

Mathematics Identity as a Predictor of Performance in Mathematics among Form Three Students in Northeast Region, Botswana

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Abstract

Mathematics proficiency is a gateway to many career opportunities worldwide. However, in Botswana, particularly in the North East Region, there is significant concern about poor performance in mathematics in the national examination. This research examined the influence of students' mathematics identity on mathematics performance among third-year secondary learners in Botswana's North East District. A correlational methodology was employed to analyze the data. The investigation was anchored in the Core Identity Framework. The target population comprised 3,382 students enrolled in their third year of secondary education for the 2025 academic calendar. A representative sample of 400 learners was drawn from eight government-funded junior secondary institutions using a combination of purposive and simple random sampling. The results demonstrated a strong and statistically significant positive association between mathematics identity and mathematics achievement ($r(386) = .85, p < .05$). Among the mathematics identity dimensions, recognition exhibited the strongest correlation with performance ($r(386) = .78, p < .05$), followed by interest ($r(386) = .77, p < .05$), and competence ($r(386) = .85, p < .05$). These findings suggest that mathematics identity substantially influences students' success in the subject. Therefore, it is essential to foster learners' enthusiasm for mathematics, enhance their confidence in their academic performance, and promote recognition of their individual capabilities in mathematical tasks. The study recommends that Guardians, educators, and all key participants in the education system collaborate to create a supportive environment that nurtures learners' mathematics identity and academic resilience. Teachers should enhance guidance and counselling to help learners develop appropriate levels of mathematics identity to achieve mathematics performance. Teachers and parents should strive to demonstrate to students that they recognize their abilities and efforts, thereby enabling them to excel in mathematics.

Keyword: *Mathematics Identity, recognition, interest, competence, Performance in Mathematics, Form Three Students*

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1. Introduction

All over the world, strong performance in mathematics opens doors to higher education, enabling students to pursue courses linked to career opportunities that are vital to a country's economy. Abbas, Mahmood, and Hayat (2024) acknowledge the crucial role of mathematics in the development of science and technology and across all levels of learning. Mwangi and

Limboro (2020) also credit mathematics with equipping learners with the foundational skills needed to succeed in industry, science, commerce, and technology.

Despite the value of strong performance in mathematics, most countries worldwide continue to experience low learning outcomes in mathematics. For example, performance in mathematics in the USA in PISA, 2022 for 15-year-old fell below the average point of OECD countries. The USA scored 465 points, while the OECD average was 472 points. Also, candidates who sat for the National Assessment of Educational Progress (NAEP) 2022 recorded an alarming drop in mathematics. The drop was so drastic that it is the largest observed since the inception of this test in 1990 (Mervosh & Ashley, 2022). The fourth graders recorded a 4-point drop in NAEP math scores from 240 out of 500 in 2019 to 236 in 2022. The 8th graders recorded an 8-point decline from 282 points in 2019 to 274 points in 2022. This decline is concerning, given that these students had received additional instruction in mathematics. For instance, the 2022 NAEP survey found that supplementary instruction was provided to students almost daily, and 1 in 4 students had tutorial classes outside school once a month (Sparks, 2022). There is a call for intervention measures, such as tutoring students in small groups and doubling up on math classes, to remedy this problem of poor mathematics performance.

In South Africa, despite the support given by NECT to the DBE to improve the quality of learners' outcomes in mathematics, the issue of poor performance persists. For instance, the results released by DBE in mathematics in 2022 for grade 12 show that fewer than a quarter of students attained a mark of 50%, the pass mark, with 77% scoring below 50%. Additionally, South Africa is performing no better than other upper-middle-income countries in mathematics performance in TIMSS. For instance, in 2019, South Africa was ranked 56th in TIMSS in grade 5 among 13 upper-middle-income countries, and 38th in grade 9 among 9 middle- to upper-income countries. Intervention measures have been proposed to address this poor performance; for instance, Cosser (2023) recommended conducting an audit of teachers whose students achieve average scores and rewarding them with higher pay than those whose scores are below average.

