reinforced by Akpalu et al. (2025), who found that students in Ghana associate mathematics with future opportunities and life success, directly

mirroring the metaphors of money and trophy. Russell (2025) also supports this view presenting mathematics as an intellectually noble pursuit whose mastery brings intrinsic and extrinsic rewards, echoing the symbolic meaning of a trophy.

Presto and Menorca (2023) found that students' motivation to use metacognitive strategies in problem-solving was often fueled by the desire for achievement, aligning with the value-oriented interpretation of mathematics as a source of recognition and reward. Collectively, these perspectives affirm that mathematics is perceived by students as a valuable asset-both materially and symbolically that contributes to personal and social advancement.

Math as History/Intellect

The metaphor of ancient Greek uniquely suggested that mathematics was perceived as deep, foundational and intrinsically linked to intellect heritage. This metaphor directly referenced the historical origins of many mathematical concepts particularly those from ancient civilizations. It implied an understanding that mathematics was not a modern invention but rather a discipline with deep roots, developed over centuries by profound thinkers. It further suggested that students recognized mathematics as a timeless intellectual pursuit-a legacy of human thought that formed a fundamental pillar of knowledge and continued to inspire intellectual exploration.

This interpretation is supported by Winter and Yoshimi (2020), who explore the philosophical and historical dimensions of mathematics through the lens of embodiment affirming its intellectual depth and longstanding culture relevance. Likewise, Kaphesi (2014) found that university students often associate mathematics with intellectual heritage and cultural continuity, reinforcing the metaphors' connection to historical legacy and scholarly depth. Together, these perspectives suggest that students recognize mathematics as not only intellectually rigorous but also historically significant a discipline that continues to reflect and contribute to the evolution of human understanding.

Math as Food/Concrete Object

The metaphor pizza and pyramid revealed that mathematics was seen as familiar, tangible, potentially enjoyable, or layered. Pizza implied something relatable, possibly enjoyable, and composed of different layers or components. This suggested that mathematics, despite its abstract nature, could be broken down into manageable, perhaps even appealing, parts that could be "consumed" or understood. Pyramid indicated a tangible structure that was often grand, possibly ancient, and built with distinct layers or levels.

This suggested that mathematics involved foundational elements that built upon each other in a hierarchical or complex manner, much like a pyramid's construction, requiring systematic understanding from base to apex. This thematic group brought a more concrete and sometimes palatable dimension to students' understanding of mathematics. Demirbilek and Korkmaz (2021) support this view by showing how students use concrete everyday metaphors

to conceptualize the abstract study concepts which reinforcing the utility of metaphors like pizza. Similarly, Teke (2023) found that pre-service teachers conceptualize mathematics as a system of layered ideas that mirroring the pyramid structure.

Furthermore, Haser et al. (2024) emphasize the importance of using concrete representations in teaching to scaffold student understanding, aligning with both metaphors and highlighting how educators help students grasp abstract mathematical concepts through familiar and structured imagery. Collectively, these findings suggest that students relate to mathematics more effectively when it is presented as a tangible, layered, and approachable subject where one they can consume or build piece by piece.

Taken together, these metaphorical themes and the supporting literature as highlighted by Asenova (2024) that students do not see mathematics as a monolithic or purely abstract discipline. Instead, as supported by Vimbelo and Bayaga (2024) they relate to it through experiential, instrument, aspirational, intellectual, and concrete lenses which are perspectives that can inform more empathetic, engaging, and effective approaches to mathematics education.

Table 3.

