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ARTICLE

A Mediation Analysis of Self-Esteem in the Relationship between Dark Triad and Loneliness among Future Science Educators

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Abstract

This study examined the structural relationships among Dark Triad traits, self-esteem, and loneliness, with particular emphasis on the mediating role of self-esteem. A quantitative cross-sectional survey design was employed, involving 165 prospective science teachers (M_{age} = 18.53, SD = 1.10) enrolled in the Science Education Study Program at Universitas Negeri Semarang. Participants meeting predefined inclusion criteria voluntarily completed three validated self-report measures: the Short Dark Triad (SD3), the UCLA Loneliness Scale, and the Rosenberg Self-Esteem Scale. Data were analyzed using Partial Least Squares Structural Equation Modelling (PLS-SEM) and hierarchical regression analysis. The results indicated that Dark Triad traits negatively predicted self-esteem ($\beta = -0.93$, $p < .001$) and positively predicted loneliness ($\beta = 0.97$, $p < .001$), whereas self-esteem negatively predicted loneliness ($\beta = -0.96$, $p < .001$). When self-esteem was included in the model, the direct effect of Dark Triad traits on loneliness decreased ($\beta = 0.63$), and the Sobel test confirmed a significant partial mediation effect ($Z = 6.13$, $SE = 0.04$, $p < .001$). These findings suggest that self-esteem functions as a protective psychological mechanism that attenuates the adverse effects of Dark Triad traits on loneliness. Accordingly, interventions aimed at strengthening self-esteem may contribute to enhancing the social and emotional well-being of prospective science educators.

Keywords: Dark Triad; Loneliness; Mediation; Self-Esteem; Teacher Education.

1. Introduction

The pursuit of a healthy and prosperous life constitutes a universal human aspiration and is explicitly reflected in the third Sustainable Development Goal, which emphasizes good health and well-being. Achieving this objective requires the adoption of adaptive lifestyle practices that respond to the increasing complexity of modern life, including balanced nutrition, regular physical activity,

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effective stress management, and meaningful social connectedness [1]. Beyond supporting physical functioning, these factors contribute to psychological resilience, which is essential for coping with contemporary demands.

For university students, the transition from late adolescence to early adulthood represents a critical developmental phase marked by emotional instability, heightened sensitivity, and internal conflicts. These challenges often interfere with their capacity to maintain well-being while managing academic and social demands [2]. The need to adapt to new environments, expectations, and routines further increases susceptibility to psychological strain. Over time, such conditions may elevate the risk of emotional difficulties, among which loneliness has emerged as a particularly prevalent concern in higher education contexts. As a subjective psychological experience that can develop gradually and intensify without explicit external indicators, loneliness has attracted increasing scholarly attention due to its significant implications for mental health and functioning.

Loneliness is commonly defined as a perceived discrepancy between desired and actual social relationships [3]. It is associated with unmet social expectations and diminished emotional competence [4]. Empirical evidence indicates that adolescents and young adults are especially vulnerable to loneliness, given the developmental demands of establishing peer relationships and adapting to new social environments [5] [6] [7]. Among university students, loneliness has been shown to impair cognitive functioning (e.g., reduced concentration and increased forgetfulness) and to exacerbate psychological distress, including anxiety [8]. Contributing factors include relocation to unfamiliar environments [9], adjustment to new living arrangements [10], and limited access to meaningful social support [11].

Importantly, loneliness may persist even among individuals with frequent social interactions, indicating that it is more closely linked to subjective perceptions than to objective social contact [12]. A substantial body of research further demonstrates that loneliness is associated with a wide range of adverse outcomes, including somatic complaints such as headaches [13] [14], heightened stress [15] [16], depression [17] [18] [19] [20] [21], anxiety [19] [22] [21], sleep disturbances [23] [24], disordered eating [25] [26], and suicidal ideation [27] [28]. These findings underscore the importance of identifying psychological factors that may either mitigate or exacerbate loneliness among university students.

Self-esteem has been consistently identified as a key psychological factor associated with loneliness. Social Exclusion Theory posits that experiences of rejection, isolation, or insufficient social support undermine individuals' perceived relational value, thereby contributing to lower self-esteem [29]. From this perspective, self-esteem functions as an internal gauge of social acceptance, reflecting the extent to which individuals perceive themselves as valued within their social environment.