In Botswana, poor performance in mathematics remains a serious issue of concern. The country has implemented intervention measures to improve performance in mathematics. For example, in 2006, Botswana introduced the SMASSE programme in secondary schools to enhance mathematics performance. Bhusumane and Nkhwalume (2019) note that teaching methodologies and intervention measures have also been put in place to try and arrest poor performance in mathematics among the junior school students, such as hands-on problem-solving activities. However, these intervention measures have not yielded substantial improvements in mathematics performance, as shown by data from the Botswana Examinations Council (BEC).

According to the Botswana Examination Council Annual Report (2024), the percentage of candidates who were awarded grade C or better in mathematics in the Junior Certificate Examination (JCE) has been low for the last four years. For instance, the percentage of candidates who scored grade C or better in 2021 was 21.91%, 20.66% in 2022, 22.49% in 2023, and 18.87% in 2024. There was a large deviation of -3.52 percentage points in the proportion of students who scored a grade C or better in 2024 compared with 2023. This implies that substantial efforts are needed to improve mathematics performance and reduce the number of candidates who perform below the national target.

In the North East Region, students' performance in mathematics is equally concerning. Data from the North East Region Education office indicates that in the year 2024, JCE, candidates who scored grade C or better were 24.5%, which was slightly lower than that of 2023 where 28% scored grade C or better, and in 2022, the percentage of candidates who scored grade C or better was 26.31% (See Table 1).

Table 1: JCE Mathematics Performance in North East Region 2022-2024

Year	Grade C or Better	Grade U
2024	26.21%	23.17%
2023	21.49%	25.35%
2022	20.75%	26.17%

Source: North-East Region Education Directorate, 2025.

As shown in Table 1, the percentage of candidates who did not meet expectations and received a grade of U is much higher than that of candidates who scored grade C or better. When so many candidates fail to meet expectations in mathematics examinations, this is concerning, as it may also prevent them from solving everyday problems. According to Kolawole and Oluwatayo (2004), mathematics encompasses a wealth of ideas that effectively contribute to essential life competencies, making its relevance in daily activities profoundly significant and impossible to overstate.

Limited research has been conducted in Botswana to examine the determinants influencing students' achievement in mathematics. For example, Namasiku (2024) analyzed the extent to which ICT is incorporated into mathematics instruction, while Kenosi et al. (2024) investigated how students' attitudes toward mathematics relate to their academic outcomes in the subject. Nonetheless, minimal attention has been paid to exploring psychological constructs such as mathematics identity and academic resilience in relation to mathematics performance. Consequently, it was imperative to examine how mathematical identity and academic resilience correlate with mathematics performance.

Anderson (2007) defines mathematics identity as the set of beliefs a learner has towards self as a student of mathematics and the perceptions others hold about the learner in a mathematics-related context. According to Cribbs et al. (2015), students who have formed their identity in mathematics depict interest in learning the subject, have high self-concepts about their ability in mathematics, and get others to recognize their ability in learning mathematics. The students also have high self-belief about their ability in learning and passing mathematics. According to Bohnstedt et al. (2021), there is a positive relationship between the student's score in mathematics identity and achievement in mathematics. A study by Cribbs (2022) shows that students whose teachers failed to recognize their ability in mathematics had low scores in mathematics identity and consequently mathematics performance.

1.1 Problem Statement

Underperformance in mathematics remains a critical concern in the North East Region of Botswana, as evidenced by the large number of students who attained grade U in the junior certificate examination (JCE) between 2022 and 2024, as detailed in Table 1. This ongoing trend of persistent poor performance in students' confidence but also jeopardizes their achievement in senior schools. Moreover, it limits their opportunities to pursue mathematics-

intensive courses in higher education. Consequently, this situation threatens to diminish the country's pool of skilled professionals, adversely impacting industrial and economic development. Existing studies in Botswana have examined various factors influencing performance in mathematics, such as the relative cost of motivation and the integration of technology in mathematics learning (Mollowakgotla, 2023; Namasiku, 2020). However, the persistence of poor performance suggests that other critical factors, such as mathematics identity, remain unexamined. Therefore, the current study sought to investigate mathematics identity as a predictor of mathematics performance among Form Three students in the North East region of Botswana.

