The Synergy Between 21st-Century Skills and Mathematical Proficiency

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ABSTRACT

The integration of 21st-century skills into mathematics education remains a critical yet underaddressed challenge, particularly in fostering adaptive expertise and addressing persistent gaps in algebraic preparation. This study aimed to investigate the relationship between 21st-century skills (critical thinking, problem-solving, creativity, innovation, communication, cooperation, and digital literacy) and mathematical proficiency in rational exponents and variation, while identifying their interaction effects on student success. A descriptive-correlational method was employed, combining quantitative regression analysis and qualitative data from structured/unstructured assessments. The study involved 172 Grade 9 students across diverse curricular tracks (STE, SPA, SPS, K–12), with 21st-century skills assessed via rubric-based evaluations and mathematical proficiency measured through DepEd-aligned percentage scores.

Results revealed a statistically significant positive correlation ($\beta=0.601$, $p=0.000$), rejecting the null hypothesis. The 21st-century skills affecting the mathematical proficiency in variation and rational exponents. The findings underscore the necessity of curriculum reforms prioritizing on enhancing the 21st-century skills instruction to bridge gaps in mathematical proficiency.

Keywords: 21st-Century Skills, Mathematical Proficiency, Mathematics Education

INTRODUCTION

The 21st century demands a global shift in mathematics education to integrate critical thinking, problem-solving, and digital literacy, enabling students to address complex societal and environmental challenges. As globalization intensifies, mathematics serves as a critical tool for fostering analytical skills necessary to navigate interconnected issues such as economic inequality, technological progress, and sustainable development [13], [8]. International assessments like PISA and TIMSS highlight disparities in mathematical proficiency, emphasizing the need for curriculum reforms that align with the demands of a rapidly evolving global landscape while addressing inequities in access to resources [11], [14]. Locally, initiatives such as the K-12 curriculum reform in the Philippines aim to enhance mathematical literacy and prepare students for active participation in national development. However, persistent challenges such as low performance in global assessments and unequal access to quality education continue to hinder efforts to bridge global aspirations with local realities [11], [2].

At the local level, integrating 21st-century skills into mathematics education requires strategies tailored to diverse student needs and contextual challenges. Effective teaching approaches, including Polya's heuristic problem-solving method and differentiated instruction frameworks, foster critical and creative thinking while making mathematics relevant to real-life applications [13], [12]. Despite these efforts, gaps remain in areas such as media literacy and leadership development within mathematics curricula. Teachers often face barriers such as inadequate training and confidence in implementing innovative pedagogies [1], [10]. Addressing these challenges necessitates systemic support through professional development programs and resource allocation. By refining instructional strategies and fostering collaboration among educators, policymakers, and

communities, local education systems can better equip students to meet both local demands and global expectations in the 21st century [14]. [2].

Meanwhile, mathematical proficiency in rational exponents and variation is pivotal for developing algebraic competency, as rational numbers form the conceptual foundation for advanced topics such as polynomial functions and exponential modeling. Research underscores that rational number comprehension uniquely predicts algebra performance, accounting for over 33% of variance in outcomes among college students [6]. This connection extends beyond procedural fluency; adaptive expertise—the ability to apply rational number concepts flexibly across contexts—has been shown to predict later algebra success more reliably than routine procedural knowledge, particularly in studies involving middle schoolers [5]. For students with mathematical difficulties, targeted interventions focusing on fraction magnitude and arithmetic yield substantial improvements, with meta-analyses demonstrating large effect sizes (Rojo et al., 2022). However, persistent challenges include variability in intervention efficacy and the need to prioritize conceptual understanding over mechanical computation. Recent efforts to develop enrichment materials emphasize scaffolding rational number concepts through real-world applications, yet implementation gaps persist due to inconsistent teacher training and curricular priorities [7]. A systematic review of proficiency frameworks highlights the necessity of integrating adaptive learning strategies and cross-notation fluency (e.g., fractions, decimals) to bridge gaps between basic skills and higher-order mathematical reasoning [4]. These findings collectively advocate for pedagogical approaches that intertwine rational number mastery with algebraic thinking through

Hence, this research study investigates the relationship between 21st-century skills (critical thinking, problem-solving, creativity, innovation, communication, cooperation, and digital literacy) and mathematical proficiency in rational exponents and variation, with the goal of informing interventions to address persistent gaps in algebraic preparation. The study aims to identify the current levels of students' 21st-century skills and mathematical proficiency, analyze their correlation, and explore how these skills interact to influence mathematical proficiency. By examining the role of adaptive expertise in rational number arithmetic and the effectiveness of targeted instructional strategies, the research seeks to provide evidence-based recommendations for curriculum design and teacher training, ultimately enhancing students' ability to apply mathematical concepts flexibly and creatively in real-world contexts.

