Open Access Library Journal
2024, Volume 11, e11816
ISSN Online: 2333-9721
ISSN Print: 2333-9705

Examining the Relationship of Mathematics Self-Concept, Academic Self-Regulation, and Academic Achievement of Pre-Service Mathematics Teachers

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How to cite this paper: Vergara, C.R. (2024) Examining the Relationship of Mathematics Self-Concept, Academic Self-Regulation, and Academic Achievement of Pre-Service Mathematics Teachers. *Open Access Library Journal*, **11**: e11816.
https://doi.org/10.4236/oalib.1111816

Received: June 11, 2024
Accepted: July 23, 2024
Published: July 26, 2024

Abstract

Many Filipino students continuously struggle to learn mathematics, and the extant literature suggests their motivation to learn may play a crucial factor in determining their success in university. It may conceivably drive students to persevere, exert more effort, and display goal-orientated behaviors. This paper examines if motivational factors such as self-concept and academic self-regulation are directly related to the mathematics achievement of pre-service mathematics teachers. A descriptive-correlational study was carried out using the purposive sampling method. A total of 71 pre-service mathematics teachers completed the survey instrument during the academic year 2023-2024 at Nueva Ecija University of Science and Technology. The results revealed that pre-service teachers had moderate mathematics achievement, mathematics self-concept, and academic self-regulation. Furthermore, a significant relationship was seen between mathematics self-concept, academic self-regulation (identified and intrinsic), and academic achievement. Finally, only mathematics self-concept serves as a significant predictor of mathematics achievement. Overall, this research study highlights the importance of mathematics self-concept and academic self-regulation in improving mathematics achievement of pre-service mathematics teachers.

Subject Areas

Mathematics Education, Social Science, Educational Psychology

Keywords

Motivation, Mathematics Self-Concept, Academic Self-Regulation, Mathematics Achievement, Pre-Service Mathematics Teachers

1. Introduction

Numerous international assessments and studies have consistently shown that Filipino students encounter ongoing challenges in learning mathematics [1] [2]. Identifying the factors that influence the academic success of pre-service mathematics teachers is crucial for enhancing mathematics education and improving student performance. Students' motivation stands out as one of the primary determinants of successful learning. Learning is inherently challenging, demanding significant mental effort; thus, motivation catalyzes this process [3]. Students motivated to learn and demonstrate good learning behavior are likelier to meet the required competency standards [4]. Hence, mathematics self-concept and academic self-regulation are essential motivational factors influencing students' educational success. This study examines the relationship between mathematics self-concept, academic self-regulation, and academic achievement among pre-service mathematics teachers.

Academic self-concept entails the students' mental depiction of their capabilities across different academic areas and school subjects [5]. Consequently, mathematics self-concept refers to an individual's subjective evaluation of their proficiency and skill in mathematics [6]. An individual's perception of their mathematical abilities before college is initially molded by experiences during primary and secondary education. This perception is further reinforced by subsequent experiences in these academic settings and by the influence of significant figures such as teachers, family members, and peers [7]. The study of Marsh *et al.* (2011) [8] points out that academic self-concept increases subsequent academic achievement and other desirable educational outcomes. In academic settings focused on fostering students' academic self-concept, educators should recognize that students' confidence in their academic abilities and the effort they invest significantly shape their academic self-concept, ultimately influencing their academic success [9]. Likewise, Skaalvik & Skaalvik (2006) [10] strongly support the idea that students' self-perceptions are important prerequisites for learning and achievement. So, mathematics self-concept is vital in influencing motivation, effort, and perseverance in learning mathematics, reducing mathematics anxiety [11]. Preventative and intervention initiatives centered on self-concept could prove beneficial in assisting students in acquiring new skills and enhancing their academic performance. A positive perception of one's mathematical abilities may encourage children to persevere with math tasks for extended periods and equip them with better strategies to handle negative feedback [12] [13]. A strong self-confidence in mathematics is frequently linked to improved academic performance and increased involvement in mathematical activities. In contrast, a diminished self-perception can result in feelings of unease, the adoption of evasive actions, and subpar achievements.