Empirical evidence indicates that individuals with low self-esteem are more likely to withdraw from social interactions and engage in negative self-evaluations, both of which intensify feelings of loneliness [30] [31]. Conceptually, self-esteem represents a global evaluation of one's self-worth in relation to others [32], and a growing body of research suggests a reciprocal association between self-esteem and loneliness in young adult populations [33] [34]. This bidirectional relationship indicates that diminished self-esteem may increase vulnerability to loneliness, while persistent loneliness may further erode self-perceptions of worth.

Within educational contexts, self-esteem plays a critical role in shaping academic motivation, persistence, achievement, and career readiness—factors that are essential for students preparing to enter professional domains [35] [36] [37] [38] [39] [40]. Given these functions, self-esteem can be conceptualized not merely as an associated variable but as a potential psychological mechanism that influences how individuals experience and respond to loneliness. Accordingly, self-esteem may operate as a buffering mechanism in higher education settings, where demands for social integration,

peer collaboration, and continuous evaluation increase the likelihood of loneliness.

Another psychological factor that has been linked to loneliness is the dark triad, which refers to a constellation of socially aversive personality traits comprising Machiavellianism, narcissism, and psychopathy. Individuals who exhibit high levels of these traits often engage in manipulation, impulsivity, emotional detachment, and aggressive conduct that undermine their capacity to form healthy social relationships [41] [42] [43] [44]. Empirical studies have reported positive associations between dark triad traits and loneliness, suggesting that individuals with these tendencies may struggle to sustain meaningful interpersonal connections due to mistrust, self-centeredness, or callous behavior [45] [46].

The relevance of the above traits becomes more pronounced in the context of future science educators, who are expected to develop emotional regulation, interpersonal awareness, and ethical classroom conduct. Educators who display narcissistic or Machiavellian tendencies may engage in favoritism, manipulative decision-making, or unethical practices that negatively shape student relationships and classroom dynamics [47] [48] [49]. When combined with low self-esteem and persistent loneliness, these tendencies may further undermine teaching effectiveness and increase susceptibility to counterproductive behavior that affects both professional preparation and long-term practice.

Beyond these personality considerations, science education introduces distinctive academic, emotional, and professional stressors that may intensify students' psychological vulnerability. Prospective science educators are required to manage high cognitive load stemming from abstract scientific concepts, demanding laboratory activities, data-based reasoning, and responsibilities related to safety procedures that require continuous attentiveness. These rigorous conditions frequently generate performance pressure, self-doubt, and internal competition, particularly when students must consistently demonstrate accuracy, precision, and conceptual mastery. Such pressures can gradually elevate emotional strain, diminish perceived competence, and increase the likelihood of social withdrawal. In addition to cognitive demands, science teacher education programs require students to navigate practicum preparation, microteaching performance, and reflective pedagogical tasks that expose them to continuous evaluation from lecturers, peers, and school mentors.

The simultaneous expectation to master pedagogical knowledge, scientific communication, and laboratory competencies creates multiple layers of responsibility that interact with students' personality profiles. For individuals exhibiting higher levels of dark triad traits or lower self-esteem, these challenges may amplify maladaptive tendencies such as avoidance, diminished help-seeking behavior, or defensive interpersonal patterns. Consequently, the unique structure of science education environments not only heightens psychological strain but may also magnify the negative interplay between dark triad traits, self-esteem, and susceptibility to socioemotional difficulties.

Despite the extensive research on loneliness, self-esteem, and dark triad traits among adolescents and the general university population, no study has examined the interaction of these psychological variables within the specific context of future science educators. Students enrolled in teacher education programs face unique psychological and professional demands that differentiate them from other university cohorts, yet the literature has not addressed how dark triad traits, self-esteem, and loneliness operate together within this group. Furthermore, existing studies have not investigated whether self-esteem serves as a mediator in the relationship between the dark triad and loneliness, leaving a conceptual and empirical gap that limits our understanding of how these variables interact in populations preparing for teaching careers. Addressing this gap offers meaningful theoretical and practical contributions because the interplay of these factors may shape not only the personal well-being of future science educators but also the classroom environments they will eventually create. For this reason, the present study provides a novel analysis by proposing and testing a me-

diation model in which self-esteem serves as an intervening mechanism linking dark triad traits to experiences of loneliness among future science educators.

