Student Self-Assessment of 6Cs Integration and Measurement of Mathematical Literacy Proficiency among High School Students in Digos City

Kristine May S. Almacin[1], Gwyneth P. Sarona[2], Hanneh Dee P. Ocampo[3], Ma. Cristine Joy V. Anter[4]
[1,2,3,4] Department of Teacher Education, UM Digos College, Digos City, Philippines

Article Info

Article history:

Received Apr 10, 2026
Revised Jul 21, 2026
Accepted Aug 23, 2026
Online First Aug 26, 2026

Keywords:

21st-Century Learning
6 Cs
Citizenship
Culture
Mathematics Proficiency
Self-Assessment

ABSTRACT

Purpose of the study: Mathematical literacy remains a persistent challenge in the Philippine education system, as evidenced by the low performance of Filipino students in PISA 2022. Addressing this challenge requires integrating 21st-century skills into the mathematics curriculum to prepare students for complex global demands. This study evaluated the relationship between self-assessed 21st-century competencies (the 6 Cs) and the mathematical proficiency of high school students (N = 676) in Digos City.

Methodology: Utilizing a descriptive-predictive research design, the study analyzed student self-assessments alongside Minimum Competency Assessment (MCA) scores using Pearson correlation and multiple linear regression.

Main Findings: Results revealed that while students demonstrated strong foundational competencies in numeracy and abstraction, their overall mathematical proficiency remained low at Level 1a. Among the non-cognitive traits, critical thinking and communication were closely correlated with abstraction and symbolic reasoning, while culture/citizenship emerged as the primary statistically significant predictor of mathematical performance. Crucially, this research contributes to the educational evaluation framework by demonstrating how non-cognitive 21st-century skills intersect with and support students' mathematical literacy, reasoning, and problem-solving abilities. To bridge observed performance gaps, the study advocates for a structured integration of the 6 Cs through culturally relevant pedagogies, real-world problem-solving, and contextualized instruction.

Novelty/Originality of this study: Ultimately, these findings carry key implications for school-based mathematics assessment systems, emphasizing the need to reform local testing frameworks to evaluate higher-order reasoning and holistic 21st-century competencies alongside traditional procedural mastery.

Corresponding Author:
Ma. Cristine Joy V. Anter
Department of Teacher Education, UM Digos College, Digos City, Davao del Sur, 8002, Philippines
Email: mariacristinejoyanter@umindanao.edu.ph

1. INTRODUCTION

Mathematical literacy remains a vast discussion and persistent global challenge, demanding effective pedagogical strategies and learning initiatives within 21st-century education [1]. At the core of this challenge lies the necessity of achieving mathematization—the mastery of solving real-life problems through mathematics [2]. The failure to achieve this level of proficiency not only hinders students' academic achievement [3] but also negatively affects their long-term outcomes [4]. This study addresses a critical gap in the Philippines, driven by the Programme for International Student Assessment (PISA) 2022 results, which revealed that only 16% of

Filipino students attained basic mathematical proficiency, lagging significantly behind global peers by approximately five to six years' worth of schooling [5]. Addressing these performance gaps highlights the role of assessment as a diagnostic and evaluative tool. Creating a meaningful assessment framework is essential for systematically evaluating students' mathematical literacy, reasoning, and problem-solving skills in real classroom settings [6], [7]. Evaluating these transferable 21st-century competencies serves as a vital indicator of educational quality, measuring a system's capacity to prepare adaptable, highly skilled graduates who can navigate complex real-world demands [8], [9].

Responding to the demands of global education, integrating the Critical Thinking, Creativity, Collaboration, Communication, Citizenship/Culture, and Character/Compassion (6 Cs) Model is essential to prepare students for social and global development [10]. This initiative aligns with the United Nations International Children's Emergency Fund (UNICEF), which promotes mathematical competence and constructive methodologies [11], and national mandates like the Department of Education's emphasis on 21st-century skills and global citizenship [12]. Local context provides further justification, with initial evidence showing that critical thinking skills enhance mathematical understanding [13]. Furthermore, the national vision of AmBisyon Natin 2040 specifically calls for formal education to ensure the acquisition of foundational literacies alongside critical thinking, problem-solving, creativity, communication, and character qualities [14].

The theoretical background of this research rests on the principles of Progressivism and Transformative Learning. John Dewey's progressivism advocates for socially engaging, experiential learning where students acquire knowledge through hands-on engagement guided by the teacher [15], [16]. Complementing this, Jack Mezirow's transformative learning theory emphasizes how learners reinterpret their experiences using critical reflection to create new, lasting insights [17], [18]. Both theories collectively promote the development of individual learners through experiential learning, which aligns closely with the integration of the 6 Cs framework.

However, existing literature assessing students' mathematical literacy and reasoning skills through the PISA framework presents notable limitations, especially regarding the integration of the 6 Cs [19], [20]. Previous studies have overwhelmingly focused on quantifying low student abilities, evaluating procedural math tests, or examining the isolated effectiveness of specific instructional models in controlled interventions [21]. There remains a marked shortage of research examining how holistic competencies such as 6 Cs directly intersect with standardized domain-specific mathematical assessments [8]. Furthermore, conventional measurement frameworks rarely evaluate how multidimensional 21st-century skill predict domain-specific mathematical performance, leaving a critical gap in contextualized diagnostic tools that capture both non-cognitive growth and cognitive reasoning within local education systems. The novelty and urgency of this research lie in its empirical bridging of 6 Cs through student self-assessments with standardized Minimum Competency Assessment (MCA). Rather than evaluating pedagogical interventions in isolation, this study provides a region-specific predictive framework that identifies competencies within the 6 Cs model that serve as significant predictors of mathematical proficiency under PISA-aligned standards. In direct response to Sustainable Development Goal 4: Quality Education [22], establishing this empirical link is urgent for retooling diagnostic assessment modalities and informing targeted curricular reform in vulnerable regional contexts.

This study generally aimed to explore the relationship between the 6 Cs model and mathematics proficiency of high school students in Digos City. Specifically, this aimed:

1. To determine the level of 6 Cs in the Minimum Competency Assessment (MCA) of high school students through the following core competencies in Mathematics:
   1.1 Numeracy Systems and Their Algebraic Properties;
   1.2 Abstraction and Symbolic Representations;
   1.3 Mathematical Structures and their Regularities;
   1.4 Functional Relationship Between Quantities;
   1.5 Mathematical Modelling as Lens onto the Real World; and
   1.6 Variation at the Heart of Statistics.
2. To determine the mathematics proficiency level of high school students with the integration of 6 Cs.
3. To determine the level of 6 Cs in the self-assessment of high school students, specifically:
   3.1 Communication;
   3.2 Collaboration;
   3.3 Critical Thinking;
   3.4 Creativity;
   3.5 Culture/Citizenship; and
   3.6 Character.
4. To determine the significant relationship between 6 Cs and Mathematics Proficiency Levels results.
5. To determine which variables of 6 Cs best predict the mathematical proficiency of high school students.

2. RESEARCH METHODS

2.1. Respondents

The target respondents of this study were students currently enrolled in the school year 2024-2025 from Grades 9 to 10, aged from 15 to 16 years old. The inclusion criteria for selecting respondents were based on the PISA Target Population 2022, which varied depending on the sampling technique used to enhance the accuracy of the data and results [23]. Purposive sampling was utilized to deliberately select students who were best equipped to provide insight into this study [24]. The schools that officially participated were three (3) private and ten (10) public secondary schools in Digos City. Due to school restrictions, class schedules, and the total number of students per school, a total of 676 respondents were selected to participate in the assessment. Table 1 provides a meaningful glimpse into the demographic profile and distribution of high school students across the various schools in Digos City. The characteristics highlighted were gender, age, grade level, and school affiliation, which may influence students' perspectives, experiences, and responses.

Furthermore, any respondents had the option to withdraw from this study when they were not physically, emotionally, and mentally fit to take the following assessments. For this, a student was excluded from participating when they dropped out of school within the academic year stated, were caught in an accident and needed full recovery, and physically absent during the specific day and time the assessments were conducted.

Table 1. The Characteristics of 676 High School Students Included in the Assessment

Profile Variables	*F*	%
Gender		
Female	383	56.7%
Male	269	39.8%
Member of LGBTQIA+	16	2.4%
Prefer not to say	8	1.2%
Age		
15 years old	416	61.5%
16 years old	260	38.5%
Grade		
Grade 9	156	23.1%
Grade 10	520	76.9%
Schools		
School A	47	7%
School B	42	6.2%
School C	44	6.5%
School D	106	15.7%
School E	30	4.4%
School F	47	7%
School G	43	6.4%
School H	70	10.4%
School I	15	2.2%
School J	25	3.7%
School K	56	8.3%
School L	85	12.6%
School M	66	9.8%

The gender distribution of high school students in Digos City revealed a predominantly female student population, with 383 students identifying as female, made up 56.7% of the total. The data suggests a healthy mix of genders in the educational setting, but the higher number of female students may indicate greater retention or enrollment rates among young women. It's important to highlight the 16 students (2.4%) who identified themselves as members of the LGBTQIA+ community. Their presence in the student body reflects the growing visibility and acceptance of diverse gender identities and sexual orientations within the younger generation. On the other hand, the age distribution of high school students in Digos City had shown that the majority of students are 15 years old, making up 61.5% of the total population. The data also revealed that a large majority of high school students in Digos City are enrolled in Grade 10, accounting for 76.9% of the total. The high concentration in Grade 10 reflected the focus of the study and data collection effort of the researchers. Lastly, among the 13 schools listed, School D stands out as the largest contributor, accounting for 15.7% of the student population.

2.2. Research Instruments

This study adopted the self-assessment questionnaire on the integration of 6 Cs in 21st-century learning by Fadhilawati et al. [25] and utilized the Minimum Competency Assessment (MCA) test model to measure the mathematical proficiency of high school students [26].

One of the instruments used was the self-assessment questionnaire that contained items designed to assess students' skills in relation to the 6 Cs in Mathematics [25]. The questionnaire specifically measured six dimensions of the 21st century skills: Communication, Collaboration, Critical Thinking, Creativity, Culture/Citizenship, and Character. These dimensions were aligned with the 6 Cs framework and designed to capture students' perceptions of their skills in mathematical contexts.

To ensure the appropriateness and contextual fit of the adopted survey questionnaire, a targeted validation process focused on face validity and content validity was executed prior to full deployment. The questionnaire was submitted for formal evaluation to a panel of expert validators from the Mathematics Department and the Research and Publication Center (RPC) of UM Digos College. The instrument was evaluated using a standardized Questionnaire Validity Rubric, earning an overall rating of 5 (Excellent) for item relevance, clarity, and alignment with learning standards. Because the instrument was adopted directly from a validated, previously published source, the underlying factor structure and construct validity had already been psychometrically established by the original authors; as such, a formal pilot testing administration was deemed unnecessary. Instead, face validity and linguistic appropriateness were confirmed through expert panelists to ensure the phrasing was clear, age-appropriate, and free of ambiguity for the local student demographic.

Furthermore, it contains five options for scoring through a 5-point Likert Scale. The scale is as follows: 1- minimal or no mastery of skills, 2 - having limited proficiency with room for improvement, 3 - having moderate proficiency, demonstrating basic understanding, 4 - having good proficiency and solid grasp of skill, and 5 - having very good mastery that showcases an advanced level of proficiency. Students were asked to rate their own proficiency in each area by assigning a score in each question. This allowed for an evaluation of how they viewed their abilities across the 6 Cs. Table 2 shows the range of means used to interpret the level of self-perceived proficiency of high school students for the 6 Cs.

Table 2. Interpretation Guide for the Level of Self-Assessment for the 6 Cs in Mathematics

Mean Values	Levels	Descriptive Meaning
4.20 – 5.00	Very High	The students perceived themselves as possessing an advanced level of proficiency in the items.
3.40 – 4.19	High	The students perceived themselves to possess an adequate or good level of proficiency for the items.
2.60 – 3.39	Moderate	The students perceived themselves as possessing a moderate level of proficiency in the items.
1.80 – 2.59	Low	The students perceived themselves as possessing a limited level of proficiency in the items.
1.00 – 1.79	Very Low	The students perceived themselves to have little to no mastery of the skills described in the items.

Another research instrument used was the Minimum Competency Assessment (MCA) test, which was conducted to assess students' mathematical proficiency. The development of the test followed the modified model of Oriondo et al., as cited in Novika [27], which includes test design, test trials, and test measurements [26]. For the test design, the initial assessment consists of 24 questions per competency, totaling 144 items subjected to testing. A test blueprint was constructed to guide the design of the Minimum Competency Assessment (MCA). It systematically matrixes six core Mathematics Content Competencies—Numeracy Systems and their Algebraic Properties, Abstraction and Symbolic Representations, Mathematical Structures and their Regularities, Functional Relationship Between Quantities, Mathematical Modeling as a Lens onto the Real World, and Variation at the Heart of Statistics—across the 6 Cs of 21st-Century Skills using two distinct assessment formats: Traditional Multiple-Choice and Complex Multiple-Choice items. This balanced matrix design guarantees equal weight across content areas while testing higher-order cognitive reasoning and skill integration through both single-response and multi-faceted problem-solving formats. Below is the test blueprint used to assess students' mathematical proficiency.