Academic self-regulation refers to individuals' cognitive, behavioral, and emotional processes to consistently and purposefully achieve their learning objectives [14]. It was anchored on the Self-Determination Theory [15] [16], which

conceptualizes motivation as a motivation, extrinsic motivation (external regulation, introjected regulation, identified regulation, integrated regulation), and intrinsic motivation. It is a continuum that describes whether the individual is non-self-determined or self-determined. Academic self-regulation only uses external regulation, introjected regulation, identified regulation, and intrinsic motivation to regulate learning. According to Ryan and Deci (2022) [17], external regulation involves behavior driven by externally imposed contingencies and outcomes, while introjected regulation occurs when individuals engage in behavior to avoid feelings of guilt or disapproval or to gain approval from others. Identified regulation emerges when individuals internalize and personally endorse the value of an action. On the other hand, intrinsic motivation is the innate drive that inspires individuals to participate in stimulating and enjoyable activities. Students who can manage their learning despite numerous classroom distractions and challenges perform better and grasp concepts more effectively than those who lack self-regulation skills [18]. In addition, Cleary *et al.* [19] & Cleary & Kitsantas (2017) [20] found that over two years in middle school, students involved in the Self-Regulation Empowerment Program had a statistically significant and notably positive trajectory in their mathematics achievement. Furthermore, students and coaches who participated in the program described it as a socially significant intervention, emphasizing its acceptability and significance. Moreover, students with strong self-regulation skills tend to achieve high final grades in mathematics, a subject that many find challenging, anxiety-inducing, or uninteresting, despite its crucial role for those aspiring to pursue STEM careers in the future [21]. Therefore, higher academic achievement is associated with effective self-regulation, as it empowers students to assume responsibility for their learning, overcome obstacles, and sustain motivation.

Although there has been separate research on the relationship between mathematics self-concept and academic self-regulation with academic performance, there is a lack of studies examining their combined influence, especially among pre-service mathematics teachers. The interplay between these constructs and their collective influence on academic achievement in pre-service mathematics teachers remains underexplored despite the extensive research on mathematics self-concept and academic self-regulation separately. Existing research frequently concentrates on either high school students or general teacher education, resulting in a lack of comprehension regarding the unique dynamics of mathematics teacher education programs.

This study aims to fill the existing research gap by investigating how mathematics self-concept and academic self-regulation impact the academic achievement of pre-service mathematics teachers. Gaining insight into these connections can provide valuable guidance for implementing focused interventions and teaching strategies to enhance pre-service teachers' self-concept and self-regulation capabilities. This, in turn, can lead to improved academic achievement and increased effectiveness in their future teaching endeavors. Therefore, this research study aimed to 1) Describe the level of academic achievement in mathematics,

self-concept, and self-regulation; 2) Determine the relationship between academic achievement in mathematics, self-concept, and self-regulation; 3) Determine the predictors of academic achievement in mathematics.

Research Objectives

This study investigates the direct relationship between mathematics self-concept, academic self-regulation, and mathematics achievement. It seeks to expand the current understanding of Self-Concept and Self-Determination Theory in educational contexts. Additionally, this research aims to examine the predictive validity of student self-perception and active participation in the classroom. The results may emphasize the importance of intervention and teaching strategies incorporating these theories. The present research intends to underscore the vital role of academic self-regulation and mathematics achievement in improving the academic achievement of pre-service mathematics teachers. In line with these objectives, the following hypotheses were tested:

1) Self-concept and Academic Self-Regulation will significantly correlate to Academic Achievement in Mathematics.

2) Self-concept and Academic Self-Regulation will significantly predict Academic Achievement in Mathematics.

2. Methodology

2.1. Research Design

This study used descriptive-correlational research design. According to Seeram (2019) [22], correlational research is a non-experimental research that facilitates predicting and explaining the relationship among variables. It comprehensively described the respondents' academic achievement, self-concept, and self-regulation. Additionally, it facilitated examining the relationships between academic achievement, self-concept, and self-regulation.

2.2. Respondents of the Study

The study's respondents consisted of 71 pre-service mathematics teachers. Respondents were selected through purposive sampling, particularly total enumeration. These respondents were second-year Nueva Ecija University of Science and Technology students specializing in mathematics education and enrolled in a mathematics class during the academic year 2023-2024.

