

CatBoost Prediction of Social Anxiety Among Students with Specific Learning Disabilities: Contributions of Rejection Sensitivity, Self-Compassion, and Peer Victimization

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ABSTRACT

The present study aimed to develop and evaluate a CatBoost machine learning model for predicting social anxiety among students with specific learning disabilities based on rejection sensitivity, self-compassion, and peer victimization, while determining the relative contribution of each predictor to model performance. This cross-sectional predictive study was conducted among 428 students with specific learning disabilities enrolled in secondary schools in Santiago, Chile. Participants completed standardized measures assessing social anxiety, rejection sensitivity, self-compassion, and peer victimization. Following data preprocessing and preliminary statistical analyses, a CatBoost machine learning algorithm was implemented to predict social anxiety levels. The dataset was divided into training (80%) and testing (20%) subsets, and hyperparameter optimization was performed using five-fold cross-validation. Model performance was evaluated using the coefficient of determination (R^2), root mean square error (RMSE), mean absolute error (MAE), and mean absolute percentage error (MAPE). Feature importance analysis and SHAP (Shapley Additive Explanations) values were calculated to identify the relative influence and directional effects of the predictors. The CatBoost model demonstrated strong predictive performance, accounting for 81.2% of the variance in social anxiety scores within the testing dataset ($R^2 = .812$). The model yielded low prediction errors (RMSE = 5.08, MAE = 3.94, MAPE = 8.46%), indicating high accuracy and generalizability. Feature importance analysis revealed that rejection sensitivity was the strongest predictor of social anxiety (41.82%), followed by peer victimization (34.67%) and self-compassion (23.51%). SHAP analyses showed that higher levels of rejection sensitivity and peer victimization were associated with increased social anxiety, whereas higher self-compassion was associated with lower social anxiety. Correlational analyses further indicated significant positive associations between social anxiety, rejection sensitivity, and peer victimization, alongside a significant negative association between social

anxiety and self-compassion. The findings demonstrate that social anxiety among students with specific learning disabilities is strongly influenced by interpersonal vulnerability factors and psychological resilience resources. Rejection sensitivity and peer victimization represent significant risk factors, whereas self-compassion serves as an important protective factor. CatBoost modeling provides an effective and interpretable approach for identifying students at risk and may support the development of targeted school-based prevention and intervention programs aimed at improving emotional well-being and social functioning.

Keywords: *Social Anxiety; Specific Learning Disabilities; Rejection Sensitivity; Self-Compassion; Peer Victimization*

1. Introduction

Social anxiety is among the most prevalent and disabling emotional difficulties experienced during adolescence and is characterized by intense fear of negative evaluation, social scrutiny, embarrassment, and rejection in interpersonal situations. During the school years, social anxiety can significantly interfere with academic engagement, peer relationships, classroom participation, emotional well-being, and long-term psychosocial development. Contemporary research has demonstrated that anxiety-related difficulties have become increasingly prominent among school-aged populations, particularly among students facing developmental, educational, and psychosocial vulnerabilities (Serenity et al., 2023; Sood et al., 2024). Adolescence represents a particularly sensitive developmental period because social acceptance and peer belonging become central psychological needs. During this stage, concerns about social status, peer approval, and interpersonal competence intensify, creating conditions under which social fears may emerge or worsen. Evidence suggests that social anxiety is not only associated with emotional distress but also predicts poorer academic outcomes, social withdrawal, loneliness, reduced quality of life, and elevated risk for subsequent psychopathology (Luoma et al., 2021; Serenity et al., 2023). Consequently, identifying the factors that contribute to social anxiety among vulnerable student populations has become an important objective for both educational and psychological research.

Students with specific learning disabilities constitute one of the groups most vulnerable to experiencing emotional and social difficulties. Specific learning disabilities encompass persistent difficulties in reading, writing, mathematics, or other academic skills despite adequate intelligence and educational opportunities. Although learning disabilities are often conceptualized primarily as academic challenges, increasing evidence demonstrates that their consequences extend far beyond classroom performance. Students with

learning disabilities frequently experience social exclusion, reduced peer acceptance, negative self-perceptions, and increased emotional distress, all of which may contribute to the development of anxiety-related symptoms (SoĀAnci & Kulesza, 2023). The psychosocial effects of learning disabilities often emerge through repeated experiences of academic failure, stigmatization, peer comparison, and perceived inadequacy. Such experiences can undermine self-confidence and increase vulnerability to social fears. Research examining children and adolescents with learning difficulties has consistently documented higher levels of emotional and behavioral problems compared to their typically developing peers, highlighting the need to better understand the psychological mechanisms that place these students at risk for adverse outcomes (Gagliano et al., 2024; Sutherland, 2025). Within educational settings, social anxiety may be particularly detrimental for students with learning disabilities because it can further reduce participation, willingness to seek help, classroom engagement, and opportunities for positive peer interaction.