Table 3. Test Blueprint for Minimum Competency Assessment

Mathematics Competencies		Numeracy systems and their Algebraic properties	Abstraction and Symbolic Representations	Mathematical Structures and their regularities	Functional Relationship Between Quantities	Mathematical Modeling as a Lens onto the Real World	Variation at the Heart of Statistics	Total
Traditional Multiple Choice	Critical Thinking	2	2	2	2	2	2	12
	Creativity	2	2	2	2	2	2	12
	Collaboration	2	2	2	2	2	2	12
	Communication	2	2	2	2	2	2	12
	Citizenship	2	2	2	2	2	2	12
	Character	2	2	2	2	2	2	12
Complex Multiple Choice	Critical Thinking	2	2	2	2	2	2	12
	Creativity	2	2	2	2	2	2	12
	Collaboration	2	2	2	2	2	2	12
	Communication	2	2	2	2	2	2	12
	Citizenship	2	2	2	2	2	2	12

To assess the reliability of the instrument and data collection procedures, a test trial was administered. A total of 30 respondents from a similar inclusion profile participated in the pilot testing, but were not included in the final assessment. Findings revealed that students generally performed moderately, with an average score of 61.83%, ranging from a high of 97 to a low of 44 out of 144 items. Item analysis was also performed, with 107 items falling within the difficulty index of 0.25 to 0.75, leaving the average items for final assessment. Moreover, the overall assessment yielded good internal consistency ($\alpha = 0.8$), as determined by the Kuder-Richardson Formula 20 (KR-20). For the actual assessment, scores will be obtained per student, which will be generally converted to percentage cut-off scores to identify their proficiency level. Below is the interpretation guide for the level of mathematical proficiency, adapted from the PISA 2022 Mathematical Framework.

Table 4. Interpretation Guide for the Level of Mathematical Proficiency

Proficiency Level	Percentage Cut-off Scores	Task Description
Level 6	66.9%-100%	Students at this level can solve abstract problems using creative and flexible thinking. They are skilled in critical thinking and are proficient in symbolic and formal math, which they use to explain their reasoning clearly. They can assess whether their actions and solutions are appropriate for the problem, considering the real-world context through the integration of the 6 Cs.
Level 5	60.7%-66.8%	Students at this level can create and work with models for complex situations, set limitations, and make assumptions. They employ organized and well-thought-out strategies to tackle challenging tasks, such as planning an experiment, devising the optimal procedure, or working with complex visualizations. They show a greater ability to solve problems that require applying mathematical knowledge not directly mentioned in the items. At this level, students reflect on their work and evaluate their mathematical results in real-world contexts, integrating the 6 Cs.
Level 4	54.5%-60.6%	Students at this level can handle complex real-world problems using clear models, sometimes involving two variables. They can describe models for undefined situations using advanced computational thinking. They begin to use critical thinking, such as judging whether a result makes sense when exact calculations are not possible. Students can combine and use different types of information, like graphs or symbols, and connect them to real-life situations. They can choose and justify solutions based on their understanding, reasoning, and methods, integrating the 6 Cs.
Level 3	48.2%-54.4%	Students at this level can create solution strategies that involve step-by-step decisions or adapting familiar concepts and apply a computational thinking approach. They can solve tasks that require multiple routine calculations, even when not all steps are clearly stated. They can use spatial reasoning, interpret and use information from different sources, including making decisions based on a two-way table. They can also work with problems involving percentages,

		fractions, decimals, and proportional relationships, integrating the 6 Cs.
Level 2	42%-48.1%	Students at this level can identify when they need to create simple strategies to solve problems, including basic simulations. They can gather relevant information from complex sources (e.g., two-way tables, charts, or 2D drawings of 3D objects). They understand basic functional relationships, can solve simple ratio problems, and interpret results literally with the integration of the 6 Cs.
Level 1a	35.8%-41%	Students at this level can answer questions in simple situations where all the necessary information is provided, and understand questions with two sources at once to identify relevant details (e.g., a table accompanied by a brief description). They can follow clear, step-by-step instructions to complete basic tasks, even if it involves repeating steps multiple times. They can combine information and apply basic methods, formulas, or rules to solve problems, typically involving whole numbers, while integrating the 6 Cs.
Level 1b	29.5%-36.7%	Students at this level can answer questions in simple situations where all the needed information is clearly shown in tables or graphics. They can identify and ignore irrelevant information if it does not apply to the question. They can also perform basic calculations when given clear, easy-to-follow instructions that incorporate the 6 Cs.
Level 1c	23.3%-29.4%	Students at this level can answer questions involving easy, simple, and familiar situations where all the needed information is clearly given. They can follow clear instructions that describe a single operation or task, integrating the 6 Cs.

2.3. Research Design and Procedure

This study utilized descriptive-predictive research design that is quantitative in nature [28], [29]. Descriptive-predictive research design summarizes and finds patterns from raw data, which determines the relationship between input and target data [30]. Thus, these designs offer a comprehensive approach, not just by showing the present data relationships but also projecting future possibilities which enhances decision making. Figure 1 illustrates the phases of the research procedure, structured into administrative clearance, instrument validation, data collection, and statistical analysis.

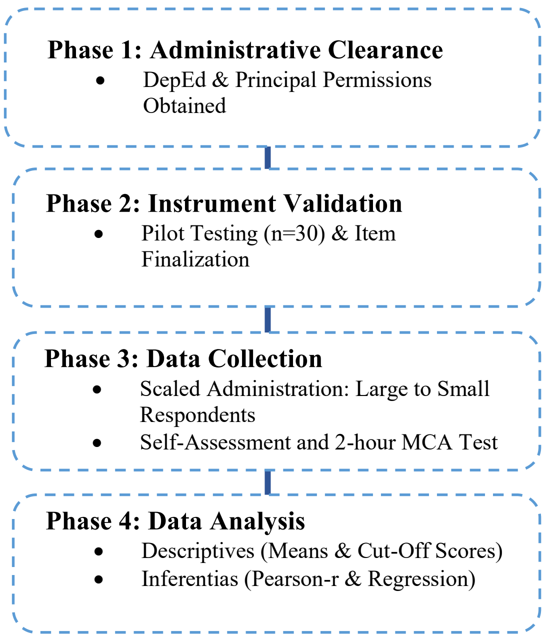


Figure 1. Research Procedure

To conduct this research at the public secondary high schools, the research procedure was administered in four distinct phases. The procedure began with submitting a formal authorization letter to the Department of Education (DepEd) Division Office of Digos City. Following the division approval, permission letters were issued to the school principals of participating institutions. These letters requested institutional clearance and aggregate demographic data of potential respondents and total population of students aged 15 to 16 years old.

To ensure integrity of the research of the research instruments, a validation phase was initiated prior to full-scale deployment. The MCA test was pilot-tested with 30 Grade 9 students from a pilot section at Digos City National High School. The data from this group were used to evaluate test parameters, item validity, aniosd internal reliability, which established the finalized version of the MCA test.

Data collection proceeds across the cleared institutions, beginning with the schools containing the largest population and concluding with the smallest. The administration sequence was strictly controlled in each setting; respondents completed the self-assessment questionnaire first to capture their self-perceptions regarding the 6 Cs followed by the the MCA test requiring a time block of approximately two hours [25], [26].

The final phase involved processing and evaluating the primary data using both descriptive and inferential statistics. The self-assessment data were subjected to Cronbach's alpha internal consistency checks and mean scores were calculated to determine perceived 6 Cs competency levels. For the MCA test, raw scores were converted to percentages and evaluated against established cut-off scores to determine mathematical proficiency. Lastly, correlation coefficients (*r*) and linear regression were conducted to evaluate the strength, direction, and predictive relationships between the 6 Cs and student mathematical literacy.

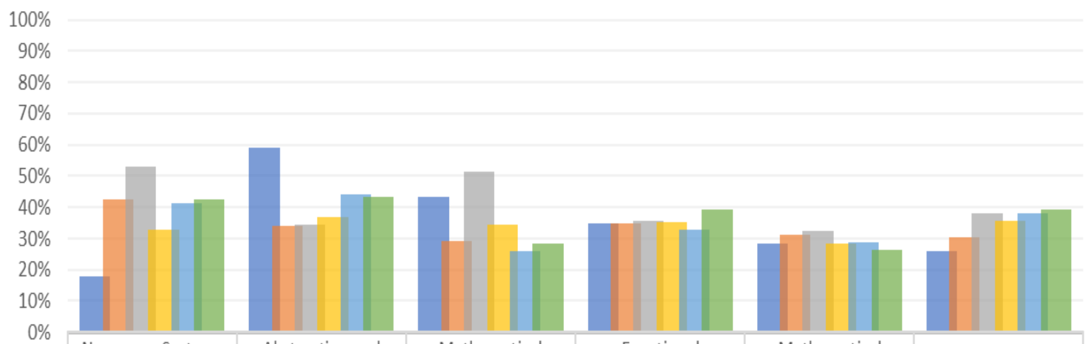
2.4. Data Analysis

The data collection process was executed systematically among the 13 participating secondary private and public high schools, moving from the institutions with the largest respondents to the smallest. During the administration, respondents were first asked to complete a self-assessment questionnaire regarding their skills on 6 Cs. Immediately following the questionnaire, students took the MCA test. The raw data gathered from both the self-assessment questionnaires and the MCA test were then compiled and organized for scoring and verification.

3. RESULTS AND DISCUSSION

3.1. Level of 6 Cs in Minimum Competency Assessment of High School Students in Digos City

Figure 2 presents the level of the 6 Cs across the core competencies of mathematics among high school students in Digos City. Each percentage represents the extent to which students demonstrate a specific competency in the 6 Cs within a particular area of mathematics. Moreover, the following highlights the most and least prominent competencies in various mathematical skill areas, aiding in the identification of strengths and areas for targeted improvement.



	Numeracy Systems and Their Algebraic Properties	Abstraction and Symbolic Representations	Mathematical Structures and their Regularities	Functional Relationship Between Quantities	Mathematical Modelling as a Lens onto the Real World	Variation at the Heart of Statistics
Critical Thinking	17.75%	58.88%	43.34%	34.66%	28.55%	26.04%
Creativity	42.55%	34.17%	29.14%	34.99%	31.07%	30.25%
Collaboration	53.03%	34.50%	51.26%	35.65%	32.40%	37.94%
Communication	32.74%	36.83%	34.25%	35.26%	28.45%	35.83%
Citizenship/Culture	41.46%	44.30%	26.13%	32.84%	28.90%	38.07%
Character	42.49%	43.27%	28.25%	39.31%	26.28%	39.20%

Figure 2. Level of 6 Cs Across the Six Core Competencies of Minimum Competency Assessment

Numeracy Systems and Their Algebraic Properties. Among the 6 Cs integrated, Collaboration (53.03%), Creativity (42.55%), and Character (42.49%) highlights potential in Numeracy Systems and Their Algebraic Properties as students appeared to have moderate performance of this 21st century skills under this competency. Collaboration, in particular, helps address gaps in algebraic understanding and improves performance [31]. Similarly, Leikin and Sriraman [32] noted that integrating creativity into math instruction and exploring different problem-solving strategies also enhances understanding of the subject matter. Strategies like Problem-Based Learning (PBL), for example, have proven effective in fostering creativity. As cited, Hanusa [33] demonstrated its effectiveness through the integration of arts and technology; such as 3D design and app development, which helped students visualize algebraic concepts. This approach significantly improved the students' retention in Algebra and their ability to apply mathematical laws [7]. Furthermore, solving linear equations often cultivates values like hard work and communication because of the steps needed to be taken before arriving at the final answer [34]. However, the notable weakness in Critical Thinking (17.75%) might be due to students' struggle to interpret problems and translating them into mathematical expressions [35]. Collectively, it is important to note that the integration of collaboration, creativity, and character, might be helpful for the students to comprehend and improve their foundational knowledge in Mathematics.

Abstraction and Symbolic Representations. Next, students demonstrated a strong alignment with Critical Thinking (58.88%) in Mathematics, Abstraction and Symbolic Representations. This suggests that students have the capacity to engage in items involving analytical skills and reasoning abilities under this domain. According to studies, students gradually develop their critical thinking skills through visual and formal representation; such as Venn and Euler Diagrams, which they prefer over formal logical rules [36]. Referring to Jean Piaget's philosophy, students develop their logical and abstract thinking around 11 years old and throughout their adulthood [37]. Thus, using forms of representation in class helps students analyze and evaluate ideas critically. Since critical thinking skills are crucial, improving the educational process through learning models in schools is encouraged [38]. Citizenship/Culture (44.30%) and Character (43.27%) was also a skill moderately exhibited by students. This suggests that external and internal motivation might be a factor for students' mathematical proficiency. According to Vygotsky, social relationships and cultural experiences play a crucial role in how children grow and develop mentally, which influences how they think and make sense of the world [39]. In addition, Kohlberg's Theory of Moral Development reflects an individual's growing ability to use abstract concepts and symbolic reasoning to navigate complex moral dilemmas, thereby enhancing character development [40]. On the other hand, with Creativity (34.17%) having the lowest level in this core competency, students might have been depending on rote memorization and procedures. Due to students' varying intelligence, students might be facing difficulties in creating visual representations, even with instructions [41].