2.3. Research Instrument

Academic Achievement in Mathematics

The researcher assessed the mathematics achievement of the pre-service mathematics teachers by examining their grades in a mathematics class. Utilizing subject grades offered a standardized and objective means to evaluate and compare the respondents' proficiency in mathematics.

Mathematics Self-Concept Scale

The Mathematics Self-Concept Scale utilized in the study was adapted from the SDQ-II [23], originally developed for high school students. This scale consists of 10 items specifically tailored to measure self-concept in mathematics. Respondents were asked to rate their agreement with each item on a scale ranging from 1 (Definitely Not True) to 4 (Definitely True). Also, negatively worded items were reverse-scored to ensure higher scores reflected a more positive perception of mathematical abilities and functioning. An example item is: "I have always done well in mathematics." The items were chosen for their relevance to the study context and demonstrated reliability with a Cronbach's alpha coefficient of .86. Thus, the instrument was valid and reliable.

Academic Self-Regulation Scale

The Academic Self-Regulation Questionnaire (SRQ-A) [24] is a tool designed to assess students' self-regulation strategies in an academic context. The SRQ-A uses four subscales: external regulation, introjected regulation, identified regulation, and intrinsic motivation. This questionnaire measures how students actively control their learning processes, including setting goals, monitoring progress, and employing effective study strategies. An example item is: "I do my homework in math class because I want the teacher to think I'm a good student." The questionnaire was rated on a scale of 1 (Not at All True) to 4 (Very True). The internal consistency for the SRQ-A was as follows: external regulation (0.86), introjected regulation (0.86), identified regulation (0.89), and intrinsic motivation (0.85). Hence, the instrument was valid and reliable.

2.4. Data Collection Procedure

The researcher followed a systematic approach to gathering data, consisting of three phases. Firstly, the research study underwent an ethics review of the college to ensure safety, fairness, and impartiality. Secondly, formal approval was obtained from the Dean of the College of Education, with further endorsement sought from the department's area chairman. Lastly, the instruments were administered through both online and face-to-face surveys. The researcher explained the study's purpose and data processing procedures to the respondents, obtained consent, and distributed the questionnaires. Following completion, students were given 10 - 15 minutes to reflect and answer the survey questionnaire.

2.5. Data Analysis

This research employed diverse statistical methods to examine the data. First, frequency count and percentage were utilized to outline the participants' academic achievement. Then, mean scores and standard deviation were employed to depict the mathematics self-concept and academic self-regulation levels. Then, Pearson's correlation coefficient was applied to explore the variables' relationships. Finally, stepwise multiple linear regression was utilized to identify the factors that predict mathematics achievement.

2.6. Ethical Considerations

The researcher ensured ethical standards were upheld in data collection. They clarified the study's purpose, obtained consent, and assured participants confidentiality. Participants volunteered and could withdraw at any time. The researchers adhered to the Philippines' Data Privacy Act of 2012. These measures safeguarded participants' rights and confidentiality.

3. Results and Discussions

3.1. Academic Achievement in Mathematics of the Pre-Service Mathematics Teachers

Table 1. Achievement in mathematics

Academic Achievement	f	%	Verbal Description
95 and above	1	1.41	Excellent
90 - 94	10	14.08	Very Good
85 - 89	26	36.62	Good
80 - 84	20	28.17	Fair
75 - 79	14	19.72	Poor
Total	**71**	**100.00**	

Table 1 illustrates pre-service mathematics teachers' academic achievement in mathematics, categorizing their performance across various grade ranges. This dataset encompasses 71 respondents, revealing a broad spectrum of academic achievement. Notably, most pre-service teachers fall within the "Good" category, with 36.62% (26 out of 71) achieving grades between 85 and 89. This suggests a decent understanding of mathematical concepts and skills among pre-service teachers. Contrarywise, 19.72% (14 out of 71) of pre-service teachers received grades categorized as "Poor" (75 - 79), signaling potential challenges or areas requiring further support. Additionally, one among pre-service teachers (1.41%) achieved an exceptional score of 95 or above, reflecting that only one had an outstanding mastery in mathematics.