METHODS

Pearson's correlation coefficient and regression analysis were employed to examine the relationship between 21st-century skills and mathematical proficiency, enabling the identification of influential factors and their interactions. The study was conducted at Isulan National High School, which hosts a diverse student body across specialized curricular tracks—Science, Technology, and Engineering (STE), Special Program in the Arts (SPA), Special Program in Sports (SPS), and the standard K–12 program. This diversity provided a robust sample (N = 172 Grade 9 students) for analyzing how varying levels of 21st-century skills correlate with mathematical competency. Participants were selected through total enumeration across five sections: two STE classes (35 students each), one SPA (28 students), one SPS (29 students), and one K–12 section (45 students), aligning with Creswell & Creswell's (2018) recommendations for sample size in educational research.

A researcher-designed test assessed 21st-century skills, including critical thinking, problem-solving, creativity, communication, collaboration, and digital literacy, with items aligned to curriculum standards emphasizing higher-order thinking. The assessment combined closed-response questions for measurable outcomes and open-ended tasks to capture students' cognitive processes. The scorings of the students' 21st-century skills were adhered on rubrics. Each skills have a rubric with a score range of zero (0) to twenty (20). The scores were transmuted into rating scale of 1 to 5. The following was used for conversion and interpretation of the level of students' 21st century skills.

Score Range	Scale	Mean Interval	Interpretation
17 – 20	5	4.21 – 5.00	Expert
13 – 16	4	3.41 – 4.20	Advanced

9 – 11	3	2.61 – 3.40	Proficient
5 – 8	2	1.81 – 2.60	Developing
0 – 4	1	1.00 – 1.80	Beginning

Mathematics proficiency was evaluated using adapted formative tests on rational exponents and variation, with scores converted to percentages and coded on a 1–5 scale per DepEd Order No. 8, s. 2015 guidelines.

Percentage	Scale	Mean Interval	Interpretation
90 – 100	5	4.21 – 5.00	Outstanding
85 – 89	4	3.41 – 4.20	Very Satisfactory
80 – 84	3	2.81 – 3.40	Satisfactory
75 – 89	2	1.81 – 2.60	Fairly Satisfactory
Below 75	1	1.00 – 1.80	Unsatisfactory

The test instrument used to measure students' math proficiency was based on materials from the Department of Education (DepEd). This made sure that the proficiency matched the competencies set by the department. It has undergone and passed rigid tests of validity and reliability by the Department's experts. Meanwhile, the test instrument for 21st century skills were tested and validated by experts in the field of Mathematic with Krippendorf's alpha value of 0.8547.

Ethical protocols ensured participant confidentiality, voluntary participation, and secure data handling, prioritizing anonymity through coded identifiers and equitable treatment across academic tracks.

FINDINGS

Table I presents the level of students' 21st-century skills based on seven key competencies: Critical Thinking, Problem-Solving, Collaboration, Communication, Innovation, Creativity, and Digital Literacy.

Table 1

The Level of Students' 21st-Century Skills

Indicators	**Mean**	**SD**	**Interpretation**
Critical Thinking (CS1)	3.13	0.82	Proficient
Problem-Solving (CS2)	3.11	0.85	Proficient
Collaboration Skills (CS3)	3.19	0.77	Proficient
Communication Skills (CS4)	3.17	0.72	Proficient
Innovation (CS5)	3.05	0.86	Proficient
Creativity (CS6)	3.09	0.86	Proficient
Digital Literacy (CS7)	3.17	0.80	Proficient
Overall	**3.13**	**0.59**	**Proficient**

The results indicate that students exhibit a proficient level in all these competencies, with overall mean = 3.13 and standard deviation (SD) = 0.59.