Mathematical Structures and Their Regularities. Students also performed well in Collaboration (51.28%) in this particular domain, but reflected lower connections with Citizenship and Culture (26.13%) and Character (28.25%), implying a need for more values-based integration. Collaborative Problem Solving or CPS; coined in PISA 2015, is acknowledged as one of the important 21st Century Skills [42]. It is a process where two or more people solve a problem together to come up with a solution, which shows the connection between mathematical understanding and CPS [43]. However, students lack values integration which implies a need for teachers to integrate values in Mathematics teaching. Currently, enhancing middle school students' cognitive and social interactions has become a key focus in current collaborative learning research [44]. As an attempt to democratize mathematics education, Olawale et al. [45] developed a model which sought to link mathematics teacher education to democracy and social reforms. They noted that mathematics education has traditionally focused on learning math purely for its own sake, which has led to challenges in promoting autonomy in education especially in South Africa. Furtherly, the goal of including mathematics in the school curriculum is to educate all members of society, not just to train future mathematicians, arguing that students and teachers must engage with social differences to connect various mathematical ideas in different cultural perspectives [45]. With these in mind, a study in Korea also revealed the growing challenges of character education in Mathematics. Hence, integrating character education into school curriculum must be considered to provide students with meaningful opportunities and for teachers to develop awareness regarding values-based education in math [46].

Functional Relationship Between Quantities. In this domain, students presented a balanced profile, with modest scores across all skill areas, particularly emphasizing Character (39.31%) and Critical Thinking (34.68%). A study published in Education Sciences examined how high school students translated linear relationships across different representations in math and physics. The findings revealed that students' performance was strongly influenced by their confidence, suggesting that promoting self-efficacy and resilience can improve comprehension in mathematics and overall character growth [47]. On the other hand, Bikić et al., [48] examined the effects of mathematical modeling in teaching linear, quadratic, and logarithmic functions. The study demonstrated an enhancement in critical thinking as well as ethical reasoning when real-life problems are incorporated into mathematics instruction. Lastly, critical thinking skill has been found to reduce misconceptions of functional relationships in Algebra [49]. They stated that students with lower critical thinking skills struggled with algebraic concepts, such as linear equations. In this context, a person is considered a good thinker when they have both critical thinking and virtues [50]. With these, we can infer that character and critical thinking skills are crucial for students to comprehend not just in this competency but other areas of math as well.

Mathematical Modelling as a Lens onto the Real World. On the other hand, Mathematical

Modelling as a Lens onto the Real World reveals weaker performance across all categories, especially in Communication (28.45%) and Character (26.28%), indicating a gap in applying mathematical thinking to real-world contexts. In the study of Bernardo et al. [51], it has also been identified that communication and character are factors of low proficiency in math among Filipino learners. One of which is the students' low motivation to attend class due to external factors like low family income and poor learning environments. Another is the misuse of gadgets and ICT integrated resources as means of learning and communication among public and private high school students [51]. As cited previously in this study, learning models in math provides a better view and effective mathematics teaching. Although the promotion of mathematical modelling is a goal for mathematics teaching worldwide, its integration into students' learning process is still debatable due to lack of empirical evidence in classroom teaching [52]. Moreover, a study shows that students struggle with the application of real-world context to math. Stating that students find it hard to connect to real-world problems as they were different from the usual ones they learned at school [53]. As suggested by Cevikbas et al. [54], further research is needed to understand what specific skills and abilities students need to be good at mathematical modelling while recognizing the value of the practical methods that have already been used successfully in different levels of education.

Variation at the Heart of Statistics. Lastly, Variation at the Heart of Statistics demonstrates an emphasis on Character (39.20%), reflecting the importance of interpreting and discussing data within ethical frameworks. Thus, in promoting statistical literacy, it should be emphasized that ethical data science is the core of Statistics [55]. Also, a study revealed how personal traits influence students' abilities to solve problems, which shows the role of character in mathematical competency [56]. In line with this, students who lack confidence and no interest in mathematics often show the same attitude for statistics [57]. On the other hand, Critical Thinking (26.04%) garnered a low percentage, signifying underlying problems in the application of analytical reasoning. It should be highlighted that aside from ethical skills, statistical literacy also emphasizes the need to have a skill in critical thinking [58]. Adding that the definition of being literate in this field means being able to evaluate information critically. Therefore, in order for students to master critical thinking skills, teaching them should be successful by choosing methods that encourage them to understand and apply such skills [59]. However, assessing these skills; particularly the critical thinking skills, poses a lot of challenges since it involves multitasking and specific knowledge in areas in which it is applied [60], for example in Mathematics.

Overall, while Collaboration and Character development are consistently nurtured in many areas, competencies like Mathematical Modelling require more attention in integrating 6 Cs skills, such as critical thinking, communication, and cultural awareness. This suggests opportunities for curriculum enhancement and more integrative pedagogy.

3.2. Level of Mathematics Proficiency with the Integration of 6 Cs Among High School Students

Table 5 displays the percentage scores of 13 schools in Digos City, representing the level of mathematics proficiency with the integration of 6 Cs across six core mathematical competencies. Each column corresponds to a specific competency, and each row indicates the performance of a school. The interpretations were adapted from the PISA 2022 Mathematics Framework.

Table 5. Level of Mathematics Proficiency with the Integration of 6 Cs

Core Competencies	Percentage Scores	Proficiency Level
School A	35.97%	Level 1a
School B	32.18%	Level 1b
School C	39.16%	Level 1a
School D	33.82%	Level 1b
School E	33.96%	Level 1b
School F	37.66%	Level 1a
School G	35.25%	Level 1b
School H	40.80%	Level 1a
School I	49.84%	Level 3
School J	47.00%	Level 2
School K	32.65%	Level 1b
School L	31.93%	Level 1b
School M	37.97%	Level 1a
Overall	37.52%	Level 1a

The overall proficiency level of schools in Digos City is classified as Level 1a, with an average rate of 37.52%. This suggests that students are capable of solving basic problems using clear and straightforward information, following procedures, and applying simple rules or formulas involving whole numbers. These skills reflect foundational mathematical understanding aligned with the integration of the 6 Cs. However, the proficiency levels among individual schools in Digos City vary significantly.

School I attained Level 3, indicating that students are capable of developing procedural strategies, adapting familiar concepts, and employing computational thinking. They can also manage complex problems, interpret information from various sources, and solve tasks involving percentages, fractions, decimals, and proportions, all while integrating the 6 Cs. Meanwhile, School J achieved Level 2, suggesting that students are able to apply organized strategies and computational thinking to solve multi-step problems. They can interpret diverse data sources and work with percentages, fractions, decimals, and ratios, demonstrating the application of the 6 Cs. While Schools I and J share some overlapping competencies, they differ in terms of problem complexity, skill depth, and the level of integration in their problem-solving approaches. School J represents a transition from basic to intermediate skills, whereas School I reflects a more advanced and integrated application of mathematical literacy and the 6 Cs. On the other hand, Schools A, C, F, H, and M attained Level 1a, which signifies that students possess strong foundational thinking skills. At this level, students are able to solve basic mathematical problems and apply simple formulas effectively. Finally, Schools B, D, G, E, K, and L reached Level 1b. Students at this level are capable of solving simple problems using clear visual aids such as tables or graphs. They can also identify and disregard irrelevant information and follow basic instructions to perform calculations, demonstrating foundational application of the 6 Cs.

Since percentage scoring in this study is adapted from PISA 2022, the obtained results in Digos City can somehow be confirmed by the past national results. According to the results of PISA 2022 Mathematics Assessment, only 16% of Filipino students achieved at least Level 2 proficiency in mathematics, significantly lower than the OECD average of 69%. The general observation among the students who participated in the assessment highlighted the students' ability to recognize and interpret simple mathematical situations independently, without the need for direct instructions [21]. It is important to note that this assessment took place during the COVID-19 pandemic, which posed numerous challenges to the education system [61]. In the present times, where restrictions were lifted, students' mathematical proficiency appeared lower than PISA 2022 national results, showing minimal improvement despite the integration of 6 Cs. The minimal improvement may be due to low motivation, poor vocabulary, difficulty in integration; particularly in critical thinking, and students' understanding of mathematical concepts [10].

Overall, students have exhibited notable strengths in specific areas. Across all schools, Numeracy Systems and Their Algebraic Properties and Abstraction and Symbolic Representations emerged as the strongest core competency, reflecting a foundational understanding of essential mathematical concepts. However, there is a clear need to enhance students' abilities in practical application and real-world problem-solving, particularly through the use of mathematical modelling [62]. Though the integration of the 6 Cs into mathematics instruction shows encouraging signs to improve students' skills [10], particularly reflected in school I and J, the overall average proficiency of 37.52% highlights significant opportunities for growth and development in students' mathematical performance in Digos City.

3.3. Level of 6 Cs in the Self-Assessment of High School Students in Digos City

The data presented in the table reflects the level of 6 Cs present among the high school students of Digos City, with Character (4.001, SD=0.816) obtaining the highest mean score. It has been shown that students perceived themselves having adequate proficiency in values education. Despite slight variations, the results collectively suggest that students generally view themselves as empathetic, compassionate, and respectful. However, the lowest mean was observed in Critical Thinking ($\bar{x}$=3.225, SD=0.726), suggesting that respondents may encounter more challenges in analyzing, evaluating, and synthesizing information. This self-assessment is relatively consistent across areas such as analyzing arguments, reflecting on experiences, and considering multiple viewpoints. Challenges emerge when applying critical thinking to unfamiliar or complex situations.

Table 6. Level of 6 Cs in the Self-Assessment of High School Students in Digos City

Items	Mean	SD
Communication	3.32	0.74
Collaboration	3.92	1.01
Critical Thinking	3.23	0.73
Creativity	3.37	0.78
Culture/Citizenship	3.54	0.77
Character	4.00	0.82

In light of today's dynamic society, it is essential to foster the development of both cognitive and affective domains of a child through education [63]. Study shows how students' personal values affect their performance and learning outcomes [64]. By that, for learning goals to be achieved effectively, every stakeholder must be able to comprehend students' behaviour as well as be a good model for them [65]. As evident in the Philippines, the mission and vision of the Department of Education (DepEd) emphasized learner-centered education by fostering a nurturing and child-friendly learning environment. DepEd's Core Values—*maka-Diyos* (God-fearing), *maka-tao* (compassionate), *maka-kalikasan* (environmentally conscious), and *makabansa* (patriotic), reflect a clear dedication to characteristics and cultural traits [66].

On the other hand, critical thinking skills are also deemed important, especially in these times where distribution of information is very rapid [67]. As the volume of available information continues to grow exponentially, it is essential for students to develop the capacity to critically evaluate and discern relevant data in both their academic pursuits and future professional careers [68]. Relevantly, Mathematics is a way for students to be critical thinkers. In literature, academic success in math class and critical thinking are directly correlated. However, it is not efficiently integrated in the curriculum [50]. To promote this skill, integration should be done in a formal learning environment. Yet for this skill to be achieved, students need motivation to learn [69]. Because if the students are less motivated and uninterested in the subject matter; particularly in Mathematics, learning will not be effective [70]. To align with student's interest, integrating teaching materials with various forms of media not only makes learning more engaging and accessible but also plays a vital role in helping students develop critical thinking skills, which are essential for navigating the complexities of today's world [71].

Overall, students generally see themselves as moderately to highly proficient in the integration of 6 Cs in 21st-century learning. While they feel confident in core abilities like empathy, there are also areas that need improvement. Specifically, students need to develop their skills in applying critical thinking and creativity, deepen their understanding of cultural biases and stereotypes, and achieve more consistency in teamwork.

3.4. Relationship Between 6 Cs and Mathematics Proficiency

Table 7 illustrates the interrelated relationship between self-assessment and MCA, incorporating the 6 Cs. The correlation coefficients shown in the table below indicate the strength and direction of their relationship. Significant correlations, denoted by asterisks, suggest meaningful associations that help identify which competencies are most strongly linked to mathematical proficiency.

Table 7. Correlation Matrix of Self-Assessment and MCA in Mathematics with the Integration of 6 Cs

	MCA on Numeracy Systems and their Algebraic Properties	MCA on Abstraction and Symbolic Representations	MCA on Mathematical Structures and their Regularities	MCA on Functional Relationship Between Quantities	MCA on Mathematical Modelling as a Lens onto the Real World	MCA on Variation at the Heart of Statistics
Self-Assessment on Communication	0.078* 0.041	0.177*** < .001	0.064 0.099	0.104** 0.007	0.101** 0.009	0.133*** < .001
Self-Assessment on Collaboration	0.166*** < .001	0.139*** < .001	0.087* 0.024	0.099* 0.010	0.097* 0.011	0.110** 0.004
Self-Assessment on Critical Thinking	0.109** 0.005	0.151*** < .001	0.083* 0.032	0.130*** < .001	0.060 0.118	0.131*** < .001
Self-Assessment on Creativity	0.106** 0.006	0.169*** < .001	0.106** 0.006	0.180*** < .001	0.077* 0.044	0.120** 0.002
Self-Assessment on Culture/Citizenship	0.134*** < .001	0.217*** < .001	0.104** 0.007	0.192*** < .001	0.079* 0.041	0.169*** < .001
Self-Assessment on Character	0.147*** < .001	0.189*** < .001	0.065 0.090	0.119** 0.002	0.020 0.604	0.128*** < .001

* $p < .05$, ** $p < .01$, *** $p < .001$

Self-Assessment on Communication. As a core 21st-century competency (6 Cs), communication shows a weak yet significant association with their understanding of abstract concepts, symbolic reasoning, and data interpretation. From this perspective, these patterns occur because communication acts as an external scaffolding mechanism; articulating ideas forces students to organize, refine, and externalize covert mental processes as implied in Vygotsky's theory [72]. These empirical findings closely align with international frameworks as well such as the PISA mathematical literacy model which evaluates students' ability to formulate, employ, and interpret mathematics in real-world contexts [73].