Most pre-service teachers had good mathematics achievement levels, indicating that many individuals have attained satisfactory content mastery. Guinocor *et al.* (2020) [25] & Rodrigo & Prudente (2024) [26] found similar findings that most Filipino education students majoring in Mathematics attained a proficient level of mathematics achievement. However, the 2022 Program for International Student Assessment (PISA) depicts a different story wherein the Philippines ranked sixth from the bottom in mathematics (76th out of 81 countries) [27]. This demonstrated that Filipino students possess insufficient proficiency in mathematics compared to their counterparts in other countries within the same age range. The findings were still logical, given that the participants in the research were pre-service mathematics teachers. Hence, they are more proficient than the

general population [28]. To summarize, although there are praiseworthy high achievers among the pre-service mathematics teachers, the considerable percentage of students falling into the "Fair" and "Poor" categories is worrisome. To improve academic achievement, it is vital to address these issues by implementing specific interventions, reviewing the curriculum, and providing professional development opportunities for instructors. This, in turn, will better prepare pre-service teachers to educate future generations of students in mathematics effectively.

3.2. Mathematics Self-Concept of the Pre-Service Mathematics Teachers

Table 2. Mathematics self-concept.

Mathematics Self-Concept	Mean	SD	Verbal Description
1. Mathematics is one of my best subjects.	3.10	0.57	Moderate
2. I do badly in tests of mathematics.*	2.25	0.65	Low
3. I have always done well in mathematics.	2.44	0.62	Low
4. I have trouble understanding anything with mathematics in it.*	2.39	0.62	Low
5. I often need help with mathematics.*	1.87	0.59	Low
6. I get good marks in mathematics.	2.77	0.46	Moderate
7. I enjoy studying for mathematics.	3.08	0.53	Moderate
8. I never want to take another mathematics course.*	2.59	0.71	Moderate
9. I look forward to mathematics classes.	3.03	0.54	Moderate
10. I hate mathematics.*	3.32	0.74	High
Overall Mean	**2.69**	**0.30**	**Moderate**

Note: *Reverse scoring was applied.

Table 2 describes the level of mathematics self-concept of the pre-service mathematics teachers. The overall mean score for mathematics self-concept was 2.69 (SD = 0.30), indicating a moderate level of self-concept among the participants. It suggests that, on average, pre-service teachers had a balanced perception of their mathematical knowledge and skills, with neither overly optimistic nor excessively pessimistic views. Item 10 has the highest mean score (M = 3.32, SD = 0.74). Since reverse scoring was applied, most pre-service mathematics teachers firmly held positive attitudes toward mathematics. Conversely, item 5 had the lowest mean score (M = 1.87, SD = 0.59). Likewise, reverse scoring was applied. The results suggest that pre-service teachers frequently seek assistance learning mathematical concepts or tasks from their teachers or peers.

Mathematics self-concept determines an individual's engagement, perseverance, and performance in mathematical tasks and courses. A moderate mean in-

dicates that pre-service mathematics teachers encounter positive and negative mathematical experiences and perspectives. The results align with the study of Delima & Cahyawati (2021) [29], where it was found that most respondents have a positive mathematics self-concept. Mathematical self-concept is crucial because it affects not only the learning process and mathematics achievement but also future career decisions and overall well-being [30]. In addition, the study of Goldman & Penner (2016) [31] shows that self-concept in mathematics is more closely related to the desire to pursue mathematics careers. Furthermore, the moderate overall mean emphasizes the importance of creating a positive and supportive learning environment in mathematics that promotes exploration, collaboration, and risk-taking. By recognizing and addressing pre-service mathematics teachers' diverse needs and experiences, educators can contribute to developing a more confident and competent generation of mathematics educators who are better equipped to inspire and engage their future students.

3.3. Describe the Academic Self-Regulation of the Pre-Service Mathematics Teachers

1) External Regulation

Table 3 shows the academic self-regulation of pre-service mathematics teachers, explicitly focusing on external regulation. The overall mean score for external regulation was 3.18 (SD = 0.36), indicating a moderate level of external

Table 3. External regulation.