The purpose of this study is to investigate the mediating role of self-esteem in the relationship between dark triad traits and loneliness among future science educators. The following hypotheses are proposed:

1. H1: Dark triad has a significant negative relationship with self-esteem.
2. H2: Self-esteem has a significant negative relationship with loneliness.
3. H3: Self-esteem mediates the relationship between the dark triad and loneliness.

2. Methods

2.1 Research Design and Participants

This study employed a quantitative approach with a cross-sectional survey design. The sampling strategy employed was convenience sampling, as data were collected from prospective science teachers who were readily accessible and met the eligibility requirements during the data collection period. Participants were prospective science teachers officially enrolled in the Science Education Study Program, Faculty of Mathematics and Natural Sciences, Universitas Negeri Semarang, during the 2023/2024 and 2024/2025 academic years. To ensure the relevance of the findings, participants were required to be actively preparing for future teaching roles and willing to complete the online questionnaire voluntarily. Only respondents who completed all instrument items without missing data were included in the final analysis. No restrictions were applied regarding gender during the recruitment process. However, gender distribution was documented to account for its potential influence on the measured psychological variables. The final sample consisted of 165 prospective science teachers, comprising 22% males and 78% females. This information was recorded to ensure analytical transparency, particularly because previous research indicates that men tend to exhibit higher scores on dark triad traits than women [50]. The inclusion of gender distribution strengthens the interpretive validity of the findings and reduces potential confounding bias.

2.2 Instruments and Data Collection

This study employed three self-report instruments with strong psychometric properties and no cross-cultural validation issues (see Table 1). The Short Dark Triad (SD3) [51] measures three dark personality traits: Machiavellianism (9 items; α = .77), narcissism (9 items; α = .71), and psychopathy (9 items; α = .80). Responses are given on a 4-point scale ranging from "strongly agree" to "strongly disagree", with higher scores reflecting stronger dark personality traits. The UCLA Loneliness Scale [52] consists of 20 items (α = .96; two-month test–retest correlation = .73) assessing subjective feelings of loneliness and social isolation. Participants rate each item on a 4-point scale from 1 (never) to 4 (often), with nine items reverse scored (frequently = 4). Lower scores indicate higher levels of loneliness. The Rosenberg Self-Esteem Scale (RSES) [53] comprises 10 items that assess global self-esteem through both positive and negative self-perceptions. Items are rated on a 4-point scale, ranging from "strongly agree" to "strongly disagree," with five items reverse-scored (strongly disagree = 1). Higher scores indicate greater self-esteem.

Table 1. Research Instrument Specifications

Variable	Indicator	Item Number
Dark Triad	Machiavellianism	1, 2, 3, 4, 5, 6, 7, 8, 9
	Narcissism	10, 11, 12, 13, 14, 15, 16, 17, 18
	Psychopathy	19, 20, 21, 22, 23, 24, 25, 26, 27
Loneliness	Environmental harmony	1*, 6*, 12, 18

	Need for friendship	2, 5*, 7, 9*, 10*, 11, 15*, 16*, 19*
	Self-isolation	3, 4, 8, 13, 14, 17, 20*
Self Esteem	Confidence in one's own abilities	1, 3, 4, 7, 10
	Distrust	2*, 5*, 6*, 8*, 9*

Note: items with * are scored reversed

2.3 Data Analysis

Participant responses obtained from the instruments were analyzed using Structural Equation Modelling (SEM) to describe the self-esteem mediation model (M) in the structural relationship between the Dark Triad (X) and Loneliness (Y) among prospective science teachers. The Partial Least Squares-Structural Equation Modelling (PLS-SEM) approach was selected because no theories or consistent results have confirmed the studied model [54] [55] [56] [57]. In addition, Hierarchical Regression Analysis (HRA) was conducted to examine whether self-esteem functions fully or partially and significantly as a mediator between the Dark Triad and loneliness. Following Baron and Kenny [58], mediation was assessed through four criteria: (a) the predictor variable (Dark Triad) must be related to the mediator variable (self-esteem); (b) the predictor variable must be related to the dependent variable (loneliness); (c) the mediator variable must be related to the dependent variable; and (d) after controlling for the mediator, the relationship between the predictor and the dependent variable should be significantly reduced, indicating that the mediator successfully intervenes between the other two variables [58]. The theoretical research framework for this model is illustrated in Figure 1.