As shown in Table 7, communication is negligibly positively correlated to MCA in Numeracy Systems and their Algebraic Properties, $r(674) = .078$, $p < .05$, suggesting that having communication skills may play a part in students' ability to improve their understanding of number systems and algebraic properties. Research conducted by Hidayati et al. [74] suggests that the use of communication in Mathematics may result in better mathematical computations in basic numeracy and in problem-based learning. Another study confirms a positive correlation indicating that interactive learning can improve self-confidence in computational skills, basic numerical ability, and in foundational mathematical concepts [75], [76]. On the other hand, the data showed a weak but positive correlation between communication and the MCA on Abstraction and Symbolic Representation, $r(674) = .177$, $p < .001$, indicating high statistical significance. Table 7 also indicates that communication and MCA on Abstract and Symbolic Skills were weakly positively correlated, $r(674) = .104$, $p < .01$. This suggests that communication skills tend to support students' abstract and symbolic skills. Thus, when students discuss their ideas together, it can possibly enhance their ability to build and comprehend visual and symbolic representations which allows them to maximize the use of representation tools, making it easier to explain abstract concepts [77], [78]. According to Lara et al. [79], communication is also associated with students' ability to explain and justify thoughts in dialogic spaces. However, the data revealed a negligible positive correlation, $r(674) = .064$, $p = .099$, indicating no relationship between students' communication skills and their ability to understand mathematical structures. Similarly, in research about functional thinking, students who have strong engagement in communication such as talking to peers, eventually improve their reasoning and show better conceptual understanding [80], [81]. By that, students who have strong communication skills tend to easily gain insights of the different variables and their relationships, which improves their argumentative skills allowing them to explain various implications and tackle real world mathematical problems through modelling [82], [83]. The self-assessment on communication was also weakly positively correlated with MCA on Mathematical Modelling as a Lens onto the Real World, $r(674) = .101$, $p < .01$, suggesting that communication may enable students to better connect mathematical concepts to real-world situations, leading to a more profound understanding. As shown, communication and MCA on Variation at the Heart of Statistics was weakly positively correlated as well, $r(674) = .133$, $p < .001$, indicating high statistical significance. It suggests that effective communication skills may actually enhance statistical skills especially in interpreting data and results. Through practice workshops, written communication can foster these statistical skills. Engaging students in communication techniques involving statistics allows scaffolding to improve it [84], [85]. This, in turn, improves student's communication skills in explaining data interpretation and variations [86]. All in all, communication help students develop deeper understanding, problem-solving skills, engagement, and supports peer learning [87].

Self-Assessment on Collaboration. As shown in the table above, collaboration showed statistically significant ($p < .05$) but generally weak to negligible positive relationships across all areas of the Minimum Competency Assessment (MCA). Overall, this pattern suggests that students' self-assessed collaborative skills are only weakly connected to their grasp of core mathematical concepts, with the most noticeable but modest association appearing in basic numeracy, abstract thinking, and statistical variation.

Specifically, collaboration had a weak positive correlation with MCA scores in Numeracy Systems and their Algebraic Properties, $r(674) = .166$, $p < .001$. This indicates that students who rate their collaborative skills higher also tend to participate more actively in class; especially when asking for clarification, which relates to a better understanding of basic numbers and algebra. Similarly, self-assessed collaboration showed a weak positive correlation with Abstraction and Symbolic Representation, $r(674) = .139$, $p < .001$. This suggests that when students work together to solve problems and discuss ideas, their performance reflects stronger reasoning with abstract ideas and mathematical symbols. Supporting these findings, research shows that collaborative learning works better than traditional lecture methods [88]. From a theoretical perspective, this aligns with Vygotsky's Social Constructivism and the Zone of Proximal Development, where working with peers and an adult; particularly the teacher, acts as a support system that reduces mental strain during complex tasks [89]. Consequently, these interactions help students manage group dynamics better, boosting both individual performance and overall problem-solving abilities [90], [91]. These peer interactions fit neatly into the PISA Collaborative Problem Solving (CPS) framework, which focuses on how students build shared understanding and create solutions together. Moreover, when students ask each other questions, it forces them to speak their thoughts aloud and refine how they understand concepts. In turn, this improves their ability to calculate, read dynamic graphs, build logical arguments, think abstractly about linear equations, and reason mathematically [92]-[94].

On the other hand, collaboration had negligible positive correlations with Mathematical Structures and Their Regularities, $r(674) = .087$, $p < .05$, Functional Relationship Between Quantities, $r(674) = .099$, $p < .05$, and Mathematical Modelling as Lens onto the Real World, $r(674) = .097$, $p < .05$. While, Variation at the Heart of Statistics showed a weak positive correlation with collaboration, $r(674) = .110$, $p < .01$, implying that working collaboratively helps students make meaningful group decisions and interpret data more effectively. These findings suggest that collaboration may contribute to students' mathematical learning by providing opportunities to engage in shared problem-solving, reasoning, and decision-making. In this regard, studies have shown that collaborative skills, such as teamwork, enhance logical intelligence in problem-solving [95] and stimulate critical thinking in analyzing problems [96]. This relationship is further supported by the finding that contemporary skills such as collaboration improve cognitive ability in logical analysis [97]. The value of collaborative learning can also be observed in students' engagement with mathematical concepts and relationships. Peer inquiry-based learning eventually enhances students' management skills in solving sets and domains [98], while students' mathematical interactions enhance their ability to conceptualize mathematical relationships [99]. Moreover, the collaborative learning approach is far more effective than conventional approaches in enhancing students' critical thinking skills in identifying mathematical relationships [100]. These findings indicate that collaboration provides students with opportunities to exchange ideas, examine different approaches, and construct understanding through interaction with others. Such processes are particularly relevant when students are required to address complex mathematical tasks [101], particularly in mathematical modelling tasks [102] and in geometrical problem solving [103]. The role of collaboration is likewise evident in tasks that require students to make decisions and interpret information. Studies have shown that when students work collaboratively, they tend to develop more effective decision-making skills in addressing statistical problems [104] and provide a reliable basis for data interpretation [105]. Thus, enhancing students' attitude towards statistics, especially in using technology to learn statistics [106]. Taken together, these studies provide support for the observed relationships between collaboration and the different areas of mathematical learning, particularly in problem-solving, mathematical relationships, modelling, decision-making, and statistical interpretation.

Self-Assessment on Critical Thinking. The overall results of self-assessment on critical thinking reveals a weak positive correlation across most MCA areas, particularly in abstraction, functional relationships, and statistics. However, studies have shown that critical thinking skills such as focus, adaptive reasoning, and strategic competency are beneficial in mathematics [35], [107]. Specifically, critical thinking was weakly positively correlated with MCA on Numeracy Systems and their Algebraic Properties, $r(674) = .109$, $p < .01$, indicating that critical thinking skills may serve as the foundational driver for mathematical problem-solving, enabling students to navigate complex algebraic structures, identify errors, and execute logical solutions [108]. Reinforcing this finding, a study by Ovan et al. [109] offers concrete evidence as to how critical thinking skills in algebraic problem solving are significantly enhanced through Problem-Based Learning (PBL) compared to conventional instruction among middle school students. Furthermore, critical thinking and MCA on abstraction and symbolic representations were also weakly positively correlated, $r(674) = .151$, $p < .001$, suggesting that developing critical thinking enables students to analyze complex information, justify interpretations, and deconstruct topics into simpler contexts [110]. On the other hand, critical thinking demonstrated a negligible positive correlation with MCA on Mathematical Structures and their Regularities, $r(674) = .083$, $p < .05$. Nevertheless, it suggests that when students actively plan, monitor, and adapt their thinking strategies, they gain deeper insight into numerical patterns, algorithmic structures, and complex topics like polynomial equations and algebraic derivative functions [111] – [113]. In addition, critical thinking and MCA on Functional Relationship Between Quantities were also weakly positively correlated, $r(674) = .130$, $p < .001$, indicating that critical thinking approaches enhance student proficiency with functional relationships. Similarly, critical thinking and MCA on Variation at the Heart of Statistics showed a weak positive correlation, $r(674) = .131$, $p < .001$, supporting prior research indicating that critical thinking improves mathematical visualization and data interpretation essential for statistical analysis, hypothesis testing, and relational reading [114].

In contrast, critical thinking and MCA on Mathematical Modelling as a Lens onto the Real World showed no statistically significant relationship, $r(674) = .060$, $p = .118$, suggesting a potential disconnection between critical thinking skills and real-world mathematical modeling problems.

To conclude, students' critical thinking skills are weakly aligned with their ability to comprehend abstract concepts through symbolic reasoning, functional relationships (e.g., domain and range), and data interpretation. Consequently, cognitive and problem-based learning approaches—rather than conventional instruction alone—better support students through the mathematical problem-solving process [115], [116].

Self-Assessment on Creativity. Creativity demonstrated a weak positive correlation with Minimum Competency Assessment (MCA) scores across five of the six mathematical domains. Specifically, creativity was weakly positively correlated with MCA on Numeracy Systems and their Algebraic Properties, $r(674) = .106$, $p < .01$, suggesting that creative thinking enhances overall performance in foundational numeracy and algebra. Supporting this finding, research indicates that creative thinking improves fluency and flexibility when working with algebraic expressions, such as linear equations [117], thereby helping students formulate original problems using mathematical symbols [118].

Similarly, creativity showed a weak positive correlation with MCA on Abstraction and Symbolic Representations, $r(674) = .169$, $p < .001$, indicating that creative skills assist students in mastering abstract concepts and symbolic notation. As cited, students who have multiple representations and visualizations enhance their ability to interpret abstract ideas efficiently [119]. A weak positive correlation was likewise observed with MCA on Mathematical Structures and their Regularities, $r(674) = .106$, $p < .01$. Furthermore, creativity was weakly positively correlated with MCA on Functional Relationships Between Quantities, $r(674) = .180$, $p < .001$, as well as MCA on Variation at the Heart of Statistics, $r(674) = .120$, $p < .01$, implying that creative skills enhance student proficiency in both functional analysis and statistical data interpretation. Engaging in creative activities fosters logical reasoning and open-ended problem solving, equipping learners to decipher spatial patterns and higher-order quantitative structures [120] – [122]. For this reason, spatial visualization develops students' ability to analyze functions [123], as well as learning relationships of structures [124]. Studies have also found that a mathematical creative self-efficacy strategy may be a factor in helping students with data analysis [125] and that creativity may help in probing various possibilities of hypotheses and interpreting data from different perspectives [126]. Furthermore, learning statistics and applying them with creative skills enhances the ability to generate plausible decisions [127].

The sole exception to this trend was MCA on Mathematical Modelling as a Lens onto the Real World, which exhibited only a negligible positive correlation with creativity, $r(674) = .077$, $p < .05$. Despite this weak association, prior research emphasizes that spatial and creative visualization skills allow students to link data, graphs, and physical objects [119], fostering analytical abilities that bridge abstract mathematical concepts and real-world applications [128]. Most importantly, creativity plays an important role in mathematical learning by encouraging students to generate and explore different approaches to mathematical problems [129].

While students' creative skills are weakly aligned with their performance in these competency areas, cultivating creative self-efficacy and flexible learning methods remains vital for empowering students to analyze symbolic representations and statistical data to make sound, well-reasoned decisions [127], [129].

Self-Assessment on Culture/Citizenship. Self-assessment on culture and citizenship demonstrated a weak positive correlation with Minimum Competency Assessment (MCA) scores across five of the six mathematical domains, yielding the overall strongest positive correlations among all evaluated non-cognitive competencies. Specifically, culture and citizenship were weakly positively correlated with MCA on Numeracy Systems and their Algebraic Properties, $r(674) = .134$, $p < .001$, implying that a sense of cultural value and civic engagement helps develop student performance in real-life numeracy and algebraic application. These findings implies that culturally responsive mathematics teaching and ethnomathematics make abstract algebraic ideas more meaningful by connecting them to students lived experiences [130] – [132], with local learning approaches successfully applied to topics such as systems of linear equations and optimization [133], [134]. Similarly, culture and citizenship showed a weak positive correlation with MCA on Abstraction and Symbolic Representations, $r(674) = .217$, $p < .001$, indicating that culture-based learning makes abstract concepts and ideas more relatable and understandable. A weak positive correlation was likewise observed with MCA on Mathematical Structures and their Regularities, $r(674) = .104$, $p < .01$, suggesting that a cultural approach allows students to better appreciate mathematical patterns and structures. Culturally relevant pedagogy has been shown to develop logical thinking and prepare learners for such complex mathematical ideas and group theory [135], [136]. Furthermore, culture and citizenship were weakly positively correlated with MCA on Functional Relationships Between Quantities, $r(674) = .192$, $p < .001$, as well as MCA on Variation at the Heart of Statistics, $r(674) = .169$, $p < .001$. These results indicate that incorporating realistic, culture-based education enhances student understanding of functions and statistical analysis; demonstrating that multicultural environments promote statistical literacy, data interpretation, and relational reasoning [137] – [139].