External Regulation	Mean	SD	Verbal Description
1. I do my homework in math class because I'll get in trouble if I don't.	3.24	0.58	Moderate
2. I do my homework in math class because that's what I'm supposed to do.	3.55	0.61	High
3. I work on my math classwork so that the teacher won't yell at me.	2.89	0.71	Moderate
4. I work on my math classwork because that's the rule.	3.23	0.64	Moderate
5. I try to answer hard questions in math class because that's what I'm supposed to do.	3.25	0.56	Moderate
6. I try to answer hard questions in math class because I want the teacher to say nice things about me.	2.75	0.58	Moderate
7. I try to do well in school because that's what I'm supposed to do.	3.48	0.58	High
8. I try to do well in school because I will get in trouble if I don't do well.	3.14	0.71	Moderate
9. I try to do well in school because I might get a reward if I do well.	3.13	0.72	Moderate
Overall Mean	**3.18**	**0.36**	**Moderate**

regulation among the participants. Item 2 has the highest mean score (M = 3.55, SD = 0.61), suggesting that many pre-service teachers are motivated to complete their homework due to a sense of obligation and adherence to expected norms and responsibilities. On the other hand, item 6 has the lowest mean score (M = 2.75, SD = 0.58), signifying that personal recognition or approval from the teacher is a less significant driver for these pre-service teachers than other external motivators.

The results are comparable to the findings of El-Adl & Alkharusi (2020) [32], wherein most students had medium levels of extrinsic motivation and self-regulation in learning mathematics. External regulation pertains to circumstances where students rely on a teacher's guidance and supervision to manage their learning processes [33]. It encourages effort and performance by utilizing rewards as positive reinforcement for desired behavior. However, the drawback lies in extrinsic motivators potentially diverting students from genuine independent learning [34]. Pre-service math teachers are moderately motivated by external factors like rules and consequences. Recognizing the significant impact of external regulation on their academic behaviors can help educators develop strategies to boost intrinsic motivation. Creating an environment that balances external demands with opportunities for independent learning can better nurture self-regulated learners committed to their academic and professional growth.

2) Introjected Regulation

Table 4 illustrates the introjected regulation of pre-service mathematics teachers. The overall mean score for introjected regulation was 3.15 (SD = 0.39), indicating moderate introjected regulation. Item 9 has the highest mean score (M = 3.65, SD = 0.48). It shows that pre-service teachers are driven by internal satisfaction and positive self-regard from academic performance. On the other hand, item 5 has the lowest mean score (M = 2.15, SD = 0.63). It only implies that the desire for peer approval or recognition is a less significant motivator for these pre-service teachers.

Introjected regulation refers to acting due to a sense of obligation rather than an internal desire or enjoyment but tends to enact it out of a sense of obligation or guilt [35] [36]. This might be evident as students feel compelled to study or perform well to avoid feelings of shame or to maintain their self-esteem. It was a crucial variable in mitigating the adverse effects of motivation on turnover intention [37]. Introjected regulation, students may develop a stronger sense of commitment and purpose in their academic endeavors, reducing their likelihood of giving up or losing interest. The data underscores that some pre-service teachers are primarily driven by the need to uphold a positive self-image and avoid negative self-perceptions. Educators can develop interventions that promote more constructive forms of motivation. By prioritizing the cultivation of internal motivation and creating a nurturing atmosphere that minimizes excessive stress it can improve their educational journey and readiness for their future careers.

Table 4. Introjected regulation.

Introjected Regulation	Mean	SD	Verbal Description
1. I do my homework in math class because I want the teacher to think I'm a good student.	3.15	0.71	Moderate
2. I do my homework in math class because I will feel bad about myself if I don't do it.	3.37	0.68	High
3. I work on my math classwork because I want the teacher to think I'm a good student.	3.13	0.66	Moderate
4. I work on my math classwork because I'll be ashamed of myself if it doesn't get done.	3.32	0.65	High
5. I try to answer hard questions in math class because I want the other students to think I'm smart.	2.15	0.63	Low
6. I try to answer hard questions in math class because I feel ashamed of myself when I don't try.	3.23	0.59	Moderate
7. I try to do well in school, so my teachers will think I'm a good student	2.94	0.59	Moderate
8. I try to do well in school because I'll feel really bad about myself if I don't do well.	3.45	0.56	High
9. I try to do well in school because I will feel really proud of myself if I do well.	3.65	0.48	High
Overall Mean	**3.15**	**0.39**	**Moderate**

3) Identified Regulation

Table 5 shows the academic self-regulation among pre-service mathematics teachers, specifically concentrating on identified regulations. The overall mean score for identified regulation was 3.52 (SD = 0.35), indicating a high level of identified regulation among the participants. Item 3 has the highest mean score (M = 3.70, SD = 0.46), which suggests that the primary driver for engaging with their math classwork is the intrinsic desire to acquire new knowledge and understanding. Meanwhile, item 6 has a relatively lowest mean (M = 3.31, SD = 0.58). This suggests that, while important, answering complex questions in class is slightly less motivating than other aspects of their academic work.