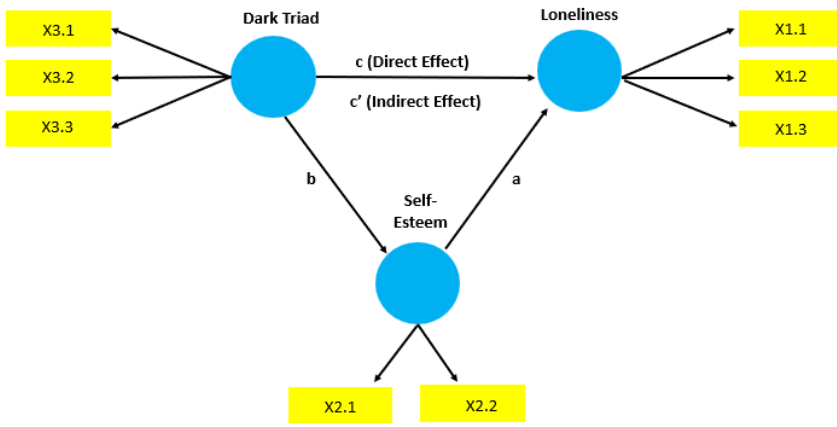

Figure 1. Theoretical Research Framework Model

3. Results and Discussion

3.1 Results

This research generally tests the mediation model of self-esteem (M) on the structural relationship between Dark Trait (X) and Loneliness (Y), which is elaborated in three proposed hypotheses. The first step is to explore the feasibility of the outer and inner models (see Figure 2). For the outer model, there are four indicators of feasibility starting from Cronbach's alpha reliability, composite reliability, convergent validity (Average Variance Extracted or AVE), and discriminant validity (cross-loading)

[59] [60] [61]. The summary in Table 2 indicates that the outer model is feasible, as each aspect has a satisfactory value.

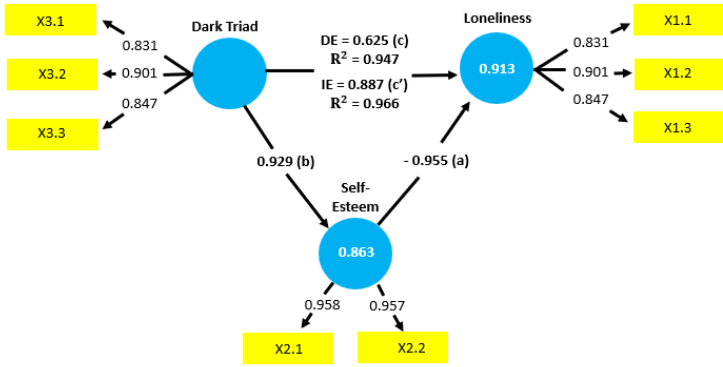

Figure 2. Structural relationship (using β coefficient) between dark triad and loneliness, with the role of self-esteem as a mediating variable

Table 2. Reliability, Convergent Validity (AVE), and Discriminant Validity (Cross-Loading)

Parameter	Dark Triad	Loneliness	Self-Esteem
Cronbach's Alpha Reliability (α)	.824	.895	.740
Composite Reliability (ρ_c)	.841	.886	.859
Average Variance Extracted (AVE)	.910	.907	.917
Cross Loading			
DT1	.706	.529	-.459
DT2	.763	.530	-.523
DT3	.790	.453	-.411
DT4	.872	.616	-.549
DT5	.665	.542	-.588
DT6	.710	.361	-.425
DT7	.727	.480	-.440
DT8	.643	.467	-.434
DT9	.843	.566	-.534
DT10	.852	.605	-.552
DT11	.723	.712	-.660
DT12	.808	.526	-.571
DT13	.871	.630	-.645
DT14	.735	.610	-.590
DT15	.822	.414	-.372
DT16	.864	.425	-.415
DT17	.818	.500	-.524
DT18	.761	.399	-.400