MCA on Mathematical Modelling as a Lens onto the Real World, exhibited a negligible positive correlation with culture and citizenship, $r(674) = .079$, $p < .05$. Despite this weaker statistical relationship, literature emphasizes that drawing from local experiences transforms students from passive recipients of knowledge into active problem-solvers [140], [141]. Students are consistently more likely to understand mathematical models when they can relate them directly to their own culture and real-life context [142] – [144].

In summary, self-assessment of culture and citizenship reveals a weak positive correlation across all six MCA domains, reflecting its integral alignment with mathematical proficiency. These empirical findings closely align with the framework of PISA, which views mathematical literacy not merely as knowing formulas, but as the ability to reason, interpret, and apply mathematics in real-world contexts. Ultimately, rather than treating culture as separate from mathematics learning, incorporating students' cultural values and local knowledge serves as a vital foundation for developing comprehensive problem-solving, critical thinking, and mathematical application skills [145] – [147].

Self-Assessment on Character. Self-assessment on character demonstrated a weak positive correlation with Minimum Competency Assessment (MCA) scores across four of the six mathematical domains, while showing no statistically significant relationship with the remaining two. Specifically, character was weakly positively correlated with MCA on Numeracy Systems and their Algebraic Properties, $r(674) = .147$, $p < .001$, indicating that character development may foster foundational skills in basic numeracy and algebra. Research states that character development may not only improve the overall student engagement but also their mathematical scores [148]. Research also demonstrates that certain character traits and positive attitudes strengthen student engagement in numeracy [149], such as effort [150], perseverance and curiosity [151], while motivation and focus support computational skills and algebraic achievement [145], [152]. Similarly, self-assessment on character and MCA on Abstraction and Symbolic Representations were weakly positively correlated, $r(674) = .189$, $p < .001$, indicating that abstract and logical reasoning are enhanced through character growth. According to literature, character education is associated with a deeper understanding of foundational concepts [153] and greater perseverance [154]. Furthermore, character was weakly positively correlated with MCA on Functional Relationships Between Quantities, $r(674) = .119$, $p < .001$, as well as MCA on Variation at the Heart of Statistics, $r(674) = .128$, $p < .001$. These results suggest that character integration helps cultivate problem-solving abilities [155] and logical-mathematical thinking [156] essential for analyzing functional relationships and statistical data. Character education has been shown to develop students' kinesthetic, auditory, and visual learning styles, which is beneficial in fostering statistical proficiency [157]. Integrating character values education has also been shown to improve students' mathematical proficiency [158], suggesting that embedding character development in the curriculum can enhance students' overall mathematical performance and engagement [159]. On the contrary, without character education, mathematics anxiety arises alongside students' impaired ability to engage in deliberate mathematical reasoning [160]. By this, students with low mathematical intelligence do not use clear problem-solving strategies [161].

Character showed no statistically significant relationship with MCA on Mathematical Structures and their Regularities, $r(674) = .065$, $p = .090$, nor with MCA on Mathematical Modelling as a Lens onto the Real World, $r(674) = .020$, $p = .604$. These findings indicate that self-assessed character traits do not directly correlate with performance in structural pattern recognition or real-world mathematical modeling. Nevertheless, prior literature suggests that even when direct correlations are absent, character-building approaches can indirectly support mathematical learning by encouraging a critical mindset toward structural relationships and real-world problem-solving [162]. Through character improvement, students' interest is enhanced as they learn through various mathematical concepts [163].

In conclusion, based on the correlation matrix of self-assessment traits and MCA domains, the data show that most of all self-assessed 6 Cs competencies are positively correlated with the MCA mathematics competencies, though the relationships are generally weak. Despite these, the consistent significance highlights the potential role of 6 Cs in improving students' mathematical understanding. This finding underscores the importance of holistic education approaches in fostering students' comprehensive mathematical understanding and performance.

3.5. Predictors of Students' Mathematics Proficiency

Based on Table 8, self-assessment in culture and citizenship has a considerable positive effect on students' mathematics performance, $\beta = 0.19$, $p < .01$, indicating a statistically significant result. On the contrary, self-assessment in collaboration has a smaller impact ($\beta = 0.08$), although it is not significant, given that it is close to the cut-off ($p = 0.056$). Thus, the entire model explains approximately 5.8% of the variance in overall mathematics performance ($R^2 = 0.058$), with the significant annual testing indicating that the model as a whole is a good fit.

Table 8. Regression Analysis for Variables Predicting Mathematical Proficiency

Variables	B	SE B	Β	P
(Constant)	23.50	2.03	-	< 0.01
Self-Assessment on Collaboration	0.04	0.02	0.08	0.056
Self-Assessment on Culture/ Citizenship	0.27	0.06	0.19*	< 0.01
R^2		.058		
F		20.71*		

**p<0.05 **p<0.01*

From the coefficients, the following regression equation can be formulated:

6 C's = 23.50 +(0.27 x Self-assessment on Culture/Citizenship)

The equation above states that for every one-unit increase in the student's self-assessment of culture/citizenship, their overall score on the 6 C's increases by approximately 0.27 points, starting from a value of 23.50. Overall, mathematics proficiency can be developed through the approach of culturally responsive pedagogy, as highlighted from the studies above, indicating that they are the best predictors of a student's personal mathematics improvement. Studies have shown that integrating a culturally based approach into the mathematics curriculum effectively enhances students' mathematical proficiency. In 21st-century learning, civic education has proven effective across multiple disciplines, including mathematics, where it improves students' practical application of conceptual understanding [164]. Similarly, students benefit from teachers who demonstrate cultural competence, which fosters critical consciousness and supports overall mathematical learning [165]. Furthermore, integrating culturally responsive pedagogies into classroom instruction and embedding indigenous perspectives within teacher training yields consistently positive feedback [166].

The findings of this study offer important practical insights for educators, curriculum developers, and academic policymakers seeking to enhance mathematical literacy through holistic instruction. By demonstrating consistent positive relationships between students' non-cognitive competencies and their Minimum Competency

Assessment (MCA) performance, this research reinforces the value of 6 Cs into the mathematics classroom. Rather than treating non-cognitive skills as peripheral to academic learning, educators can utilize 6 Cs across diverse topics such as algebra, functions, and statistical reasoning. Furthermore, because these non-cognitive traits align closely with the real-world application goals of the PISA framework, embedding them into teacher preparation programs and instructional designs equips learners with the persistence, critical consciousness, and flexibility needed to navigate complex mathematical problems beyond the classroom.

Despite these meaningful contributions, several methodological and statistical limitations should be considered when interpreting the findings. First, although the correlation and regression analyses revealed statistically significant relationships across several domains, the overall effect sizes remained predominantly weak. Specifically, the regression model accounted for only 5.8% of the variance in mathematical proficiency, leaving over 94% of the variance unexplained and likely influenced by unmeasured factors such as prior academic achievement, instructional quality, socioeconomic status, or mathematics anxiety. Second, while self-assessed culture and citizenship emerged as a significant predictor, other non-cognitive traits including collaboration, failed to achieve independent statistical significance in the multivariate model. Third, although the sample size ($N = 676$) provided robust statistical power for regression testing, the data were gathered within specific regional and institutional contexts, which may limit the direct generalizability of the results to broader student populations. Finally, because the study utilized a cross-sectional design, the observed predictive relationships cannot establish direct causality. Long-term longitudinal research is needed to determine whether cultivating these non-cognitive competencies; especially Culture/Citizenship, leads to sustained improvements in mathematical performance over time.

4. CONCLUSION

Researchers observe the lack of integration of region-specific skills in the mathematical educational sector referred to as the self-assessed traits. Thus, this study looked for possible relationships between these traits exhibited by the students of Digos City, Davao del Sur, and their performance in core areas of mathematical competencies toward improving their general mathematical proficiency. This study highlights the dynamic between students' self-assessed non-cognitive competencies and their demonstrated mathematical performance. While learners generally report moderate to high proficiency across the 6 Cs; with Character and Collaboration scoring highest, Critical Thinking yielded the lowest mean score, pointing to a key target for development alongside communication and cultural awareness. Academically, students displayed solid foundational capabilities in Numeracy Systems and Abstraction and Symbolic Representations. However, an overall average mathematical proficiency score of 37.52% reveals a substantial deficit in real-world problem-solving and mathematical modeling. Correlational analysis indicated that Abstraction and Symbolic Representations held the strongest relationship with Critical thinking and Communication while self-assessed Culture/Citizenship demonstrated the most consistent positive association across all competency domains. Crucially, multiple regression identified Culture/Citizenship as the sole statistically significant predictor of mathematical proficiency, underscoring the academic value of culturally grounded instruction.

Based on the findings, several recommendations are proposed to enhance high school students' mathematical proficiency in Digos City. Students should be engaged in real-world mathematical problems through problem-based learning, discovery learning, collaborative discussions, and mathematical modelling to strengthen critical thinking, communication, metacognition, and complex problem-solving while addressing individual learning needs. Teachers should receive training in culturally responsive pedagogy and the integration of the 6Cs into mathematics instruction, classroom activities, and assessment practices. School divisions should develop community-relevant tasks, embed the 6Cs and culturally responsive practices into the curriculum, and strengthen the connection between foundational competencies and higher-order problem-solving. Educational institutions should emphasize cultural and citizenship education in mathematics and utilize students' self-assessment data to guide personalized instruction and targeted interventions. Future researchers are encouraged to examine the influence of cultural and citizenship backgrounds on mathematical proficiency and explore innovative learning strategies aligned with 21st-century learning needs.

ACKNOWLEDGEMENTS

The researchers sincerely thank God Almighty for His guidance and blessings throughout this research. The researchers also express their gratitude to their adviser, panelists, validators, statistician, participating schools, and the Department of Science and Technology–Science Education Institute (DOST-SEI) for their valuable support and assistance. Finally, the researchers deeply appreciate their families for their unconditional love, encouragement, and support in completing this study.