Among the skills, Collaboration (mean = 3.19, SD = 0.77) received the highest mean score, suggesting that

students are highly adept at working with others. This aligns with the 2024 essay by the Strawbees Education Team asserting that collaboration beyond mere teamwork; it is fundamental to 21st-century competencies, influencing our learning, communication, and innovation in the contemporary STEAM-oriented landscape. Meanwhile, Innovation (mean = 3.05, SD = 0.86) scored the lowest, indicating that while students are proficient in this skill, there may be room for improvement in fostering creativity and original thinking.

The standard deviation values range from 0.72 to 0.86, indicating moderate variability in students' self-assessed proficiency across different competencies. Despite slight variations, the findings suggest a well-balanced proficiency level across all the measured skills, reinforcing the idea that 21st-century education effectively cultivates essential competencies for academic and professional success.

Table 2

The Level of Students' Mathematics Proficiency

Indicators	Mean	SD	Interpretation
Variation (MP1)	3.91	0.93	Strongly Satisfactory
Rational Exponents (MP2)	3.85	0.94	Strongly Satisfactory
Overall	**3.88**	**0.85**	**Strongly Satisfactory**

Table II presents the descriptive statistics for students' mathematics proficiency, focusing on two competencies: Variation and Rational Exponents. The overall mean score for mathematics proficiency is 3.88 (SD = 0.85), interpreted as "Strongly Satisfactory," indicating that students generally perform well in mathematical tasks related to these competencies. Among the competencies, Variation has a slightly higher mean score of 3.91 (SD = 0.93), suggesting that students are more proficient in understanding and solving problems involving variation. Meanwhile, Rational Exponents has a mean score of 3.85 (SD = 0.94), also interpreted as "Strongly Satisfactory," reflecting a solid grasp of mathematical concepts involving rational exponents.

The results suggest that students demonstrate a commendable level of proficiency in both competencies, which are essential for mastering more advanced mathematical concepts. However, the slight difference in scores indicates that students may benefit from additional support or practice in rational exponents to ensure balanced competency across topics. These findings emphasize the importance of reinforcing foundational mathematical skills, as they play a critical role in students' success in STEM-related subjects and their overall academic performance. By addressing these areas, educators can further enhance students' confidence and competence in mathematics.

TABLE 3

Regression Analysis Of 21st Century Skills and Mathematical Proficiency

Regression Weights	Beta Coefficient	R^2	f	p-value
CS → MP	0.601	0.362	96.332	0.000

The findings of the study reveal a significant positive relationship between 21st-century skills (CS) and mathematical proficiency (MP), as evidenced by the regression analysis results. The beta coefficient (β=0.601) indicates that for every unit increase in 21st-century skills, mathematical proficiency improves by 0.601 units. The R^2 value of 0.362 suggests that 36.2% of the variance in mathematical proficiency is explained by students' 21st-century skills. Furthermore, the F-statistic (96.332) and the p-value (p=0.000) confirm the model's statistical significance at a 95% confidence level, leading to the rejection of the null hypothesis that there is no relationship between 21st-century skills and mathematical proficiency.

These findings align with prior research emphasizing the importance of integrating 21st-century skills into

mathematics education. The implications are profound: educators should prioritize curriculum designs that incorporate authentic tasks and problem-solving activities to foster these skills.

CONCLUSIONS

The study's findings reveal that students demonstrated 21st-century skills at a level slightly below advanced proficiency, while their mathematical proficiency approached the outstanding benchmark set by the Department of Education. Notably, the analysis confirmed that 21st-century skills serve as a robust predictor of mathematical achievement, underscoring their foundational role in fostering algebraic competency and problem-solving adaptability. These results collectively emphasize the critical need for targeted interventions to elevate students' 21st-century competencies, particularly in areas like critical thinking and digital literacy, to align with curricular goals and ensure sustained academic success in mathematics.

RECOMMENDATIONS

To address the interplay between 21st-century skills and mathematical proficiency, problem-based learning (PBL) should be integrated into mathematics curricula. Research demonstrates that PBL tasks significantly enhance creativity, critical thinking, communication, and collaboration compared to traditional methods. For instance, real-world tasks that simulate workplace environments—such as modeling exponential growth in economics or optimizing logistics—boost student engagement and retention of mathematical concepts while fostering skills like innovation and digital literacy.

Curriculum design must emphasize all five components of mathematical proficiency: conceptual understanding, procedural fluency, strategic competence, adaptive reasoning, and productive disposition. This holistic approach ensures students develop both foundational arithmetic skills and the ability to apply mathematics flexibly in novel contexts. Concurrently, teacher training programs should prioritize innovative pedagogies that align with 21st-century competencies, as educator confidence directly impacts student outcomes.