Students' Metaphors and Their Epistemological Views

Grade Level	Metaphors	Implied Epistemological Views
Grade 7	game, adventure	Math is seen as exploratory, playful, and dynamic. Students view learning math as a challenge or journey, not just memorization or rules.
	lifestyle, life	Indicates that students see math as embedded in daily life—a constant, natural part of living rather than an isolated subject.
Grade 8	dream	Reflects abstract or idealized thinking. Students may find math confusing or distant but also view it as imaginative or meaningful.
	calculator, building, time	Suggests a more structured and functional view. Math is a tool for organizing and measuring reality—focused on logic, rules, and application.
	Life	Reinforces belief in math as integrated into life, combining practical and existential perspectives.
Grade 9	pizza, clock, cube, ruler, pyramid	Emphasizes concrete understanding and measurable structure. Math is viewed as physical and practical, though pyramid may hint at layered, symbolic meaning.
Grade 10	river	Symbolizes flow and complexity, suggesting math is seen as a continuous process with twists and turns—dynamic and not always linear.
	money, trophy	Represents value and achievement. Students connect math to success, rewards, and future outcomes, reflecting instrumental and goal-oriented beliefs.
	ancient Greek	Implies a deep, historical, and intellectual perspective. Math is tied to culture, philosophy, and human knowledge.
	life	Maintains the theme of math being essential to existence, indicating a sustained personal connection with the subject.

Table 3, the metaphors students used across grade levels revealed evolving beliefs about what mathematics is and how it works. These insights reflect a range of epistemological views from seeing math as fixed and structured to viewing it as creative, meaningful, and deeply connected to life.

Grade 7: Experiential and Playful Views in Early Grades

Students in Grade 7 described mathematics as a “game” and an “adventure”, indicating a view of math as exploratory and dynamic, where challenges are met with curiosity and engagement. These metaphors aligned with Vimbelo and Bayaga (2024), who advocate for a humanizing pedagogy which are embedding mathematics in relatable, real-life contexts to enhance student engagement. Similarly, the metaphor “lifestyle” or “life” reflects the belief that math is integrated into daily existence, resonating with Barete and Taja-on (2023), who found that students relate better to mathematics when it’s contextualized within their lived realities. This also supports Akpalu et al. (2025), whose Ghanaian study reported that students with positive, personal associations with math tended to achieve higher performance outcomes.

Grade 8: Transitional Perspectives

Grade 8 introduces more functional metaphors like “calculator,” “building,” and “time”, indicating a shift toward instrumental and structural views of math. This echoes the findings of Brandt et al. (2020), who highlight that cognitive ability and structured thinking become more aligned with academic success in mathematics during adolescence. The “dream” metaphor from the same grade suggests that some students still relate to math as an imaginative or abstract space, which matches the dual nature of metaphor discussed in Chan and Reynolds (2022), where students see math both as functional and as a realm of creative or personal meaning.

Grade 9: Concrete and Practical Views

By Grade 9, students use physical and tangible metaphors such as “pizza,” “clock,” “ruler,” and “cube”, reinforcing a perception of math as structured, measurable, and useful. These metaphors directly align with Asenova (2024), who emphasizes the need for math education to move beyond abstraction and address the ontological creativity of learners which are rooted in practical and conceptual understanding. This also reflects the metaphorical concreteness that Teke (2023) and Demirbilek and Korkmaz (2021) found in students’ conceptualizations of math showing that learners increasingly relate to math through objects, symbols, and spatial reasoning as they mature.

Grade 10: Intellectual, Aspirational, and Historical Views

In Grade 10, students’ use metaphors such as “river,” “money,” “trophy,” “ancient Greek,” and “life” reflects a complex and multifaceted understanding of mathematics. The metaphor of a “river” suggests a view of mathematics as fluid and process oriented, aligning with Winter & Yoshimi (2020), who describe math as an embodied and evolving experience rather than a static body of knowledge. References to “money” and “trophy” indicate more instrumental and outcome focused beliefs, consistent with Harefa (2023), who associates students’ interest in mathematics with its perceived value and future utility.

The mention of “ancient Greek” reflects an intellectual and historical appreciation of mathematics, echoing the perspectives of Russell (2025) and Haser et al. (2024), who emphasize the philosophical and cultural legacy of mathematical learning. Finally, the recurring metaphor “life” which appears across multiple grade levels underscores the perception of mathematics as essential and ever present shaped by family expectations and the everyday relevance of mathematics.