REFERENCES

[1] S. Sujatha and K. Vinayakan, "Curriculum and instructional trends," *International Journal of Applied and Advanced Scientific Research (IJAASR)*, vol. 655, no. 2, pp. 65–71, 2022.
[2] L. M. Rizki and N. Priatna, "Mathematical literacy as the 21st century skill," *Journal of Physics: Conference Series*, vol. 1157, no. 4, Art. no. 042088, Feb. 2019, doi: 10.1088/1742-6596/1157/4/042088.
[3] D. Opfer, C. Bell, E. Klieme, D. McCaffrey, J. Schweig, and B. Stecher, "Understanding and measuring mathematics teaching practice," *OECD eBooks*, Nov. 2020, doi: 10.1787/98e0105a-en.
[4] Z. Özaydin and Ç. Arslan, "Assessment of mathematical reasoning competence in accordance with PISA 2021 mathematics framework," *Kuramsal Eğitimbilim*, vol. 15, no. 3, pp. 453–474, Jul. 2022, doi: 10.30831/akukeg.1027601.
[5] C. Chi, "Philippines still lags behind world in math, reading and science — PISA 2022," *Philstar.com*, Dec. 6, 2023.
[6] M. Cris, "Enhancing mathematical proficiency assessment: Insights from mathematics teachers," *Science International*, vol. 35, pp. 773–780, Nov.–Dec. 2023.
[7] Organisation for Economic Co-operation and Development, "PISA 2022: Mathematics framework," 2022.
[8] E. Care, H. Kim, A. Vista, and K. Anderson, *Education System Alignment for 21st Century Skills: Focus on Assessment*. Washington, DC, USA: Center for Universal Education at The Brookings Institution, 2018.
[9] R. Sugianto, M. Syaifuddin, and Y. Cholily, "Development of E-LKPD oriented minimum competency assessment (MCA) on 6C's ability of high school students," *Al-Jabar: Jurnal Pendidikan Matematika*, vol. 13, pp. 433–453, Dec. 2022, doi: 10.24042/ajpm.v13i2.15559.
[10] S. Inganah, R. Darmayanti, and N. Rizki, "Problems, solutions, and expectations: 6C integration of 21st century education into learning mathematics," *JEMS: Jurnal Edukasi Matematika dan Sains*, vol. 11, no. 1, pp. 220–238, Mar. 2023, doi: 10.25273/jems.v11i1.14646.
[11] M. Buechner, "UNICEF urges action to transform education, end learning poverty," *UNICEF USA*, Sep. 2022.
[12] Department of Education, "General shaping paper 2023," *Official Gazette of the Philippines*.
[13] R. Barrios, M. Theresa, E. Low, R. Kaye, and S. Bihasa, "The critical thinking skills in mathematics of the first year college students: SPIDA cognitive theory," *International Journal of Advanced Multidisciplinary Studies*, vol. II, no. 8, 2022.
[14] National Economic and Development Authority, "AmBisyon Natin 2040," 2015.
[15] D. Sarian, "Dewey and progressivism," *Front Range Christian School*, Feb. 2020.
[16] M. Williams, "John Dewey in the 21st century," *Journal of Inquiry & Action in Education*, vol. 9, no. 1, pp. 91–102, 2017.
[17] J. Mezirow, "Perspective transformation," *Studies in Adult Education*, vol. 9, no. 2, pp. 153–164, Oct. 1977, doi: 10.1080/02660830.1977.11730750.
[18] Western Governors University, "What is the transformative learning theory," Jul. 2020.
[19] H. Almarashdi and A. Jarrah, "Assessing tenth-grade students' mathematical literacy skills in solving PISA problems," *Social Sciences*, vol. 12, Art. no. 33, Jan. 2023, doi: 10.3390/socsci12010033.
[20] W. Widjaja, "Towards mathematical literacy in the 21st century: Perspectives from Indonesia," *Southeast Asian Mathematics Education Journal*, vol. 1, no. 1, pp. 75–84, Nov. 2011, doi: 10.46517/seamej.v1i1.12.
[21] Organisation for Economic Co-operation and Development, "PISA 2022 results (Volume I and II) – Country notes: Philippines," Dec. 2023.
[22] United Nations, "Goal 4: Ensure inclusive and equitable quality education and promote lifelong learning opportunities for all," 2025.
[23] Organisation for Economic Co-operation and Development, "The PISA target population, the PISA samples, and the definition of schools: PISA 2022 results (Volume I)," OECD.
[24] R. S. Robinson, "Purposive sampling," *Springer eBooks*, vol. 1, no. 1, pp. 5645–5647, Jan. 2024, doi: 10.1007/978-3-031-17299-1_2337.
[25] D. Fadhilawati, E. N. Malahayati, and Suyitno, "Transforming 21st century education through integration of 6Cs and digital technologies in classroom learning: A case study in higher education," *Novateur Publications*, pp. 114–135, Jun. 2023.
[26] M. Syaifuddin, "Minimum competency assessment to measure mathematical literacy of junior high school students," *Journal of Education Research and Evaluation*, vol. 6, no. 2, pp. 316–326, Jun. 2022, doi: 10.23887/jere.v6i2.46263.
[27] R. Novika, E. Istiyono, and A. A. Notiavina, "Developing an assessment instrument to measure the minimum competency of high school physics using item response theory," *Jurnal Penelitian dan Evaluasi Pendidikan*, vol. 29, no. 1, pp. 98–113, Apr. 2025, doi: 10.21831/pep.v29i1.70700.
[28] P. Slater and F. Hasson, "Quantitative research designs, hierarchy of evidence and validity," *Journal of Psychiatric and Mental Health Nursing*, vol. 32, no. 3, pp. 656–660, Dec. 2024, doi: 10.1111/jpm.13135.
[29] A. van Witteloostuijn, J. Vanderstraeten, H. Slabbinck, M. Dejardin, J. Hermans, and W. Coreynen, "From explanation of the past to prediction of the future: A comparative and predictive research design in the social sciences," *Social Sciences & Humanities Open*, vol. 6, no. 1, Art. no. 100269, 2022, doi: 10.1016/j.ssaho.2022.100269.
[30] J. Heo, H. Lim, S.-C. Yun, S. Ju, S. Y. Park, and R. Lee, "Descriptive and predictive modeling of student achievement, satisfaction, and mental health for data-driven smart connected campus life service," *Learning Analytics and Knowledge*, Mar. 2019, doi: 10.1145/3303772.3303792.
[31] A. J. S. Cajandig and Z. C. Ledesma, "The synergy between 21st-century skills and mathematical proficiency," *International Journal of Research and Innovation in Social Science*, vol. IX, no. IV, pp. 1470–1475, May 2025, doi: 10.47772/IJRISS.2025.90400108.

[32] R. Leikin and B. Sriraman, "Empirical research on creativity in mathematics (education): From the wastelands of psychology to the current state of the art," *ZDM – Mathematics Education*, Mar. 2022, doi: 10.1007/s11858-022-01340-y.
[33] C. R. H. Hanusa, "Encouraging student creativity in mathematics through 3D design and 3D printing," *arXiv.org*.
[34] N. Aisyah, M. Sumayeka, U. Chotimah, and I. Marion, "Secondary school students' character values in mathematics," *3rd Sriwijaya University International Conference on Learning and Education*, pp. 188–193, Jan. 2018, doi: 10.5220/0009994800002499.
[35] A. Lubis and D. Permatasari, "Level of critical thinking ability in solving numeration problems in the minimum competency assessment," *Desimal Jurnal Matematika*, vol. 6, no. 1, pp. 63–72, Apr. 2023, doi: 10.24042/djm.v6i1.14611.
[36] H. Bronkhorst, G. Roorda, C. Suhre, and M. Goedhart, "Student development in logical reasoning: Results of an intervention guiding students through different modes of visual and formal representation," *Canadian Journal of Science, Mathematics and Technology Education*, vol. 21, no. 2, pp. 378–399, Apr. 2021, doi: 10.1007/s42330-021-00148-4.
[37] M. Cerovac and T. Keane, "Early insights into Piaget's cognitive development model through the lens of the technologies curriculum," *International Journal of Technology and Design Education*, vol. 35, no. 1, pp. 61–81, Jun. 2024, doi: 10.1007/s10798-024-09906-5.
[38] Z. Zulfikar, Z. Azis, and M. D. Nasution, "Students' critical thinking ability through the application of the creative problem solving (CPS) model assisted by Autograph," *JMEA: Journal of Mathematics Education and Application*, vol. 1, no. 3, pp. 142–147, 2022, doi: 10.30596/jmea.v1i3.12099.
[39] B.-C. Chen, "Using Vygotsky's sociocultural theory to explore ethnic cultural representation in Taiwanese preschool children's play," *Frontiers in Education*, vol. 10, Apr. 2025, doi: 10.3389/feduc.2025.1569322.
[40] K. Cherry, "Kohlberg's theory of moral development," 2025.
[41] Z. E. Ünal, M. Aslı, G. Kartal, S. Özel, and D. C. Geary, "Visual and symbolic representations as components of algebraic reasoning," *Journal of Numerical Cognition*, vol. 9, no. 2, pp. 327–345, Jul. 2023, doi: 10.5964/jnc.11151.
[42] Organisation for Economic Co-operation and Development, "PISA 2015 collaborative problem solving," 2015.
[43] S.-M. E. Harding, P. E. Griffin, N. Awwal, B. M. Alom, and C. Scoular, "Measuring collaborative problem-solving using mathematics-based tasks," *AERA Open*, vol. 3, no. 3, Art. no. 2332858417728046, Jul. 2017, doi: 10.1177/2332858417728046.
[44] Y. Cao, "Research on collaborative problem-solving teaching in a secondary school mathematics classroom," *Perspectives on Rethinking and Reforming Education*, pp. 1–18, Jan. 2024, doi: 10.1007/978-981-99-7386-6_1.
[45] B. E. Olawale, V. Mncube, and C. R. Harber, "Democratic citizenship education: Towards a model for establishing democratic mathematics teacher education," *South African Journal of Higher Education*, vol. 36, no. 3, pp. 177–193, 2022, doi: 10.20853/36-3-4681.
[46] D.-J. Kim, S.-C. Bae, S.-H. Choi, H.-J. Kim, and W. Lim, "Creative character education in mathematics for prospective teachers," *Sustainability*, vol. 11, no. 6, Art. no. 1730, Mar. 2019, doi: 10.3390/su11061730.
[47] I. Testa and D. Catena, "High school students' performances in transitions between different representations of linear relationships in mathematics and physics," *Education Sciences*, vol. 12, no. 11, Art. no. 776, Nov. 2022, doi: 10.3390/educsci12110776.
[48] N. Bikić, D. Burgić, and V. Kurtić, "The effects of mathematical modelling in mathematics teaching of linear, quadratic and logarithmic functions," *European Journal of Mathematics and Science Education*, vol. 2, no. 2, pp. 129–144, Dec. 2021, doi: 10.12973/ejmse.2.2.129.
[49] S. Kanwal, W. Mahmood, M. Akram, and N. Pervez, "Effect of critical thinking skills on misconceptions of students in learning mathematics at the elementary school level," *The Critical Review of Social Sciences Studies*, vol. 2, no. 2, pp. 818–839, Nov. 2024, doi: 10.59075/dh559c79.
[50] B. Arisoy and B. Aybek, "The effects of subject-based critical thinking education in mathematics on students' critical thinking skills and virtues," *Eurasian Journal of Educational Research*, vol. 21, no. 92, Mar. 2021, doi: 10.14689/ejer.2021.92.6.
[51] A. B. I. Bernardo, M. O. Cordel, M. R. C. Lapinid, J. M. M. Teves, S. A. Yap, and U. C. Chua, "Contrasting profiles of low-performing mathematics students in public and private schools in the Philippines: Insights from machine learning," *Journal of Intelligence*, vol. 10, no. 3, Art. no. 61, Sep. 2022, doi: 10.3390/jintelligence10030061.
[52] G. Kaiser, "Mathematical modelling and applications in education," *Encyclopedia of Mathematics Education*, pp. 553–561, 2020, doi: 10.1007/978-3-030-15789-0_101.
[53] U. T. Jankvist and M. Niss, "Upper secondary school students' difficulties with mathematical modelling," *International Journal of Mathematical Education in Science and Technology*, pp. 1–30, Mar. 2019, doi: 10.1080/0020739X.2019.1587530.
[54] M. Cevikbas, G. Kaiser, and S. Schukajlow, "A systematic literature review of the current discussion on mathematical modelling competencies: State-of-the-art developments in conceptualizing, measuring, and fostering," *Educational Studies in Mathematics*, vol. 109, no. 2, pp. 205–236, Oct. 2021, doi: 10.1007/s10649-021-10104-6.
[55] J. Utts, "Enhancing data science ethics through statistical education and practice," *International Statistical Review*, vol. 89, no. 1, pp. 1–17, Mar. 2021, doi: 10.1111/insr.12446.
[56] J. Sitorus, B. Sinaga, L. Handayani, and D. J. M. Siagian, "Influence of students' learning style and personality characteristics on their mathematics problem-solving skills," *Frontiers in Education*, vol. 10, 2025, doi: 10.3389/feduc.2025.1540865.
[57] L. Opstad, "Attitudes towards statistics among business students: Do gender, mathematical skills and personal traits matter?" *Sustainability*, vol. 12, no. 15, Art. no. 6104, Jul. 2020, doi: 10.3390/su12156104.