The results were similar to the findings of Abun & Magallanes (2018) [38] in that most STEM students have highly identified self-regulation. They explain that students have consciously acknowledged the importance of completing homework and classwork, actively participating in class discussions, and striving for academic success to attain personally valued goals. The consistently high mean scores across all items reflect a strong personal identification with learning and academic achievement goals. Identified regulation entails consciously recognizing and valuing a behavior, leading to acceptance when the action holds personal significance. This type of regulation is associated with more positive and adaptive outcomes [39]. It is a self-directed form of extrinsic motivation,

Table 5. Identified regulation.

Identified Regulation	Mean	SD	Verbal Description
1. I do my homework in math class because I want to understand the subject.	3.48	0.61	High
2. I do my homework in math class because it's important to me to do my homework.	3.58	0.52	High
3. I work on my math classwork because I want to learn new things.	3.70	0.46	High
4. I work on my math classwork because it's important to me to work on my classwork.	3.51	0.50	High
5. I try to answer hard questions in math class to find out if I'm right or wrong.	3.52	0.50	High
6. I try to answer hard questions in math class because it's important to me to try to answer hard questions in class.	3.31	0.58	High
7. I try to do well in school because it's important to me to try to do well in school.	3.51	0.50	High
Overall Mean	3.52	**0.35**	High

where behavior comes from personal choice rather than external pressure. Even if some students lack interest in math, they may consider it important because it supports their career goals [40]. Pre-service mathematics teachers are driven by a clear understanding of the importance of their educational activities and a deep-seated desire to excel and comprehend the subject matter thoroughly. Encouraging self-reflection on personal objectives and cultivating an environment that prioritizes and encourages intrinsic motivation can further strengthen their dedication to professional development and learning.

4) Intrinsic Motivation

Table 6 examines the academic self-regulation of pre-service mathematics teachers through the lens of intrinsic motivation. The overall mean score for intrinsic motivation was 2.86 (SD = 0.50), indicating a moderate level of intrinsic motivation among the participants. Item 10 has the highest mean score (M = 3.24, SD = 0.58). Pre-service teachers derive the most enjoyment from performing well in school. On the other hand, item 5 has the lowest mean score (M = 2.55, SD = 0.65). Although still moderate, this lower score suggests that the enjoyment explicitly derived from tackling difficult questions in class is less significant compared to other academic activities.

Intrinsic motivation stems from within and is fueled by the desire for exploration, curiosity, and experimentation, which are inherently motivating behaviors. Research over time has revealed that students with strong intrinsic motivation typically excel academically compared to those with weaker inherent drive [41]. In addition, Heyder *et al.* (2020) [42] mention in their paper that students'

Table 6. Intrinsic motivation.

Intrinsic Motivation	Mean	SD	Verbal Description
1. I do my homework in math class because it's fun.	2.87	0.68	Moderate
2. I do my homework in math class because I enjoy doing my homework.	2.87	0.59	Moderate
3. I work on my math classwork because it's fun.	2.93	0.71	Moderate
4. I work on my math classwork because I enjoy doing my classwork.	2.93	0.59	Moderate
5. I try to answer hard questions in math class because I enjoy answering hard questions.	2.55	0.65	Moderate
6. I try to answer hard questions in math class because it's fun to answer hard questions.	2.62	0.75	Moderate
7. I try to do well in school because I enjoy doing my schoolwork well.	3.24	0.58	Moderate
Overall Mean	**2.86**	**0.50**	**Moderate**

intrinsic motivation in mathematics is a crucial indicator of their willingness to invest effort, maintain persistence, and achieve learning objectives. Moreover, Lui (2021) [43] reported similar results of students' moderate intrinsic motivation (interest) in mathematics and suggested that educators can benefit from a dual approach that cultivates an incremental mindset and emphasizes both mastery and performance-approach goals, as this strategy promotes intrinsic motivation and boosts academic performance.