The Grade 10 findings affirm a developmental shift in how students perceive mathematics, moving from playful and experiential views in earlier grades to more complex, aspirational, and intellectual understandings. Metaphor like “river,” “money,” “trophy,” “ancient Greek,” and “life” illustrate this progression, reflecting evolving views of math as dynamic, valuable, historically rich, and integral to daily life. These insights align with the work of Alam & Mohanty (2024) and reinforce the idea that students’ mathematical identity becomes more nuanced and reflective as they advance through their educational journey.

Table 4.

Explore How Age, Grade Level or Prior Math Experiences Influence Metaphor Choice

Grade Level	Common Metaphor Types	Developmental Implication
Grade 7	game, lifestyle, adventure	Younger students see math as playful, active, part of identity
Grade 8	dream, time, calculator	Transitional thinking; abstract and instrumental metaphors emerge
Grade 9	pizza, cube, pyramid, ruler	Concrete metaphors dominate—suggest growing familiarity with mathematical objects
Grade 10	river, trophy, ancient Greek	Metaphors become symbolic, historical, value-laden—suggestive of deeper conceptual or reflective thinking

Table 4 illustrates how students metaphors choices for mathematics evolve across grade levels highlighting the influence of age, cognitive development and prior experiences.

At the entry level, the prevalence of metaphors like game, lifestyle, and adventure reflects a playful, identity-driven understanding of mathematics. This aligned with Vimbelo and Bayaga (2024), who emphasize the importance of humanizing pedagogy in early math

education to connect learning with students, lived realities. Similarly, Barete and Taja-on (2023) highlight how embedding mathematics in personal and everyday contexts can enhance student engagement and perception, supporting the notion that younger learners tend to view math as active, experiential and integral to life. Akpalu et al. (2025) also found that students with strong personal connections to mathematics often exhibit better performance, reinforcing the developmental importance of these early metaphorical associations.

As students' progress to Grade 8, metaphors such as dream, time, and calculator mark a transitional cognitive phase, where abstract and instrumental thinking begin to emerge. This duality of imaginative and functional views echoes Chan and Reynolds (2022), who describe how students often hold simultaneously metaphoric beliefs about math's abstract beauty and its utility. The increased presence of instrumental metaphors is also consistent with Brandt et al. (2020), who observe that structured thinking and cognitive development become more pronounced in adolescence, contributing to more goal-oriented and analytical understandings of mathematics.

By the time students reach Grade 9, metaphor choices become increasingly concrete and object-based, including terms like pizza, cube, pyramid and ruler. These metaphors suggest a deepening familiarity with mathematical concepts and tools, grounded in physical and spatial reasoning. Asenova (2024) highlights the role of ontological creativity in engaging students with tangible mathematical representations. This is echoed by Teke (2023); Demirbilek and Korkmaz (2021), who found that Mid-secondary learners often associate math with measurable, real-world objects which are indicating a strengthening of conceptual and procedural understanding.

At this advanced stage, Grade 10 students used more abstract and culturally rich metaphors like river, trophy, and ancient Greek, reflecting deeper conceptual thinking and critical reflection. River suggested fluidity and evolution in math echoing Winter and Soshimi's (2020) view of embodied understanding. Trophy denoted outcome-driven motivation, aligning with Harefa's (2023) findings on perceived value and student interest. Ancient Greek implied historical and philosophical appreciation, consistent with Russell (2025) and Haser et al. (2024). The continued use of life reinforced Ingram & Meaney's (2021) view that math identity is shaped by everyday relevance and social context. Additionally, Alam and Mohanty (2024) advocated for promoting abstract thinking in upper grades which supported the symbolic metaphors observed here. This progression mirrored Atkins et al. (2020), who highlighted the role of accumulated experience and self-perception in shaping STEM identity.

In summary, the progression of metaphors across grade levels is well-substantiated by current literature. It demonstrated how students' metaphoric choices evolve not only with age and academic level but also through the depth and quality of their mathematical experiences. As students mature and encounter more complex mathematical ideas, their metaphors became

increasingly sophisticated which indicated a more nuanced, reflective, and integrated mathematical identity.

CONCLUSIONS

This study investigated how junior high school students conceptualize mathematics through metaphor, revealing a developmental progression in their mathematical beliefs and identity formation. Utilizing a qualitative, phenomenological approach, the analysis of students' visual and written responses from Grades 7 to 10 yielded six core metaphorical themes: mathematics as a journey, life, tool, value, history, and tangible object.

