**Original Research Article**

**A QUANTITATIVE STUDY ON 21ST-CENTURY LEARNING SKILLS AND MATHEMATICAL IDENTITY OF MATH MAJORS**

Abstract

This study examined the influence of 21st-century learning skills on the mathematical identity of math majors. Many students struggle to develop a strong mathematical identity, which affects their engagement and confidence. Using a descriptive-correlational design, data were gathered from 100 math majors from different schools in Davao City. The 21st-Century Skills Instrument and the Mathematical Identity Instrument were adapted to collect survey responses. Findings revealed a very high level of 21st-century learning skills and a high level of mathematical identity. The results indicate a statistically significant relationship between 21st-century learning skills and mathematical identity, which implies that for every increase in 21st-century learning skills, there is a corresponding increase in mathematical identity and vice versa. Linear Regression analysis indicated that 21st-century learning skills explained 49.7% of the variance in mathematical identity. The findings support the Constructivist Theory, suggesting that students who engage in critical thinking, collaboration, and digital literacy are more likely to develop a positive mathematical identity. The study recommends integrating 21st-century learning strategies in the mathematics curriculum to support identity formation and enhance academic development.

***Keywords:*** *21st-century learning skills, mathematical identity, math majors, Davao City, Philippines*

Introduction

In today's rapidly evolving world, developing a student's mathematical identity as an individual's self-concept and emotional connection to mathematics has become a significant issue in education. Many students, regardless of their cultural or academic backgrounds, struggle to develop a positive identity in mathematics because of rigid instructional approaches, societal stereotypes, and fixed mindsets (Cobb et al., 2009). These factors cause numerous learners to frequently perceive mathematics as inaccessible and irrelevant, leading to disengagement, anxiety, and poor performance (Nasir, 2002). The global trends indicate that when students perceive themselves as incompetent in mathematics, their enthusiasm to engage with the subject weakens, negatively impacting STEM education outcomes globally.

In the Philippines, issues concerning students' mathematical identity remain to exist. Filipino students often exhibit elevated mathematics anxiety and low self-efficacy, particularly when exposed to traditional, teacher-centered pedagogy (David, 2015; Valdez, 2020). Despite national reforms to improve mathematics education, teaching practices frequently neglect to foster students' affective development and identity formation (Garvida, 2013). Many learners experience a sense of disconnection from mathematics due to its abstract and test-driven manner, lacking relevance to real-life contexts or personal growth. These concerns are alarming among pre-service teachers, as their impressions of mathematics might affect their future instructional practices.

In regions such as Davao City, students continue to face challenges that hinder the development of a strong mathematical identity. Baltazar (2022) stated that students enrolled in General Mathematics courses often show different analytical problem-solving skills based on their emotional intelligence, indicating that even mathematics majors may lack the self-awareness and self-regulation required to build confidence in math-related tasks. Additionally, the use of innovative strategies significantly assisted local mathematics students in overcoming disengagement and apprehension towards mathematics, which are typical constraints to identity development (Baog & Dacudao, 2024). These studies emphasized that local mathematics majors may still need emotional and instructional support to establish an intense and persistent attraction for mathematics, even among those specializing in the subject.

Despite several studies investigating factors influencing students' performance in mathematics, limited research focuses on how 21st-century learning skills shape the mathematical identity of math majors. This gap is critical, as mathematical identity significantly influences students' belief, engagement, confidence, and perseverance in math-related fields (Boaler, 2013; Cobb et al., 2009). When these issues remain unresolved, students may experience low self-efficacy, math anxiety, and poor academic performance. Furthermore, lacking essential 21st-century skills such as critical thinking, cooperation, and digital literacy may hinder learners' capacity to adjust to contemporary academic and professional requirements (National Research Council, 2012). Eventually, this study is urgently needed to comprehend and strengthen the role of 21st-century learning skills in developing positive mathematical identity among future educators and professionals. Examining this study seeks to provide insights to help educators design more effective strategies for supporting learners' holistic growth in mathematics, thus fostering competence and confidence in their academic journey.

This study examines the relationship between 21st-century learning skills and the mathematical identity of math majors from selected schools in Davao City. Specifically, it seeks to answer the following questions: (1) What is the level of 21st-century learning skills among math majors in learning and innovation skills, life and career skills, interdisciplinary skills, and information, media, and technology skills? What is the level of their mathematical identity in terms of belief, attitude, confidence, and persistence? (2) Is there a significant relationship between 21st-century learning skills and the mathematical identity of math majors in Davao City? (3) Do 21st-century learning skills significantly influence the mathematical identity of math majors in Davao City?

Ho1: There is no significant relationship between 21st-century learning skills and the mathematical identity of math majors in Davao City.