Thus, students with a sincere interest and intrinsic motivation towards mathematical concepts and problem-solving are more inclined to actively participate in learning activities, persevere in the face of difficulties, and ultimately achieve a profound comprehension and mastery of mathematical skills. Educators can help future teachers develop stronger intrinsic motivation by creating an educational environment emphasizing enjoyment and personal interest in learning. This can positively impact their teaching practices and ability to inspire similar motivations in their students.

3.4. Relationship between Academic Achievement, Mathematics Self-Concept, and Academic Self-Regulation of Pre-Service Mathematics Teachers

Table 7 presents the correlational analysis highlighting the importance of self-concept and various forms of academic regulation in improving the academic achievement of pre-service mathematics teachers.

Firstly, the correlation analysis shows a significant moderate relationship between academic achievement and mathematics self-concept ($r = 0.577$, $p < 0.01$). This indicates that pre-service mathematics teachers with a higher self-concept in mathematics tend to have better academic achievement. Rueda-Gomez *et al.*

Table 7. Correlation of academic achievement, mathematics self-concept, and academic self-regulation.

Variables	1	2	3	4	5	6
Academic Achievement	1					
External Regulation	0.101	1				
Introjected Regulation	0.226	0.555**	1			
Identified Regulation	0.292*	0.542**	0.588**	1		
Intrinsic Motivation	0.259*	0.321**	0.548**	0.499**	1	
Self-Concept	0.577**	0.288*	0.323**	0.469**	0.495**	1

Note: *$p < 0.05$, **$p < 0.01$.

(2023) [44] also found a direct association between students' mathematical self-concept and academic performance. Students who believed excelling in mathematics increased their sense of value in the classroom and achieved better academic results. Similarly, Aren, Frenzel & Goetz (2020) [45] concluded mathematics self-concept had a significant correlation to grades and test scores; positive beliefs in one's competence drive success and accomplishments. Mathematics self-concept encompasses a student's perception of their abilities in mathematics, suggesting that positive self-perceptions can enhance academic achievement.

Academic self-regulation, measured through different forms of motivation, also shows significant correlations with academic achievement. Identified regulation, which refers to engaging in an activity because it is personally meaningful and aligned with one's values, shows a weak significant correlation with academic achievement ($r = 0.292$, $p < 0.05$). This implies that pre-service teachers that perceive mathematics learning as valuable and meaningful had slightly better their academic achievement. Likewise, intrinsic motivation, which involves engaging in an activity for inherent satisfaction, correlates positively with academic achievement ($r = 0.259$, $p < 0.05$). This suggests that pre-service mathematics teachers who find intrinsic enjoyment and interest in mathematics had achieved slightly higher academically. The results were similar to the study of Daniela (2015) [46], which found that learning outcomes/performance strongly correlates with all scales of self-regulation and motivation concepts except the external regulation scale. Academic performance improves when individuals are conscious of their objectives, exert control over their impulses, regulate their behavior, adhere to guidelines, prioritize thorough planning, and persist in striving for success. In line with this, Zhang *et al.* (2016) [47] infer that identified regulation significantly predicted interpersonal performance and adaptive performance. Meanwhile, Iyamuremye *et al.* (2023) [48] found that intrinsic motivation correlated positively with career motivation and significantly and positively correlated with mathematics achievement. Furthermore, Harges *et al.* (2017) [49] conclude that high-achieving students consistently had more posi-

tive attitudes toward mathematics and significantly higher intrinsic motivation than low-achieving students.

Meanwhile, the correlation between academic achievement and introjected regulation (r = .226, p > .05) is insignificant, indicating that motivation driven by internal pressures and self-worth contingencies did not affect academic achievement. Also, external regulation, which involves engaging in activities due to external rewards or pressures, shows no significant correlation with academic achievement (r = .101, p > .05), indicating that extrinsic motivators might not effectively enhance academic achievement.