Findings indicate that Grade 7 students primarily associated mathematics with playful and experiential metaphors such as game, adventure, and lifestyle which reflecting an exploratory and identity embedded perspective. By Grade 8, students began to express more abstract (dream) and instrumental (calculator, time) metaphors, suggesting a cognitive shift toward structured reasoning and functionality. In Grade 9, metaphors became increasingly concrete and object-oriented (pizza, ruler, pyramid), pointing to a growing familiarity with mathematical tools and their relevance to real-world context. By Grade 10, students employed more symbolic and culturally nuanced metaphors such as river, trophy, and ancient Greek reflecting deeper conceptual thinking, historical awareness, and aspirational views of mathematics.

The persistent appearance of life across all grade levels underscores students' enduring perception of mathematics as fundamental and omnipresent aspect of human experience. These metaphorical shifts, shaped by age, cognitive development, and prior experience, illuminate the evolving nature of students' epistemological views.

Overall, the findings affirm that metaphors are not merely linguistic expressions but serve as meaningful cognitive and affective representations of students' mathematical understanding. Recognizing these metaphorical constructs provides valuable insight for educators and curriculum designers, enabling more empathetic, contextually relevant, and developmentally aligned pedagogical practices that foster positive mathematical identities throughout secondary education.

RECOMMENDATIONS

Based on the findings, several recommendations are offered for teachers, curriculum developers, and future researches.

For Teachers

Encourage students to develop and share their own metaphors for mathematical concepts. This practice helps learners connect abstract ideas with familiar experiences, making

mathematical more approachable. Use student-generated metaphors as valuable diagnostic tools. They can reveal misconceptions and serve as starting points for meaningful discussions that bridge everyday thinking with formal mathematics. Plan activities that match learners' developmental stages-integrating playful and experiential metaphors for younger students while gradually supporting more abstract and symbolic reasoning in higher grade level.

For Curriculum Developers

Incorporate metaphor-based activities and reflection exercises into instructional materials and assessments to deepen students' conceptual understanding. Design resources that highlight mathematics as not only computational but also cultural, historical, and symbolic, helping students appreciate the subject from multiple perspectives. Ensure that the curricula reflect students' evolving ways of thinking, making materials both contextually meaningful and developmentally appropriate.

For Future Research

Extend the study to larger and more diverse groups of students to validate the developmental trends observed. Explore how metaphor analysis might be effectively combined with other pedagogical approaches such as problem-based learning or technological-enhanced strategies. Examine how teachers' own metaphorical views of mathematics influence their institutional choices and ultimately, student engagement. Future studies may also investigate how university students conceptualize mathematics through metaphors, providing insight into the transition from secondary to higher education and broadening understanding of mathematical identity formation across education stages.

By putting these recommendations into practice, educators and researchers can use metaphor analysis not only to better understand students' thinking but also to create more engaging, responsive, and empowering mathematics learning experiences.

REFERENCES

- Adeshola, I., & Adepoju, A. P. (2024). The opportunities and challenges of ChatGPT in education. *Interactive Learning Environments*, 32(10), 6159-6172.
<https://doi.org/10.1080/10494820.2023.2253858>
- Akpalu, R., Boateng, P. A., Ayisi, E., & Owusu, J. (2025). Students' perceptions of mathematics and the impact on their achievement among senior high school students in Ghana. *International Journal of Research and Innovation in Social Science*, 9(1), 3829-3840.
<https://dx.doi.org/10.47772/IJRIS.2025.9010299>
- Alam, A., & Mohanty, A. (2024). Unveiling the complexities of 'Abstract Algebra' in University Mathematics Education (UME): fostering 'Conceptualization and Understanding' through