Ho2: There is no significant influence between the 21st-century learning skills and the mathematical identity of math majors in Davao City.

This study was anchored on Constructivist Theory, which asserts that learners actively construct knowledge based on their experiences (Vygotsky, 1978). Constructivism supports instructional strategies in mathematics education, emphasizing exploration, collaboration, and real-world problem-solving. Laurillard (2012) argued that modern learning environments must be designed to foster critical thinking and creativity, both key components of 21st-century skills. This theory underpins the integration of active and inquiry-based learning approaches that aim to develop students' higher-order thinking skills and, by extension, their academic identities.

**MATHEMATICAL IDENTITY**

* Belief
* Attitude
* Confidence
* Persistence

**21st CENTURY- LEARNING SKILLS**

* Learning and Innovation Skills
* Life and Career Skills
* Interdisciplinary
* Information, Media, and Technology Skill
* s

*Figure 1 Conceptual Framework of the 21st Century Learning Skills and Mathematical Identity*

Method

This study employed a descriptive correlational research design to examine the relationship between the math majors' 21st-Century Learning Skills and Mathematical Identity. The study respondents are 100 math majors from different Davao City, Philippines schools during the academic year 2024 – 2025. The researchers applied snowball sampling to select the respondents and identify the target respondents among the math majors since they were recommended by classmates and teachers who knew their subject area.

To measure the math majors to their mathematical identity level, this study adopted a 5-point Likert scale of the Mathematical Identity Instrument by the study of (Sahin et al., 2019). Meanwhile, to quantify 21st-century learning skills, the researchers adapted a 5-point Likert scale of the Development and Validation of a 21st Century Skills Instrument: Measuring Secondary School Students' Skills (Bala, 2024). The researchers began data collection by obtaining informed consent from the respondents, ensuring they understood the study's purpose and that participation was voluntary, with the option to withdraw anytime. After securing consent, the researchers sent survey questionnaires to math majors from various schools, reaching participants through referrals from initial respondents to broaden the sample. Ethical standards were followed throughout the process by maintaining participants' privacy and confidentiality, keeping personal information anonymous, and using the data solely for research purposes.

 Descriptive statistics, such as means and standard deviation, were used to determine the levels of 21st-century learning skills and mathematical identity among the math majors. Pearson's r correlation was applied to evaluate the relationship between these skills and mathematical identity. Additionally, regression analysis was conducted to determine the individual and combined influence of 21st-century learning skills on the mathematical identity of math majors from different schools.

Results and Discussion

**Table 1. Descriptive Table**

|  |  |  |  |
| --- | --- | --- | --- |
| **Variables and Their Indicators** | **Standard Deviation** | **Mean** | **Verbal Description** |
| **21st Century Learning Skills** | **.23** | **4.22** | **Very High** |
|  Learning and Innovation Skills | .25 | 4.26 | Very High |
|  Life and Career Skills | .27 | 4.16 | High |
|  Interdisciplinary | .32 | 4.22 | Very High |
|  Information, Media, and Technology Skills | .27 | 4.24 | Very High |
| **Mathematical Identity** | **.28** | **4.11** | **High** |
|  Belief | .32 | 4.10 | High |
|  Attitude | .30 | 4.23 | Very High |
|  Confidence | .41 | 4.12 | High |
|  Persistence | .36 | 3.99 | High |

Table 1 presents the level of 21st Century Learning Skills and Mathematical Identity among math majors. The overall mean score for 21st Century Learning Skills was 4.22, categorized as very high. This implies that the respondents perceive themselves as highly equipped with essential 21st-century learning skills. Among the indicators, Information, Media, and Technology Skills obtained the highest mean of 4.24, highlighting the respondents' strong proficiency in using digital tools and media. In contrast, Life and Career Skills showed the lowest mean of 4.16, indicating slightly less confidence in managing personal and professional goals.

The findings show that critical thinking, digital and media literacy skills, and interdisciplinary collaboration are essential for 21st-century learners, especially in Science, Technology, Engineering, and Mathematics (Voogt & Roblin, 2012). Similarly, Binkley et al. (2012) established a validated approach for evaluating 21st-century abilities and observed that students in dynamic learning contexts frequently exhibit advanced skills in innovation, ICT literacy, and collaboration. Consequently, these findings affirm the results in this study that math majors show a high to very high level of self-assessed 21st-century learning skills, indicating preparedness for modern academic and professional challenges.

Conversely, the overall mean score for Mathematical Identity was 4.11, categorized as high. This indicates that the respondents often positively perceive themselves regarding mathematics. Among the indicators, attitude obtained the highest mean of 4.23, implying a strong positive disposition toward mathematics. However, persistence had the lowest mean of 3.99, suggesting potential for improvement in maintaining effort when facing mathematical challenges.