It must be noted that mathematics self-concept is significantly correlated with external regulation (r = .288, p < .05), introjected regulation (r = .323, p < .01), identified regulation (r = .469, p < .01), and intrinsic motivation (r = .495, p < .01). The findings suggest that fostering a positive mathematics self-concept among pre-service teachers can enhance their self-regulatory behaviors, particularly those driven by intrinsic interest and personal value. This, in turn, can lead to better academic outcomes.

3.5. Predictors of Academic Achievement in Mathematics of Pre-Service Mathematics Teachers

The stepwise regression analysis results in Table 8 indicate that mathematics self-concept significantly predicts academic achievement in pre-service mathematics teachers. The results of the analysis reveal that only self-concept explains 33.3% (R^2 = 0.333) of the variance in academic achievement in mathematics among pre-service teachers (F = 34.422, p < 0.001), which implies that self-concept significantly predicts academic achievement in mathematics. In addition, the unstandardized coefficient (B) for Self-Concept is 9.44, with a standard error (SE) of 1.61, indicating that academic achievement in mathematics increases by approximately 9.44 points for each unit increase in self-concept. Moreover, the standardized coefficient Beta (β) is 0.577, highlighting a statistically significant moderate positive relationship between self-concept and academic achievement (t = 5.867, p < 0.001). This substantial proportion suggests that self-concept is a critical factor in improving the academic achievement of pre-service mathematics teachers.

Table 8. Predictors of academic achievement in mathematics.

Variable	B	SE	Beta (β)	t	Sig.	f	R^2	p
(Constant)	59.39	4.35						
Self-Concept	9.44	1.61	0.577	5.867	0.000	34.422	0.333	0.000

The data were consistent with Parker *et al.* (2017) [50], who stated that mathematics achievement was strongly and positively associated with mathematics self-concept and self-efficacy. They also reveal that mathematics self-concept predicts tertiary entrance ranks and undertaking post-school studies in science, technology, engineering, or mathematics. The longitudinal study conducted by

Susperreguy *et al.* (2018) [51] provides solid evidence that mathematics self-concept ability predicts later achievement. Notably, students with a more positive perception of their mathematics and reading abilities demonstrated higher achievement in these subjects, even among the lowest performers. These findings indicate that a positive self-concept of ability significantly influences motivation and academic success over time and across different performance levels. Furthermore, Clem *et al.* (2021) [52] deduced that the self-concept of ability and mathematical performance are developmentally interconnected. Enhancing students' enjoyment of math and alleviating their math anxiety can further strengthen their self-concept of ability in this subject.

These findings highlight the crucial role of mathematics self-concept in determining academic achievement. Since a stronger self-concept is linked to superior academic achievement, it is imperative to implement interventions that enhance pre-service teachers' perceptions of their mathematical abilities. Educational strategies should prioritize strengthening self-concept through positive reinforcement, creating supportive learning environments, and providing opportunities for mastery in mathematics. By cultivating a strong self-concept, educators can significantly improve the academic achievement of pre-service mathematics teachers, enabling them to reach higher academics.

4. Conclusion

This paper sheds light on how pre-service perceptions of their mathematical abilities and capacity to regulate their learning behaviors influence their academic achievement. Hence, the present study concluded the following statements based on the analysis. First, most of these pre-service mathematics teachers demonstrated a satisfactory understanding of mathematical concepts and skills, but further improvement is needed. Regarding self-concept, the pre-service teachers had a balanced perception of their mathematical knowledge and abilities. In terms of academic self-regulation, pre-service mathematics teachers have a strong personal commitment to their goals and moderate levels of motivation from both external factors and internal pressures. They also find satisfaction and interest in mathematics. Furthermore, the correlational analysis reveals that pre-service teachers with high levels of self-concept, identified regulation, and intrinsic motivation had better mathematics achievement. Lastly, the regression analysis further emphasizes that mathematics self-concept significantly predicts academic achievement, highlighting its crucial role in determining academic success. These findings suggest that educational interventions may enhance self-concept, helping pre-service teachers achieve higher academic standards and deeper engagement with their mathematical studies. Further studies with extended time frames and larger sample sizes are encouraged to validate the research paper's results.

Conflicts of Interest

The author declares no conflicts of interest.

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