- advanced pedagogical approaches. *Cogent Education*, 11(1).
<https://doi.org/10.1080/2331186X.2024.2355400>
- Albay, E. M., & Aquino, R. L. (2024). Utilizing flipped classroom and the first principles of effective instruction in teaching finite geometry. *International Journal of Instruction*, 17(1), 177–192.
<https://doi.org/10.29333/iji.2024.17110a>
- Albay, E. M., Aquino, R. L., Alambra, R. V. E., Eisma, D. V., & Quiambao, R. D. (2024). Assessing graduates' attributes and job performance for program curriculum enhancement. *International Journal of Evaluation and Research in Education (IJERE)*, 13(4), 2689-2697. <http://doi.org/10.11591/ijere.v13i4.27090>
- Albay, E. M., & Eisma, D. V. (2025). Using design thinking for developing pre-service teachers' creativity in designing teaching plans to promote interactive learning in mathematics. *Learning and Instruction*, 96, 102070. <https://doi.org/10.1016/j.learninstruc.2024.102070>
- Asenova, M. (2024). Is theoretical topic-specific research “old fashioned”? An epistemological inquiry about the ontological creativity of Mathematics Education Research. *Mathematics Education Research Journal*, 36(4), 849-870. <https://doi.org/10.1007/s13394-023-00471-z>
- Atkins, K., Dougan, B. M., Dromgold-Sermen, M. S., Potter, H., Sathy, V., & Panter, A. T. (2020). “Looking at myself in the future”: how mentoring shapes scientific identity for STEM students from underrepresented groups. *International Journal of STEM Education*, 7, 1-15.
<https://doi.org/10.1186/s40594-020-00242-3>
- Barete, M. G., & Taja-on, E. P. (2024). Students' perception in learning the course mathematics in the modern world: A qualitative study. *East Asian Journal of Multidisciplinary Research*, 3(7), 2977-2988. <https://doi.org/10.55927/eajmr.v3i7.10071>
- Brandt, N. D., Lechner, C. M., Tetzner, J., & Rammstedt, B. (2020). Personality, cognitive ability, and academic performance: Differential associations across school subjects and school tracks. *Journal of Personality*, 88(2), 249-265. <https://doi.org/10.1111/jopy.12482>
- Chan, K. K., & Reynolds, B. L. (2022). Metaphoric beliefs of students engaged in dynamic mathematics lessons. *Eurasia Journal of Mathematics, Science and Technology Education*, 18(10), em2169. <https://doi.org/10.29333/ejmste/12463>
- Demirbilek, N., & Korkmaz, C. (2021). Study concept as a metaphor from the lenses of university students. *African Educational Research Journal*, 9(1), 227-236.
https://www.netjournals.org/z_AERJ_21_028.html
- Gadanidis, G., Hughes, J. M., Namukasa, I., & Scucuglia, R. (2024). Computer programming puzzles, mathematics education, and the culture of learning. In *Ways of Thinking in STEM-based Problem Solving* (pp. 218-234). Routledge.
<https://www.taylorfrancis.com/chapters/edit/10.4324/9781003404989-16>
- Gibbs Jr, R. W., & Siman, J. (2021). How we resist metaphors. *Language and Cognition*, 13(4), 670-692. <https://doi.org/10.1017/langcog.2021.18>
- Harefa, D. (2023). The relationship between students' interest in learning and mathematics learning outcomes. *Afore: Jurnal Pendidikan Matematika*, 2(2), 1-11. <https://doi.org/10.57094/afore.v2i2.1054>