These findings involve previous research that found that strong mathematical identity in attitude and confidence correlates with active participation, long-term engagement, and academic achievement in mathematics (Boaler & Selling, 2017). Additionally, Graven and Heyd-Metzuyanim (2019) discovered in a further study that belief and perseverance substantially influence the development of a positive mathematical identity. This reveals that students who often manifest confidence in math and believe in its relevance are likelier to see themselves as competent. The high results in this study, especially in attitude, affirm that the Math majors in this context not only possess but also frequently show the essential traits that support success in mathematics.

**Table 2. Test of Relationship**

|  |  |
| --- | --- |
| **Independent Variable** | **Dependent Variable** |
| **r-value** | **p-value** | **Decision on Ho** | **Interpretation** |
| **21st-Century Learning Skills** | .705 | .000 | Rejected | Significant |

Table 2 shows a significant relationship between 21st-century learning skills and mathematical identity among math majors. The results show a significant positive relationship, with a computed Pearson correlation coefficient (R-value) of .705 and a p-value of .000. Since the p-value is less than the standard significance level of 0.05, the null hypothesis is rejected, indicating that 21st-century learning skills have a statistically significant correlation with mathematical identity. This suggests that students who consistently manifest high levels of 21st-century competencies also demonstrate strong mathematical identities. Hence, the more frequently students apply creative thinking, collaboration, adaptability, and digital skills, the more likely they will maintain positive beliefs, attitudes, and confidence in their mathematical journey.

 The findings support that 21st-century learning skills are essential in enhancing learner identity and engagement, particularly when implemented in innovative, collaborative, and technology-integrated settings (Trilling & Fadel, 2009). Moreover, Boaler (2016) stated that students engaged in dynamic and engaging mathematics instruction, which fosters 21st-century skills, will likely grow more robust mathematical mindsets and identities. As supported by Dweck (2006), learners who are encouraged to think critically, persevere, and embrace challenges cultivate a positive and resilient academic identity. This research asserts that 21st-century learning skills directly influence students' confidence and self-concept in mathematics.

**Table 3: Regression Table**

|  |  |
| --- | --- |
| **Independent Variable** | **Dependent Variable** |
| **R2-value** | **F-value** | **p-value** | **Decision on Ho** | **Interpretation** |
| **21st-Century Learning Skills**  | 49.7% | 96.90 | .000 | Rejected | Significant |

 Table 3 displays the results of the regression analysis in examining the influence of 21st-century learning skills on the mathematical identity of math majors. The regression model reveals an R² value of 49.7%, showing that nearly half of the variance in mathematical identity can be attributed to students’ 21st-century learning skills. The F-value of 96.90 and the p-value of .000 imply that the result is statistically significant. This leads to rejection of the null hypothesis (Ho), which states no significant relationship exists. This means that 21st-century learning skills significantly influence mathematical identity among math majors.

The findings align with Boaler (2016), who emphasized that students develop stronger mathematical identities when exposed to innovative learning environments that encourage critical thinking, collaboration, and self-expression. Similarly, Trilling and Fadel (2009) argued that 21st-century skills are essential to student engagement and self-concept, particularly in mathematics. A recent study by Bicer et al. (2021) indicated that career readiness and problem-solving confidence significantly influence students' development of their STEM identity.

The findings of this study concluded that 21st-century learning skills have a significant relationship and strong positive influence on the mathematical identity of math majors. Based on the interpretation of the mean scores, the level of 21st-century learning skills was very high, meaning these skills are always manifested. In contrast, the level of mathematical identity was high, indicating it is often manifested. This suggests that students are regularly engaged in learning experiences that develop essential 21st-century competencies and foster a strong identity in self-concept for mathematics. The correlation results further reveal that for every increase or decrease in 21st-century learning skills, there is a corresponding increase or decrease in mathematical identity. Moreover, the regression result of (R² = 49.7%) indicates that 21st-century learning skills significantly influence mathematical identity, which implies that other factors influence mathematical identity that were not part of the present study. These results confirm the Constructivist Theory, emphasizing that integrating critical thinking, collaboration, creativity, and technology in learning environments supports students in constructing a stronger and more positive mathematical identity.

Based on the study's findings, it is recommended that educational institutions enhance curriculum design by integrating 21st-century learning skills, particularly life and career skills, to strengthen students' mathematical identity. Instructors may adopt constructivist-aligned teaching methods that encourage reflection, collaboration, and problem-solving to develop confidence and persistence in mathematics. Future research may examine other contributing factors to mathematical identity beyond the scope of this study, including socio-emotional influences and digital learning contexts. Additionally, targeted interventions that foster real-world learning experiences may further support identity development and academic growth in mathematics.

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