[58] S. Koga, "Characteristics of statistical literacy skills from the perspective of critical thinking," *Teaching Statistics*, vol. 44, no. 2, Mar. 2022, doi: 10.1111/test.12302.
[59] N. Alsaleh, "Teaching critical thinking skills: Literature review," *The Turkish Online Journal of Educational Technology*, vol. 19, no. 1, Jan. 2020.
[60] B. T. Miller, "Creativity, critical thinking, communication, and collaboration: Assessment, certification, and promotion of 21st century skills for the future of work and education," *Journal of Intelligence*, vol. 11, no. 3, Art. no. 54, Mar. 2023, doi: 10.3390/jintelligence11030054.
[61] S. Meinck, J. Fraillon, and R. Strietholt, *The Impact of the COVID-19 Pandemic on Education: International Evidence from the Responses to Educational Disruption Survey (REDS)*. Amsterdam, The Netherlands: International Association for the Evaluation of Educational Achievement, 2022.
[62] A. Tasarib, R. Rosli, and A. S. Rambely, "Impacts and challenges of mathematical modelling activities on students' learning development: A systematic literature review," *Eurasia Journal of Mathematics, Science and Technology Education*, vol. 21, no. 5, Art. no. em2641, May 2025, doi: 10.29333/ejmste/16398.
[63] K. A. A. Gamage, D. M. S. C. P. K. Dehideniya, and S. Y. Ekanayake, "The role of personal values in learning approaches and student achievements," *Behavioral Sciences*, vol. 11, no. 7, pp. 1–23, Jul. 2021, doi: 10.3390/bs11070102.
[64] I. Suciati, I. Idrus, H. Hajerina, N. Taha, and D. Wahyuni, "Character and moral education based learning in students' character development," *International Journal of Evaluation and Research in Education*, vol. 12, no. 3, p. 1185, Sep. 2023, doi: 10.11591/ijere.v12i3.25122.
[65] A. S. Rahmatullah, E. Mulyasa, S. Syahrani, F. Pongpalilu, and R. E. Putri, "Digital era 4.0: The contribution to education and student psychology," *Linguistics and Culture Review*, vol. 6, no. S3, pp. 89–107, Jan. 2022, doi: 10.21744/lingcure.v6nS3.2064.
[66] K. T. Kilag *et al.*, "How does Philippines's education system compare to Finland's?" *Basic and Applied Education Research Journal*, vol. 4, no. 1, pp. 19–27, Jun. 2023, doi: 10.11594/baerj.04.01.03.
[67] S. Vincent-Lancrin *et al.*, *Fostering Students' Creativity and Critical Thinking: What It Means in School*. Paris, France: OECD Publishing, 2019, doi: 10.1787/62212c37-en.
[68] H. Van Le and L. Q. Nguyen, "Promoting L2 learners' critical thinking skills: The role of social constructivism in reading class," *Frontiers in Education*, vol. 9, Jun. 2024, doi: 10.3389/feduc.2024.1241973.
[69] R. M. Sari, S. Sumarmi, I. K. Astina, D. H. Utomo, and R. Ridhwan, "Increasing students' critical thinking skills and learning motivation using inquiry mind map," *International Journal of Emerging Technologies in Learning (iJET)*, vol. 16, no. 3, p. 4, Feb. 2021, doi: 10.3991/ijet.v16i03.16515.
[70] D. Harefa, "The relationship between student's interest in learning and mathematics learning outcomes," *Afore: Jurnal Pendidikan Matematika*, vol. 2, no. 2, pp. 1–11, Sep. 2023, doi: 10.57094/afore.v2i2.1054.
[71] R. A. Negoro, A. Rusilowati, and M. P. Aji, "Scratch-assisted waves teaching materials: ICT literacy and students' critical thinking skills," *Journal of Turkish Science Education*, Mar. 2023, doi: 10.36681/tused.2023.011.
[72] E. J. P. Escultor and L. A. Dulay, "Lived experiences of teachers handling mother tongue as a subject in private elementary schools," 2023.
[73] Organisation for Economic Co-operation and Development, "Mathematics literacy," 2024.
[74] Hidayati, Z. Abidin, and B. I. Ansari, "Improving students' mathematical communication skills and learning interest through problem based learning model," *Journal of Physics: Conference Series*, vol. 1460, Art. no. 012047, Feb. 2020, doi: 10.1088/1742-6596/1460/1/012047.
[75] M. Rafli, E. Syahputra, and Y. Yusnadi, "Influence of problem based learning model and early mathematics ability to mathematical communication skills and self-confidence in junior high school," *American Journal of Educational Research*, vol. 6, pp. 1539–1545, Nov. 2018, doi: 10.12691/education-6-11-12.
[76] F. Harun, Suparman, Y. Hairun, T. Machmud, and I. Alhaddad, "Improving students' mathematical communication skills through interactive online learning media design," *Journal of Technology and Humanities*, vol. 2, no. 2, pp. 17–23, Oct. 2021, doi: 10.53797/jthkkss.v2i2.3.2021.
[77] P. Z. Tupamahu, T. G. Ratumanan, and C. Laamena, "Students' mathematical representation and communication ability in mathematics problem solving," *Jurnal Didaktik Matematika*, vol. 10, no. 1, pp. 111–130, Apr. 2023, doi: 10.24815/jdm.v10i1.29376.
[78] C. C. Bach, E. Bergqvist, and U. T. Jankvist, "Students' dynamic communication while transforming mathematical representations in a dynamic geometry environment," *ZDM*, vol. 56, no. 4, pp. 543–557, May 2024, doi: 10.1007/s11858-024-01575-x.
[79] S. Lara, M. C. González-Torres, S. Ibarrola-García, and A. Zúñiga, "Fostering communicative competence and motivation through ComunicARTE program," *Sustainability*, vol. 13, no. 5, Art. no. 2600, Mar. 2021, doi: 10.3390/su13052600.
[80] L. F. Utami, I. Pramudya, and I. Slamet, "Students' mathematical communication skills in terms of concrete and abstract sequential thinking styles," *Al-Jabar: Jurnal Pendidikan Matematika*, vol. 11, no. 2, pp. 371–381, Dec. 2020, doi: 10.24042/ajpm.v11i2.7486.
[81] R. Martins, F. Viseu, and H. Rocha, "Functional thinking: A study with 10th-grade students," *Education Sciences*, vol. 13, no. 4, Art. no. 335, Mar. 2023, doi: 10.3390/educsci13040335.
[82] P. Tutt, "Using mathematical modeling to get real with students," *Edutopia*, Feb. 2023.
[83] Y. Anisa, R. Fahruza, and M. Hafiz, "Students' mathematical communication skills in mathematics learning," *International Journal of Innovative Research in Computer Science and Technology*, vol. 11, pp. 39–43, Dec. 2023, doi: 10.55524/ijircst.2023.11.6.7.

[84] L. A. Hildreth, M. Miley, E. Strickland, and J. Swisher, “Writing workshops to foster written communication skills in statistics graduate students,” *Journal of Statistics and Data Science Education*, pp. 1–10, Nov. 2022, doi: 10.1080/26939169.2022.2138800.
[85] T. Prvan and A. A. Bilgin, “Statistics projects and their importance in developing written communication and dissemination skills,” *Bridging the Gap: Empowering and Educating Today's Learners in Statistics. Proceedings of the Eleventh International Conference on Teaching Statistics*, Oct. 2022, doi: 10.52041/iase.icots11.t13b3.
[86] O. A. Jazi, K. Daignault, and C. Uggenti, “Statistics education workshop,” Statistical Society of Canada.
[87] J. B. Khadka, “Role of mathematical communication for learning mathematics,” *Journal of Educational Research and Innovation*, vol. 4, no. 1, pp. 68–76, Dec. 2024, doi: 10.3126/jeri.v4i1.75791.
[88] N. Aziz, A. Zarina, M. Nadzri, and Z. Othman, “Cooperative learning methods and algebraic proficiency: Insights from secondary school education,” *Jurnal Intelek*, vol. 19, 2024.
[89] K. Shabani, K. Mohammad, and S. Ebadi, “Vygotsky's zone of proximal development: Instructional implications and teachers' professional development,” *English Language Teaching*, vol. 3, no. 4, p. 237, Nov. 2010, doi: 10.5539/elt.v3n4p237.
[90] D. A. Ching, “Two cubed approach in a collaborative classroom and the enhanced algebra and social skills of college students,” *Universal Journal of Educational Research*, vol. 8, no. 10, pp. 4920–4930, Oct. 2020, doi: 10.13189/ujer.2020.081064.
[91] F. Saadati and C. Reyes, “Collaborative learning to improve problem-solving skills: A relation affecting through attitude toward mathematics,” *Research in Mathematics Education*, pp. 187–202, 2019, doi: 10.1007/978-3-030-29215-7_10.
[92] F. G. Putra, A. Saregar, R. Diani, M. Misbah, S. Widyawati, and K. Imama, “Enhancing mathematical reasoning: Role of the search, solve, create, and share learning,” *Journal of Education and Learning (EduLearn)*, vol. 18, no. 3, pp. 961–969, Aug. 2024, doi: 10.11591/edulearn.v18i3.21399.
[93] P. Lahann and D. V. Lambdin, “Collaborative learning in mathematics education,” *Encyclopedia of Mathematics Education*, pp. 94–95, 2020, doi: 10.1007/978-3-030-15789-0_23.
[94] R. Marasabessy, “Study of mathematical reasoning ability for mathematics learning in schools: A literature review,” *Indonesian Journal of Teaching in Science*, vol. 1, no. 2, pp. 79–90, Dec. 2021, doi: 10.17509/ijotis.v1i2.37950.
[95] E. Xu, W. Wang, and Q. Wang, “The effectiveness of collaborative problem solving in promoting students' critical thinking: A meta-analysis based on empirical literature,” *Humanities and Social Sciences Communications*, vol. 10, no. 1, pp. 1–11, Jan. 2023, doi: 10.1057/s41599-023-01508-1.
[96] S. Ghavifekr, “Collaborative learning: A key to enhance students' social interaction skills,” *MOJES: Malaysian Online Journal of Educational Sciences*, vol. 8, no. 4, pp. 9–21, Oct. 2020.
[97] Gunawan, A. Harjono, M. Nisyah, M. Kusdiastuti, and L. Herayanti, “Improving students' problem-solving skills using inquiry learning model combined with advance organizer,” *International Journal of Instruction*, vol. 13, no. 4, pp. 427–442, Oct. 2020, doi: 10.29333/iji.2020.13427a.
[98] M. Novitasari, E. Suharini, M. Arbarini, and B. Sumardjoko, “Communicative child friendly mathematics learning management: Collaborative skills in problem solving,” *MOJEM: Malaysian Online Journal of Educational Management*, vol. 11, no. 1, pp. 23–35, 2023.
[99] B. Baiduri, O. R. U. Putri, and I. Alfani, “Mathematical connection process of students with high mathematics ability in solving PISA problems,” *European Journal of Educational Research*, vol. 9, no. 4, pp. 1527–1537, Oct. 2020, doi: 10.12973/eu-jer.9.4.1527.
[100] Yousef, “The effect of the collaborative learning technique on students' educational performance in math,” *Journal for the Mathematics Education and Teaching Practices*, vol. 2, no. 2, pp. 93–103, Dec. 2021.
[101] E. Sulistyowati, A. Rohman, and J. Hukom, “Flipped classroom model: Minimizing gaps in understanding mathematical concepts for students with different academic abilities,” *European Journal of Mathematics & Science Education*, vol. 5, no. 1, pp. 27–37, Mar. 2024, doi: 10.12973/ejmse.5.1.27.
[102] E. Taranto, G. Colajanni, A. Gobbi, M. Picchi, and A. Raffaele, “Fostering students' modelling and problem-solving skills through operations research, digital technologies and collaborative learning,” *International Journal of Mathematical Education in Science and Technology*, vol. 55, no. 8, pp. 1–42, Oct. 2022, doi: 10.1080/0020739X.2022.2115421.
[103] N. Klang, N. Karlsson, W. Kilborn, P. Eriksson, and M. Karlberg, “Mathematical problem-solving through cooperative learning—the importance of peer acceptance and friendships,” *Frontiers in Education*, vol. 6, Aug. 2021, doi: 10.3389/feduc.2021.710296.
[104] A. Mesghina, G. Hong, and A. Durrell, “Cooperative learning in introductory statistics: Assessing students' perceptions, performance, and learning in heterogeneous and homogeneous groups,” *Journal of Statistics and Data Science Education*, pp. 1–26, Jan. 2024, doi: 10.1080/26939169.2024.2302175.
[105] Kanika, S. Chakraverty, P. Chakraborty, and M. Madan, “Effect of different grouping arrangements on students' achievement and experience in collaborative learning environment,” *Interactive Learning Environments*, vol. 31, no. 10, pp. 1–13, Feb. 2022, doi: 10.1080/10494820.2022.2036764.
[106] A. Cujba and M. Pifarré, “Enhancing students' attitudes towards statistics through innovative technology-enhanced, collaborative, and data-driven project-based learning,” *Humanities and Social Sciences Communications*, vol. 11, no. 1, Aug. 2024, doi: 10.1057/s41599-024-03469-5.
[107] U. O. Asekun, “Developing algebraic reasoning in the intermediate phase to encourage critical thinking: A case study of teachers,” Mar. 2023.
[108] B. Cahyono, Kartono, B. Waluyo, and Mulyono, “Analysis critical thinking skills in solving problems algebra in terms of cognitive style and gender,” *Journal of Physics: Conference Series*, vol. 1321, no. 2, p. 022115, Oct. 2019, doi: 10.1088/1742-6596/1321/2/022115.