- Haser, Ç., Arslan, O., & Çelikdemir, K. (2024). Who is a mathematics teacher and what does a mathematics teacher do? *International Journal of Science and Mathematics Education, 22*(2), 283-305. <https://doi.org/10.1007/s10763-023-10378-7>
- Hill, J. L., Kern, M. L., Seah, W. T., & van Driel, J. (2020). Feeling good and functioning well in mathematics education: Exploring students' conceptions of mathematical well-being and values. *ECNU Review of Education, 4*(2), 349-375. <https://doi.org/10.1177/2096531120928084>
- Ingram, N., & Meaney, T. (2021). "My parents are pretty pleased with my math's": students' navigation of identity stories about mathematics. *Research in Mathematics Education, 24*(1), 51-68. <https://doi.org/10.1080/14794802.2021.1938190>
- Kaphesi, E. (2014). Third-year university mathematics education students' metaphorical understanding of mathematics teaching and learning. *African Journal of Research in Mathematics, Science and Technology Education, 18*(3), 276-286. <https://doi.org/10.1080/10288457.2014.962729>
- Katrancı, Y., Kiral, B., & Kedikli, D. (2021). Pre-service high school mathematics teachers' perceptions about mathematics and mathematics teachers: A metaphorical approach. In W. B. James, C. Cobanoglu, & M. Cavusoglu (Eds.), *Advances in global education and research* (Vol. 4, pp. 1–14). USF M3 Publishing. <https://digitalcommons.usf.edu/m3publishing/vol3/iss2021/50/>
- Khadpe, P., Krishna, R., Fei-Fei, L., Hancock, J. T., & Bernstein, M. S. (2020). Conceptual metaphors impact perceptions of human-AI collaboration. *Proceedings of the ACM on Human-Computer Interaction, 4*(CSCW2), 1-26. <https://doi.org/10.1145/341523>
- Lutovac, S. (2020). How failure shapes teacher identities: Pre-service elementary school and mathematics teachers narrated possible selves. *Teaching and Teacher education, 94*, 103120. <https://doi.org/10.1016/j.tate.2020.103120>
- Men, F. E., Pantaleon, K. V., & Tamur, M. (2024). Metaphorical thinking intervention in learning and its impact on mathematical reasoning ability. *Mosharafa: Jurnal Pendidikan Matematika, 13*(1), 29–38. <https://doi.org/10.31980/mosharafa.v13i1.1973>
- Presto, A. C., & Menorca, E. (2023). Students metacognitive strategies in solving mathematics problems in distance learning: A phenomenological study. *International Journal of Multidisciplinary: Applied Business and Education Research, 4*(4), 1259-1269. <http://dx.doi.org/10.11594/ijmaber.04.04.21>
- Russell, B. (2025). The study of mathematics. In *Mysticism and logic* (pp. 54-68). Routledge. <https://doi.org/10.4324/9781003604990-4>
- Savas, G., Danisman, S., & Kacar, S. N. (2024). Metaphorical perceptions of secondary school students on new generation mathematics questions. *Kulliye, 5*(2), 332-346. <https://doi.org/10.48139/aybukulliye.1358322>
- Shone, E. T., Weldemeskel, F. M., & Worku, B. N. (2023). Strategies of enhancing students' mathematics perception and self-efficacy to improve their mathematics achievement. *Cogent Education, 10*(2), 2285642. <https://doi.org/10.1080/2331186X.2023.2285642>
- Teke, B. (2023). Pre-service mathematics teachers and undergraduate mathematics students' metaphorical perceptions of the concept of mathematics. *International Journal of Scholars in Education, 6*(2), 181-203. <https://doi.org/10.52134/euader.1347872>

- Verschaffel, L., Schukajlow, S., Star, J., & Van Dooren, W. (2020). Word problems in mathematics education: A survey. *ZDM Mathematics Education*, 52, 1–16. <https://doi.org/10.1007/s11858-020-01130-4>
- Vimbelo, S., & Bayaga, A. (2024). Transforming mathematics education in TVET Colleges through humanizing pedagogy: An exploration of teaching approaches, student engagement, and real-life examples. *IETE Journal of Education*, 65(2), 139-154. <https://doi.org/10.1080/09747338.2024.2324808>
- Walfurqan. (2020). Investigating of students' metaphorical thinking in solving algebra problems. *Journal of Mathematics Pedagogy*, 1(2), 54-61. <https://journal.unesa.ac.id/index.php/JOMP/article/view/9717>
- Wang, Y. (2024). Examining the role of sense of belonging and formative assessment in reducing the negative impact of learning anxiety in mathematics. *European Journal of Psychology of Education*, 39, 431–453. <https://doi.org/10.1007/s10212-023-00701-9>
- Winter, B., & Yoshimi, J. (2020). Metaphor and the philosophical implications of embodied mathematics. *Frontiers in Psychology*, 11, 569487. <https://doi.org/10.3389/fpsyg.2020.569487>