2. Theoretical Review

The study was anchored on the Core Identity Theory (Cobb & Hodge, 2011). The theory's proponents stipulate that core identity reflects one's enduring sense of identity. Holland and Lave (2001) view identity as a 'thickening' process in which an individual is predisposed to a social environment, thereby becoming the sum of socially and culturally interpreted experiences. Thus, the theory suggests that an individual's identity is informed by their accumulated experiences. According to Envey, Goldberg, and Welsh (2006), mathematics identity is the lens through which an individual views themselves in relation to mathematics, shaping one's perception and navigation of daily interactions with mathematics. The theorists stipulate that an individual's decisions and long-term engagement in mathematics will be influenced by the identity one holds towards mathematics. Researchers suggest that a student's mathematical identity comprises three fundamental elements: curiosity or enthusiasm for the subject, recognition by others as mathematically inclined, and a sense of capability or achievement in mathematical tasks. Interest is conceptualized as the eagerness and the desire an individual has towards thinking and learning mathematics. Recognition involves a student's self-perception and how significant others, such as teachers, peers, and parents, perceive the student in relation to mathematics. Martin (2006) proposes that recognition encompasses the 'construct' others ascribe to one in relation to mathematics ability, which is vital in giving one a sense of mathematics identity. Lastly, the construct of competence/performance involves the beliefs students hold about their ability to understand and perform in mathematics. Hazari et al. (2010) link the concept of competence/performance to self-efficacy by Bandura (1997).

Core identity theory provided the theoretical basis for subsequent studies. For instance, Cribbs et al. (2022) conducted a study to investigate how students view a "math person" among university students in the USA. The findings of this study showed that interest, competence, and performance played a key role in developing the students' identity in mathematics. Additionally, it was evident that students who did not receive recognition from their tutors scored low on mathematics identity. In this study, the investigator applied this theoretical framework to explore the association between mathematics identity and academic performance in mathematics among third-year secondary school learners in Botswana's North East Region.

3. Methodology

This study employed a correlational research design. This design was used to describe relationships between or among variables in the study (Lillykuty & Samson, 2018). The study was conducted in the North East Region, Botswana. The region has 18 public junior schools. The region selection was due to its persistently low performance in math in the Junior Certificate Examination (JCE), as reported by the North East Region Education Office for 2022-2024.

The intended population for this research included all third-year learners enrolled in public junior secondary schools within Botswana’s North East Region as of 2025. The study’s target population comprised 18 government-funded institutions, collectively serving 3,382 students. Form three learners were purposively selected for this investigation because they were preparing for the Junior Certificate Examination (JCE), administered at the conclusion of the academic calendar. The researcher strategically employed purposive sampling to select the North East Region of Botswana due to its consistently low performance in mathematics on the Junior Certificate Examination (JCE) between 2021 and 2023. Following this, stratified sampling was used to group the 18 schools into four strata corresponding to the four sub-regions of the North East region. Subsequently, simple random sampling was used to select eight educational institutions and a total of 400 learners, ensuring that every participant had an equal probability of selection.

Mathematics identity was measured using instruments developed by Cribbs and Utley (2023) for fifth through twelfth grade. Math scores for each student were obtained from the students’ progressive reports—the mean scores in mathematics at the end of term one and term two in 2025. The scores were then converted to T-scores for purposes of comparison. The researcher coded the quantitative data in SPSS in preparation for statistical analysis. Std dev s, means, and percentages are among the descriptive statistics that were used to present data outcomes. The researcher employed inferential statistical techniques to test the null hypothesis.