	DT19	.794	.582	-.568
	DT20	.714	.505	-.495
	DT21	.747	.523	-.537
	DT22	.652	.481	-.531
	DT23	.711	.491	-.506
	DT24	.764	.480	-.477
	DT25	.624	.488	-.475
	DT26	.782	.609	-.582
	DT27	.703	.550	-.521
	L1	.128	.804	-.127
	L2	.774	.815	-.786
	L3	.721	.797	-.771
	L4	.716	.788	-.744
	L5	.618	.631	-.539
	L6	.589	.646	-.583
	L7	.749	.774	-.755
	L8	.669	.737	-.728
	L9	.494	.758	-.463
	L10	.539	.681	-.504
	L11	.687	.728	-.608
	L12	.556	.695	-.568
	L13	.400	.722	-.415
	L14	.477	.603	-.483
	L15	.417	.733	-.431
	L16	.412	.731	-.398
	L17	.272	.688	-.290
	L18	.223	.790	-.191
	L19	.138	.890	-.180
	L20	.260	.766	-.278
	SE1	-.723	-.741	.770
	SE2	-.458	-.510	.733
	SE3	-.832	-.864	.880
	SE4	-.838	-.869	.902
	SE5	-.763	-.780	.825
	SE6	-.785	-.824	.836
	SE7	-.732	-.701	.807
	SE8	-.651	-.657	.758
	SE9	-.656	-.648	.762

The evaluation of the structural (inner) model indicates acceptable model performance, as reflected by the coefficients of determination (R^2) and effect sizes (f^2). These results suggest that the proposed model adequately explains the relationships among self-esteem, Dark Triad traits, and loneliness (see Figure 2). Notably, the use of global goodness-of-fit (GoF) indices in PLS-SEM should be interpreted with caution, as their applicability remains debated in the literature [54] [61]. Furthermore, the prerequisite analysis on hypothesis testing concluded that the variables of self-esteem, dark triad, and loneliness have a normal distribution (see Table 3), so that Hierarchical Regression Analysis (HRA) can be conducted. Regarding the relationship between the research variables, it appears that there is a significant but negative high correlation (r = -.929) between dark trait and self-esteem and a significant and positive high correlation (r = .973) between dark trait and loneliness.

Table 3. Descriptive Statistics, Correlation, and Normality Test Results

Scale	Self-esteem	Dark Triad	Loneliness
Self-esteem	1	-.929*	-.955*
Dark Triad		1	.973*
Loneliness			1

Mean	27.227	69.773	49.720
SD	7.672	11.917	8.523
Kolmogorov-Smirnov	.200**	.153**	.169**

* All correlation coefficients are significant at the level $p < .001$
** All normality tests are significant at the level $p < .001$

The summary of the regression analysis (see Table 4) concludes that all three hypotheses of this study are accepted. Although this was specifically only partial, not 100%, mediation was identified in the relationship between the dark trait and loneliness. In the first hypothesis, the value of $\beta = -.929$ with $p < .001$; in the second hypothesis, the value of $\beta = -.955$ with $p < .001$; and the third hypothesis, Baron & Kenny's [58] criteria and Sobel Test statistics which showed a decrease in beta weight ($\beta = 0.973$ to 0.625) after self-esteem was added to the equation. Hierarchical Regression Analysis confirmed the correlation results, providing answers to the three hypotheses proposed in this study.

Table 4. Standardized Coefficients for the Mediation Model

Antecedent	**Consequent**			
			M (Self-Esteem)	
	β	SE	t	*p*
X (Dark Triad)	-.929	.028	-21.428	.000*
		$R^2 = .863$; $F = 459.164$, $p = .000*$		
			Y (Loneliness)	
	β	SE	t	*p*
M (Self-Esteem)	-.955	.038	-27.621	.000*
		$R^2 = .913$; $F = 762.915$, $p = .000*$		
			Y (Loneliness)	
	β	SE	t	*p*
X (Dark Triad)	.973	.019	36.142	.000*
		$R^2 = .947$; $F = 1306.221$, $p = .000*$		
			Y (Loneliness)	
	β	SE	t	*p*
X (Dark Triad)	.625	.042	10.707	.000*
M (Self-Esteem)	-.374	.065	-6.412	.000*
		$R^2 = .966$; $F = 1032.548$, $p = .000*$		

* All β Coefficients significant at $p < .001$

Based on the identification of the mediation effect summarized in Table 5, it is evident that the direct effect of the Dark Triad on loneliness ($c' = .625$; $p < .001$) is smaller than the indirect effect through self-esteem ($a \times b = -.955 \times -.929 = .887$; $p < .001$). In terms of the mediation direction, the findings indicate complementary mediation, meaning that both the direct and indirect effects support the hypotheses. This suggests that individuals with higher Dark Triad scores tend to have lower self-esteem, which in turn increases their level of loneliness.