[109] O. Ovan, S. F. S. Sirate, and M. Mulyati, “Problem-based learning in algebra: Fostering critical thinking skills among middle school students,” *Pedagogy Review*, vol. 5, no. 2, pp. 223–232, 2026.
[110] C. K. Y. Chan, “Problem-solving and critical thinking competencies,” 2021.
[111] M. Marzuki, I. Rusmar, W. Wahyudin, and D. Juandi, “Cognitive flexibility: Exploring students’ critical thinking skills in solving mathematical problems,” *KnE Social Sciences*, Apr. 2024, doi: 10.18502/kss.v9i13.15968.
[112] R. Rohati, Y. S. Kusumah, and K. Kusnandi, “Exploring students’ mathematical reasoning behavior in junior high schools: A grounded theory,” *Education Sciences*, vol. 13, no. 3, p. 252, Mar. 2023, doi: 10.3390/educsci13030252.
[113] V. D. Susanti, I. Krisdiana, and F. Adamura, “Students’ mathematical critical thinking reviewed from self-regulated learning,” *Journal of Physics: Conference Series*, vol. 1613, p. 012008, Aug. 2020, doi: 10.1088/1742-6596/1613/1/012008.
[114] B. Chechan, E. Ampadu, and A. Pears, “Effect of using Desmos on high school students’ understanding and learning of functions,” *Eurasia Journal of Mathematics, Science and Technology Education*, vol. 19, no. 10, p. em2331, Oct. 2023, doi: 10.29333/ejmste/13540.
[115] S. Dolapcioglu and A. Doğanay, “Development of critical thinking in mathematics classes via authentic learning: An action research,” *International Journal of Mathematical Education in Science and Technology*, vol. 53, no. 6, pp. 1–24, Sep. 2020, doi: 10.1080/0020739X.2020.1819573.
[116] A. Rahmatika, “The effect of Think-Talk-Write cooperative learning assisted by GeoGebra software on students’ critical thinking (case study of SMA Al-Hidayah Medan),” *IJEMS: Indonesian Journal of Education and Mathematical Science*, vol. 3, no. 1, p. 1, Jan. 2022, doi: 10.30596/ijems.v3i1.9877.
[117] S. W. P. Nugroho, Riyadi, and Triyanto, “Analysis of students’ creative thinking skill in solving algebra problem,” *Journal of Physics: Conference Series*, vol. 1539, no. 1, p. 012086, May 2020, doi: 10.1088/1742-6596/1539/1/012086.
[118] M. A. Adeoye and H. A. Jimoh, “Problem-solving skills among 21st-century learners toward creativity and innovation ideas,” *Thinking Skills and Creativity Journal*, vol. 6, no. 1, pp. 52–58, 2023, doi: 10.23887/tscj.v6i1.62708.
[119] D. L. J. B. Ybañez, “The role of visualization towards students’ mathematical abstraction: The case of probability,” 2023.
[120] [20] M. Kholil, “Students’ creative thinking skills in solving mathematical logic problem with open-ended approaches,” *Journal of Physics: Conference Series*, vol. 1465, p. 012044, Feb. 2020, doi: 10.1088/1742-6596/1465/1/012044.
[121] A. J. Starko, *Creativity in the Classroom*. Taylor and Francis, 2021, doi: 10.4324/9781003105640.
[122] N. Zielinski, “Transforming mathematics education with creativity,” *Culminating Experience Projects*, Dec. 2023.
[123] M. Khalid, S. Saad, S. R. Abdul Hamid, M. Ridhuan Abdullah, H. Ibrahim, and M. Shahrill, “Enhancing creativity and problem-solving skills through creative problem solving in teaching mathematics,” *Creativity Studies*, vol. 13, no. 2, pp. 270–291, May 2020, doi: 10.3846/cs.2020.11027.
[124] L. Kontrová, V. Biba, and D. Šusteková, “Relationship between mathematical education and the development of creative competencies of students,” *European Journal of Contemporary Education*, vol. 10, no. 1, pp. 89–102, 2021.
[125] W. V. A. D. Karunarathne and A. Calma, “Assessing creative thinking skills in higher education: Deficits and improvements,” *Studies in Higher Education*, vol. 49, no. 1, pp. 1–21, Jun. 2023, doi: 10.1080/03075079.2023.2225532.
[126] R. L. Marrone and D. H. Cropley, “The role of learning analytics in developing creativity,” *Advances in Analytics for Learning and Teaching*, pp. 75–91, Jan. 2022, doi: 10.1007/978-3-031-06333-6_5.
[127] C. E. Lopes and S. A. Corrêa, “Statistics education that promotes creativity and criticality in childhood.”
[128] X. Lu and G. Kaiser, “Can mathematical modelling work as a creativity-demanding activity? An empirical study in China,” *ZDM–Mathematics Education*, Oct. 2021, doi: 10.1007/s11858-021-01316-4.
[129] A. Bicer, “Multiple representations and mathematical creativity,” *Thinking Skills and Creativity*, vol. 42, p. 100960, Oct. 2021, doi: 10.1016/j.tsc.2021.100960.
[130] N. A. Abdulrahim and M. J. Orosco, “Culturally responsive mathematics teaching: A research synthesis,” *The Urban Review*, vol. 52, no. 1, Apr. 2020, doi: 10.1007/s11256-019-00509-2.
[131] J. L. Harding, “Ethnomathematics affirmed through cognitive mathematics and academic achievement: Quality mathematics teaching and learning benefits,” *Springer eBooks*, pp. 1–30, Jan. 2021, doi: 10.1007/978-3-030-44982-7_5-1.
[132] V. Geiger, I. Gal, and M. Graven, “The connections between citizenship education and mathematics education,” *ZDM–Mathematics Education*, vol. 55, no. 5, pp. 923–940, Sep. 2023, doi: 10.1007/s11858-023-01521-3.
[133] D. Andriani *et al.*, “Understanding the number concepts through learning connected mathematics (CM): A local cultural approach,” *Universal Journal of Educational Research*, vol. 8, no. 3, pp. 1055–1061, Mar. 2020, doi: 10.13189/ujer.2020.080340.
[134] D. H. Siswanto, H. Kuswantara, and N. Wahyuni, “Implementation of problem based learning approach culturally responsive teaching to enhance engagement and learning outcomes in algebraic function limit material,” *EDUCATUM Journal of Science, Mathematics and Technology*, vol. 12, no. 1, pp. 80–88, 2022, doi: 10.37134/ejsmt.vol12.1.9.2025.
[135] B. R. Acharya, M. P. Kshetree, B. Khanal, R. K. Panthi, and S. Belbase, “Mathematics educators’ perspectives on cultural relevance of basic level mathematics in Nepal,” *Journal on Mathematics Education*, vol. 12, no. 1, pp. 17–48, Jan. 2021.
[136] Sudarsono, Kartono, Mulyono, and S. Mariani, “The effect of STEM model based on Bima’s local cultural on problem solving ability,” *International Journal of Instruction*, vol. 15, no. 2, pp. 83–96, 2022.
[137] A. Khalemsky and Y. Stukalin, “Effect of students’ ethnic and cultural backgrounds on the success of practical projects within statistics and data science courses,” *Statistics Education Research Journal*, vol. 23, no. 2, p. 2, Dec. 2024, doi: 10.52041/serj.v23i2.721.
[138] T. Weiland and I. Williams, “Culturally relevant data in teaching of statistics and data science courses,” *Journal of Statistics and Data Science Education*, pp. 1–16, Aug. 2023, doi: 10.1080/26939169.2023.2249969.

[139] E. Zuliana, S. I. A. Dwiningrum, A. Wijaya, and J. Hukom, "The effect of culture-based mathematics learning instruction on mathematical skills: A meta-analytic study," *Journal of Education and Learning (EduLearn)*, vol. 19, no. 1, pp. 191–201, Feb. 2025, doi: 10.11591/edulearn.v19i1.21172.
[140] T. Mgonja, S. Marx, and P. Moyer-Packenham, "Multicultural education: A review of culturally relevant pedagogy for students of color in mathematics," *Multicultural Education*, vol. 7, no. 6, p. 2021, 2021, doi: 10.5281/zenodo.5013858.
[141] C. S. Taylor, *Culturally and Socially Responsible Assessment: Theory, Research, and Practice*, in *Multicultural Education Series*. New York, NY, USA: Teachers College Press, 2022.
[142] R. Pourdavood, K. McCarthy, and T. McCafferty, "The impact of mental computation on children's mathematical communication, problem solving, reasoning, and algebraic thinking," *Athens Journal of Education*, vol. 7, no. 3, pp. 241–253, Aug. 2020.
[143] G. French, T. Farrell, M. McCormack, S. Nic Mhuirí, and C. Sheil, "Enabling community engagement to support literacy, digital literacy, and numeracy development for all children: A review of the literature," *Doras.dcu.ie*, pp. 1–26, 2022. Accessed: Aug. 20, 2026.
[144] D. H. Clements, R. Lizcano, and J. Sarama, "Research and pedagogies for early math," *Education Sciences*, vol. 13, no. 8, p. 839, 2023, doi: 10.3390/educsci13080839.
[145] D. Harefa and F. Hulu, "Mathematics learning strategies that support Pacansila moral education: Practical approaches for teachers," *Afore: Jurnal Pendidikan Matematika*, vol. 3, no. 2, pp. 51–60, 2024, doi: 10.57094/afore.v3i2.2299.
[146] L. Rigney, R. Garrett, M. Curry, and B. MacGill, "Culturally responsive pedagogy and mathematics through creative and body-based learning: Urban Aboriginal schooling," *Education and Urban Society*, vol. 52, no. 8, pp. 1159–1180, 2020, doi: 10.1177/0013124519896861.
[147] W. Sumarni and S. Kadarwati, "Ethno-STEM project-based learning: Its impact to critical and creative thinking skills," *Jurnal Pendidikan IPA Indonesia*, vol. 9, pp. 11–21, Mar. 2020, doi: 10.15294/jpii.v9i1.21754.
[148] A. Amiruddin, M. Qorib, N. Naimi, and D. Deliati, "The role of inductive learning models on the students self-regulated learning in math journaling," *Cypriot Journal of Educational Sciences*, vol. 17, no. 7, pp. 2428–2446, 2022.
[149] H. Hardianto and A. Makmur, "Development of digital modules in the context of Bugis culture towards strengthening character education and improving numeracy," *MaPan: Jurnal Matematika dan Pembelajaran*, vol. 12, no. 2, pp. 219–234, 2024, doi: 10.24252/mapan.2024v12n2a2.
[150] N. Nurrahmah, L. Agustina, and N. Nurhayati, "Students abstract thinking abilities in terms of mathematical disposition," *Al-Jabar: Jurnal Pendidikan Matematika*, vol. 12, no. 1, pp. 147–160, 2021, doi: 10.24042/ajpm.v12i1.8652.
[151] H. M. Siregar, "Character education in mathematics learning through habits of mind development to support the achievement of students' cognitive mathematical ability," *Integral (Jurnal Penelitian Pendidikan Matematika*, vol. 6, no. 2, pp. 140–151, 2024, doi: 10.24905/jppm.v6i2.128.
[152] N. Suren and K. M. Ali, "The effects of mathematics anxiety and motivation on students' mathematics achievement," *International Journal of Education in Mathematics, Science and Technology*, vol. 8, no. 3, pp. 190–218, 2020.
[153] R. Y. Tyaningsih, R. Y. Baidowi, and M. A. Maulyda, "Integration of character education in basic mathematics learning in the digital age," *Advances in Social Science, Education and Humanities Research*, vol. 488, pp. 187–192, 2020.
[154] K. Komalasari and A. B. Yakubu, "Implementation of student character formation through Islamic religious education," *At-Tadzkir: Islamic Education Journal*, vol. 2, no. 1, pp. 52–64, 2023, doi: 10.59373/attadzkir.v2i1.16.
[155] A. Wakit and R. H. Kusumodestoni, "Problem based learning with a scientific approach with character in mathematics learning," *Al-Jabar: Jurnal Pendidikan Matematika*, vol. 11, no. 1, pp. 121–132, 2020, doi: 10.24042/ajpm.v11i1.6411.
[156] N. Thambu, H. J. Prayitno, and G. A. N. Zakaria, "Incorporating active learning into moral education to develop multiple intelligences: A qualitative approach," *Indonesian Journal on Learning and Advanced Education (IJOLAE)*, vol. 3, no. 1, pp. 17–29, 2020, doi: 10.23917/ijolae.v3i1.10064.
[157] R. Darmayanti, "Digital comic learning media based on character values on students' critical thinking in solving mathematical problems in terms of learning styles," *SSRN Electronic Journal*, 2024, doi: 10.2139/ssrn.4803023.
[158] K. Khadijah, I. Suciati, K. Khaerani, A. Manaf, and S. Sutamrin, "Schools' character education values and students' mathematics learning achievement: A meta-analysis," *Jurnal Cakrawala Pendidikan*, vol. 40, no. 3, pp. 670–683, 2021, doi: 10.21831/cp.v40i3.39924.
[159] D. Sulistyaningsih, P. Purnomo, and A. Aziz, "Development of learning design for mathematics manipulatives learning based on e-learning and character building," *International Electronic Journal of Mathematics Education*, vol. 14, no. 1, 2021, doi: 10.29333/iejme/3996.
[160] R. J. Jiang *et al.*, "How mathematics anxiety affects students' inflexible perseverance in mathematics problem-solving: Examining the mediating role of cognitive reflection," *British Journal of Educational Psychology*, vol. 91, no. 1, 2020, doi: 10.1111/bjep.12364.
[161] R. Sekaryanti, R. Darmayanti, Choirudin, Usmiyatun, E. Kestoro, and U. Bausir, "Analysis of mathematics problem-solving ability of junior high school students in emotional intelligence," *Jurnal Gantang*, vol. 7, no. 2, pp. 149–161, 2022, doi: 10.31629/jg.v7i2.4944.
[162] J. M. Veith, B. Girnat, and P. Bitzenbauer, "The role of affective learner characteristics for learning about abstract algebra: A multiple linear regression analysis," *EURASIA Journal of Mathematics, Science and Technology Education*, vol. 18, no. 10, 2022.
[163] N. S. Utami, S. Prabawanto, and D. Suryadi, "How students generate patterns in learning algebra? A focus on functional thinking in secondary school students," *European Journal of Educational Research*, vol. 12, no. 2, pp. 913–925, 2023, doi: 10.12973/eu-jer.12.2.913.
[164] R. Winthrop, "The need for civic education in 21st-century schools," *Brookings Institution*, Jun. 2020.

[165] C. A. Thomas, R. Q. Berry III, and R. Sebastian, "Examining the elements of culturally relevant pedagogy captured and missed in a measure of high-quality mathematics instruction," *ZDM–Mathematics Education*, vol. 56, no. 5, pp. 953–964, 2024, doi: 10.1007/s11858-024-01595-7.

[166] G. Sarra and B. Ewing, "Culturally responsive pedagogies and perspectives in mathematics," in *Indigenous Education in Australia*, pp. 148–161, 2021, doi: 10.4324/9780429263453-12.