4. Results

To determine whether a relationship exists between mathematics identity and mathematics performance, the researcher tested the null hypothesis, which was stated as follows: H_{01} : There is no significant relationship between mathematics identity and mathematics performance. To test this hypothesis, the mathematics identity score and mathematics performance score were subjected to Pearson’s Correlation Coefficient, and the results of this bivariate analysis are presented in Table 2.

Table 2: Correlation between Mathematics Identity and Mathematics Performance

		Mathematics Performance	Mathematics Identity
Mathematics Identity	Pearson Correlation	.85**	1
	Sig. (2-tailed)	.00	
	N	386	386

Note $N=386^{**}$. Correlation is significant at the 0.01 level (2-tailed).

Table 2 indicates that mathematics identity had a strong positive correlation with mathematics performance ($r(386) = .85$). Consequently, the null hypothesis was not upheld, leading to the inference that a meaningful association exists between the two constructs. Prompted by these findings, the researcher identified correlations among mathematics identity domains using Pearson Correlation analysis. The findings are presented in Table 3.

Table 3: Correlation between Mathematics Identity Subscales and Mathematics Performance

		Mathematics performance
Interest	Pearson Correlation Sig2-tailed)	.77** .00
Recognition	Pearson Correlation Sig2-tailed)	.78** .00
Competence/performance	Pearson Correlation Sig. (2-tailed)	.66** .00

Note N=386**. Correlation is significant at the 0.01 level (2-tailed).

As shown in Table 3, all three subscales of mathematics identity were significantly correlated with mathematics performance. The mathematics identity subscale of recognition had the highest correlation coefficient ($r(386) = .78$), followed by the subscale of interest ($r(386) = .77$). Lastly, the least correlation was in the subscale of competence/ performance, where the correlational coefficient was ($r(386) = .66$). The researcher advanced to compute the coefficients of determination for mathematics identity, which accounted for the overall variation in learners' performance in mathematics. The dataset was analyzed using multiple regression techniques, and the findings are displayed in Table 4.

Table 4: Model Summary for Mathematics Identity Subscales

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.87 ^a	.75	.75	4.99

Note. N= 386. Predictors: (constant), Competence, Recognition, Interest

As indicated in Table 4, the coefficient of determination ($R^2 = .75$) was substantial, suggesting that 75% of the variation in students' mathematics achievement could be attributed to the dimensions of mathematics identity. The researcher then examined whether notable mean differences existed across the subcomponents of interest, as shown in Table 5.

Table 5: ANOVA for Model of the Subscales of Mathematics Identity

Model		Sum of Squares	Df	Mean Square	F	Sig.
1	Regression	28982.989	3	9661.00	387.78	.00 ^b
	Residual	9517.01	382	24.91		
	Total	38500.00	385			

Note. N=386, a= Dependent Variable: Mathematics Performance, b. (Constant) competence, Recognition, Interest

Based on the ANOVA results summarized in Table 5, a notable variation in mean scores across the mathematics identity dimensions was observed ($F(3, 382) = 387.78, p = .00$). These outcomes indicate a statistically significant difference in average scores among respondents identified as having interest, competence, and recognition. This meant that students who scored highly on the recognition subscale of the mathematics identity could perform better than their counterparts. The researcher further examined the predictive weight of individual subscales of mathematics identity. The findings are presented in Table 6.

Table 6: Regression Coefficients for the Predictors of Mathematics Performance from Mathematics Identity Subscales

Model		Unstandardized Coefficients		Standardized Coefficients	T	Sig.
		B	Std. Error	Beta		
1	(Constant)	-20.51	2.43		-8.44	.00
	INT	1.97	.20	.38	10.09	.00
	REG	2.30	.21	.40	11.16	.00
	CMP	.75	.12	.21	6.34	.00

Note. $N=386$, a. Dependent Variable: Mathematics Performance, INT - Interest, REG - Recognition, CMP- Competence.