Table 5. Direct and Indirect Effects

Effect Types	**Path**	**Effect**	*p*
Direct Effect	Dark Triad → Loneliness (c')	.625	.000*
Indirect Effect	Dark Triad → Self-Esteem → Loneliness ($a \times b$)	$-.955 \times -.929 = .887$	.000*

*significant at level $p < .001$

3.2 Discussion

The present study investigated the structural relationships among the dark triad, self-esteem, and loneliness by validating the measurement and structural components of the SEM-PLS model. The outer model evaluation demonstrated strong internal consistency, convergent validity, and discriminant validity, confirming that the indicators appropriately represented their respective constructs. Cronbach's Alpha and Composite Reliability values met recommended thresholds, while AVE and cross-loading patterns established valid construct differentiation. The fulfillment of these criteria confirms that the measurement framework provides a solid foundation for interpreting the subsequent structural results. These outcomes align with methodological recommendations by [60], [57], [62], [59], and [54], underscoring the soundness of the measurement model.

Structural evaluation further demonstrated substantial explanatory power, with R^2 indicating that loneliness was predominantly influenced by the dark triad and self-esteem. Effect size values indicated meaningful contributions from both predictors, while the GoF value suggested adequate model suitability. These findings provide initial confirmation that the relational structure among the dark triad, self-esteem, and loneliness functions consistently within the population of prospective science teachers studied. Meeting all analytical criteria positioned the model for reliable hypothesis testing, consistent with the standards outlined by [62] and [56]. Taken together, the structural assessments show that the model accurately captures the mechanisms under investigation.

Following confirmation of model adequacy, hypothesis testing was conducted to assess the interrelationships among the constructs. The first hypothesis was supported, revealing a significant negative association between the dark triad and self-esteem. This relationship suggests that individuals who exhibit more pronounced dark triad traits tend to experience lower self-esteem. Although this finding contrasts with the perspectives of [50] and [63], it aligns with arguments that high self-esteem may be context-dependent and can manifest in either adaptive or maladaptive forms [64]. A more coherent theoretical explanation is that the negative association may reflect the dominance of vulnerable narcissism, which is characterized by insecurity and hypersensitivity and is consistently linked with lower self-esteem as reported in recent studies [65].

In collectivistic cultural contexts, individuals tend to adopt a more self-critical rather than self-enhancing orientation, and positive self-regard is not considered a universal motive [66]. Moreover, self-enhancement and self-protection motivations appear more prevalent in Western rather than Eastern societies [67]. These patterns imply that prospective science teachers may perceive dark traits as incompatible with the ethical and relational expectations of their future profession, thereby lowering rather than elevating their self-esteem. This interpretation reflects the developmental emphasis within teacher preparation programs, which cultivate professional competence, reflective practice, and moral grounding.

The manifestation of dark triad traits within educational contexts has been documented in prior studies, particularly in teachers' interpersonal behaviors and instructional decisions [68] [69] [70]. Narcissistic tendencies may draw attention away from student needs; Machiavellian traits may encourage manipulation; and psychopathic attributes may reduce empathy and accountability. The negative link found in this study reinforces the understanding that when teacher candidates internalize professional norms emphasizing care, fairness, and responsibility, dark traits clash with these expectations and subsequently diminish their self-perception. This highlights why personality development remains central to teacher training and future teaching practice.

The second hypothesis was also supported, demonstrating a significant negative relationship between self-esteem and loneliness. This finding aligns with research indicating that individuals with higher self-esteem tend to display stronger social effectiveness, greater emotional stability, and resilience when navigating social environments [71] [72] [73] [74] [75]. Individuals with strong self-

esteem tend to feel competent, valued, and socially connected, which protects them from loneliness and related mental health challenges [30]. These results support the theoretical premise that self-esteem functions as a psychological buffer, promoting social adjustment and protecting emotional well-being among prospective teachers. This reinforces the importance of self-esteem as a central component in the conceptual model.