Critical thinking and problem-solving skills, which correlate strongly with academic performance in mathematics, should be explicitly cultivated through tasks requiring analysis of complex data or ethical dilemmas. Additionally, information and technology literacy, entrepreneurship, and innovation should be embedded into instruction, as these skills predict academic success in mathematics. Interventions targeting both domains simultaneously—such as coding projects that integrate algebraic reasoning—are particularly effective, given the strong positive correlation between 21st-century skills and mathematical proficiency.

Finally, differentiated instruction frameworks should be implemented to address diverse learning needs and foster adaptive expertise in mathematics. By tailoring tasks to students' skill levels and curricular tracks (e.g., STE vs. conventional programs), educators can ensure equitable access to opportunities for growth. These strategies collectively aim to leverage the interaction effect between 21st-century skills and mathematical proficiency, preparing students for success in both academic and real-world contexts.

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REFERENCES

1. Adnan, M., & Ismail, N. (2018). The willingness of mathematics teachers in facing 21st century skills. Turkish Online Journal Of Design Art And Communication. https://doi.org/10.7456/1080SSE/180.
2. Bircan, M., & Akman, E. (2023). The relationship between students' 21st-century skills and academic performance in science and mathematics. Educational Policy Analysis and Strategic Research. https://doi.org/10.29329/epasr.2023.525.13.

3. Borovik, A., Kocsis, Z., & Kondratiev, V. (2022). Mathematics and Mathematics Education in the 21st Century.
4. Helsa, Y., Juandi, D., & , T. (2024). Mathematics proficiency - a systematic literature review. KnE Social Sciences. https://doi.org/10.18502/kss.v9i13.15965.
5. McMullen, J., Hannula-Sormunen, M., Lehtinen, E., & Siegler, R. (2020). Distinguishing adaptive from routine expertise with rational number arithmetic. Learning and Instruction, 68, 101347. https://doi.org/10.1016/j.learninstruc.2020.101347.
6. Powell, S., Gilbert, J., & Fuchs, L. (2019). Variables influencing algebra performance: Understanding rational numbers is essential. Learning and Individual Differences. https://doi.org/10.1016/J.LINDIF.2019.101758.
7. Ramadani, E., & Sukardi, S. (2024). Empowering mathematical proficiency by developing enrichment book in the topic of rational numbers. AKSIOMA: Jurnal Program Studi Pendidikan Matematika. https://doi.org/10.24127/ajpm.v13i2.8448.
8. Rizki, L., & Priatna, N. (2019). Mathematical literacy as the 21st century skill. Journal of Physics: Conference Series, 1157. https://doi.org/10.1088/1742-6596/1157/4/042088.
9. Rojo, M., King, S., Gersib, J., & Bryant, D. (2022). Rational number interventions for students with mathematics difficulties: a meta-analysis. Remedial and Special Education, 44, 225 - 238. https://doi.org/10.1177/07419325221105520.
10. Şengül, S., Erçoban, M., & Zora, L. (2021). An evaluation of mathematics secondary school curricula from the perspective of 21st century skills. IEDSR Association. https://doi.org/10.46872/pj.415.
11. Şengül, S., Kaplan, E., Atabay, Y., Tutkun, N., & Yildiz, B. (2021). Investigation of secondary education mathematics curriculum in the context of 21st century skills. IEDSR Association. https://doi.org/10.46872/pj.412.
12. Setambah, M., Ariffin, A., Zaini, S., Jaafar, A., Negara, H., & Hanazono, H. (2025). Exploring the need for differentiated instruction frameworks in enhancing 21st-century skills in mathematics education. Journal of Management World. https://doi.org/10.53935/jomw.v2024i4.641.
13. Szabo, Z., Körtesi, P., Guncaga, J., Szabo, D., & Neag, R. (2020). Examples of problem-solving strategies in mathematics education supporting the sustainability of 21st-century skills. Sustainability, 12, 10113. https://doi.org/10.3390/su122310113.
14. Turhan, G., & Demirci, I. (2021). What are the 21st-century skills for pre-service science and mathematics teachers: discussion in the context of defined 21st-century skills, self-skills and education curricula. Journal of Educational Issues. https://doi.org/10.5296/JEI.V7I1.18278.