The following predictive equation for predicting mathematics performance from mathematics identity subscales was developed from Table 6:

$$\hat{Y} = -20.51 + .38 \text{ INT} + .40 \text{ REG} + .21 \text{ CMP}$$

As shown in Table 6, the three subscales of mathematics identity had significant positive predictive indices for mathematics performance. This meant that an increase in students' scores on any of the three subscales of mathematics identity was associated with higher mathematics performance scores. The highest predictive weight was for domain recognition ($\beta=.40, p=.00$), followed by domain interest ($\beta=.38, p=.00$), and competence ($\beta=.21, p=.00$). This indicated that the strongest predictor of mathematics performance was recognition, followed by interest, and the weakest was competence.

5. Discussion

The study examined the association between learners' mathematics identity and their academic performance in the subject. The findings demonstrated a strong and positive linkage between these two constructs. Additional statistical exploration was undertaken to assess the interrelationships among the distinct elements of mathematics identity; it was established that all subscales of mathematics identity had significant predictive power for mathematics performance.

The findings of this study concurred with those of Radisic et al. (2024), who explored the relationship between mathematics achievement and mathematics identity among primary schools in six European countries. The study reported a positive and significant relationship in the mathematics identity subscale of recognition that the scale tested and achieved in mathematics. Appiah et al. (2022) also reported similar findings that students' confidence in mathematics (competence) had a strongly significant positive association with achievement in mathematics among senior school students in Ghana. Additionally, Bohrstedt et al. (2020)

reported similar findings of a significant mathematics identity and achievement in mathematics among high school students in the USA. These findings of the existence of a strong relationship were evident despite different scales used to collect data and samples derived from different geographical locations, thus there were no cross-cultural differences among the students at different levels.

The outcomes of the present investigation partially aligned with those reported by Ulum (2025), whose research examined the influence of mathematics identity on academic performance among primary school learners in Turkey. The findings of this study reported a , significant association, whereas the present study reported a strong relationship. In Ghana, Salifu and Bakari (2022) reported that the math identity component of interest had a weakly significant correlation between interest and math achievement. In Botswana, Kenosi (2024) explored the relationship between students' attitudes in math and math self- efficacy, which in the present study were conceptualized to fall under mathematics identity subscales of interest and competence/performance among junior school students. The outcomes of this investigation aligned with those of the current study, confirming a notable and favorable association between mathematics identity and students' performance in the subject. Additionally, the study highlighted modest positive correlations between learners' attitudes toward mathematics and math self-efficacy. It is noteworthy that mathematics achievement was positively associated with math achievement at all levels, although the strength of this association varied. These findings clearly indicate the crucial role of mathematics identity in mathematics performance.

6. Limitations

When interpreting the results of this study, the reader should consider the following limitations. First, this study was limited to the mathematics identity domains of recognition, interest, and competence as defined in the mathematics identity scale. Secondly, this study was confined to a few junior schools selected from the North East Region of Botswana; therefore, generalizing the findings beyond This Region should be done with caution. Furthermore, this study used a self-report questionnaire, which may have introduced bias in respondents' responses. Thus, diverse scales such as interview schedules and focus group discussions may be used to assess students' mathematics identity in future studies. Lastly, the study was limited by a correlational research design; thus, its findings did not establish causality between mathematics identity and mathematics performance.

7. Conclusion

The initial focus of the research was to assess the association between mathematics identity and learners' performance in mathematics. The results revealed a statistically significant and positive correlation between the two variables. Further examination of the mathematics identity dimensions, namely interest, recognition, and competence/performance, was conducted. These findings suggest that mathematics identity substantially influences students' success in the subject. Therefore, it is essential to foster learners' enthusiasm for mathematics, enhance their confidence in their academic performance, and promote recognition of their individual capabilities in mathematical tasks. Significant others, such as teachers and parents, should recognize learners' mathematical abilities.

8. Recommendations

Guardians, educators, and other key participants in the education system should collaborate to create a supportive environment that nurtures learners' mathematics identity and academic resilience.

Teachers should enhance guidance and counselling to help learners develop appropriate levels of mathematics identity to achieve mathematics performance.

Teachers and parents should strive to show students that they recognize their abilities and efforts so that they can excel in mathematics.

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