The third hypothesis was partially supported, with findings indicating that self-esteem mediates the relationship between the dark triad and loneliness. The reduction of the direct coefficient of the dark triad after the inclusion of self-esteem, together with the Sobel Test results, confirmed this mediating effect. These results demonstrate that dark traits influence loneliness not only directly but also indirectly by undermining individuals' self-esteem, which acts as an internal psychological pathway linking personality to social-emotional outcomes. However, because the direct pathway remained significant, the mediation was identified as partial rather than full, consistent with the criteria proposed by [58] and [76]. This partial mediation suggests the presence of additional factors that may further explain how dark traits shape loneliness.

Effect identification analysis provided further clarity by showing that the indirect effect through self-esteem was stronger than the direct effect of the dark triad. This aligns with the classification of complementary mediation, where both direct and indirect effects are significant and operate in the same direction [61]. These findings strengthen the conceptual framework of the study by confirming that self-esteem serves as a critical mechanism through which personality traits translate into feelings of social disconnection among prospective science teachers. Future investigations may explore additional mediators such as empathy, emotional regulation, or social support, which may contribute to a more comprehensive understanding of these dynamics.

The broader implications of these findings underscore the importance of considering prospective teachers' emotional and psychosocial characteristics [77] [78]. Empirical evidence suggests that teacher–student relationships characterized by care, trust, support, and high expectations have a positive influence on students' motivation and well-being [79]. Teacher personality and character also play central roles in learning success, student engagement, and personal development [80] [81]. In the current cultural context, dark triad traits may be perceived as incompatible with the communal values and professional expectations of teachers, who are ideally seen as caring, humble, cooperative, and socially responsible. This perception can lead individuals with such tendencies to experience internal conflict in developing their identity as future educators. This situation may also reflect manifestations of vulnerable narcissism as a subtype of narcissism that is marked by insecurity and hypersensitivity, and that tends to amplify negative self-evaluations when social norms emphasize moral character and relational harmony.

The evidence from this study underscores the importance for prospective teachers to cultivate positive self-esteem and mitigate detrimental personality traits that increase vulnerability to loneliness, as these factors impact their readiness to become competent, adaptive, and emotionally resilient educators. Strengthening alignment between personal values and the expectations of the teaching profession becomes essential to reduce psychological strain experienced by individuals who struggle to meet communal and ethical standards. Teacher education programs should continue emphasizing character development, empathy, and professional ethics while providing systematic support to help prospective educators manage maladaptive tendencies without stigma or self-devaluation. Enhancing psychological resilience and self-understanding remains critical in preparing future teachers for effective professional practice.

4. Conclusion

This study provides empirical evidence that Dark Triad traits are negatively associated with self-esteem and positively associated with loneliness, with self-esteem functioning as a significant partial mediator. These findings suggest that self-esteem may serve as an important psychological mechanism through which socially aversive personality traits influence loneliness among prospective science teachers. By examining both direct and indirect effects, the study contributes to a more nuanced understanding of the interplay between personality characteristics and socio-emotional outcomes within educational contexts.

The results further indicate that strengthening self-esteem may help attenuate the negative implications of Dark Triad tendencies for emotional well-being and social adjustment. Accordingly, teacher education programs may benefit from incorporating structured developmental components, such as social-emotional learning, mentorship, and counseling, aimed at enhancing emotional regulation, interpersonal competence, and self-evaluative processes. However, such implications should be interpreted cautiously, given the cross-sectional nature of the data, which precludes causal inference.

Several limitations should be acknowledged. The use of a single-institution sample restricts the generalizability of the findings, and the reliance on self-report measures raises the possibility of common method bias. In addition, although gender distribution was reported, gender was not controlled for in the analysis. Future research should address these limitations by employing more diverse and representative samples, incorporating longitudinal or experimental designs, and examining the potential role of gender as a covariate or moderator through multi-group analyses. Such approaches would provide a more robust basis for understanding how personality traits and self-evaluative processes interact over time in shaping loneliness.

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