One of the most influential interpersonal factors associated with social anxiety is rejection sensitivity. Rejection sensitivity refers to the tendency to anxiously expect, readily perceive, and intensely react to social rejection. Individuals high in rejection sensitivity often interpret ambiguous social situations as threatening and may become excessively vigilant to signs of exclusion or disapproval. Such cognitive-emotional patterns are closely aligned with the core features of social anxiety, including fear of negative evaluation and avoidance of social interactions. Adolescents who anticipate rejection are more likely to experience heightened emotional arousal during interpersonal encounters and may engage in avoidance behaviors that reinforce anxiety over time. The importance of interpersonal experiences in shaping emotional functioning has been emphasized across numerous developmental and psychopathological models (Bemmouna & Weiner, 2023; Hesselink, 2023). Students with learning disabilities may be particularly vulnerable to rejection

sensitivity because academic struggles can increase exposure to criticism, misunderstanding, and social marginalization. When repeated experiences of failure or exclusion occur, adolescents may develop expectations that rejection is inevitable, thereby increasing susceptibility to social anxiety. Understanding the role of rejection sensitivity may therefore provide valuable insights into why some students with learning disabilities develop significant social fears while others demonstrate greater resilience.

Peer relationships represent another critical domain influencing psychological adjustment during adolescence. Positive peer interactions provide opportunities for belonging, identity formation, and emotional support, whereas negative peer experiences can have profound consequences for mental health. Among these adverse experiences, peer victimization has emerged as one of the strongest predictors of emotional distress. Peer victimization encompasses a range of harmful behaviors, including physical aggression, verbal harassment, social exclusion, relational bullying, and cyberbullying. Extensive evidence indicates that victimized students are at elevated risk for anxiety, depression, low self-esteem, loneliness, and social withdrawal (Ahmed et al., 2022; Harsono & Febriyana, 2026; K. et al., 2023). Contemporary reviews have highlighted the widespread prevalence of bullying and its significant psychological consequences across educational contexts (Küing et al., 2025; Mihaela-Corina, 2022). Furthermore, longitudinal findings demonstrate that experiences of victimization contribute to persistent emotional difficulties that may continue well beyond adolescence (Hui et al., 2026; Shen et al., 2025). From a developmental perspective, repeated victimization may strengthen perceptions of social threat and reinforce expectations of rejection, thereby increasing vulnerability to social anxiety.

The relationship between peer victimization and emotional functioning appears especially relevant for students with learning disabilities. Research has consistently shown that students with special educational needs often experience lower levels of peer acceptance and higher rates of bullying than their peers without disabilities (Li, 2025). Learning-related difficulties may make students more visible targets for exclusion or harassment, particularly in educational environments where differences are poorly understood or inadequately accommodated. Studies examining school experiences among children with language and learning disorders have reported significant associations between victimization, impaired social skills,

and poorer psychosocial outcomes (García et al., 2021). Similarly, research has identified peer-group integration as an important protective factor that reduces vulnerability to victimization among students with learning disabilities (Marini et al., 2023). School and peer cultures play a substantial role in shaping these experiences, influencing whether students feel accepted, marginalized, or stigmatized within their educational communities (Gordon & Levesque, 2025). Consequently, investigating peer victimization as a predictor of social anxiety may provide important insights into the social mechanisms underlying emotional difficulties among students with learning disabilities.

While risk factors are important, contemporary psychological research increasingly emphasizes the role of protective factors that promote resilience and adaptive functioning. One such factor is self-compassion. Self-compassion refers to treating oneself with kindness, understanding, and acceptance during times of difficulty or failure. It encompasses self-kindness rather than self-criticism, recognition of common humanity rather than isolation, and mindful awareness rather than over-identification with negative emotions. Self-compassion has received growing attention as a protective psychological resource associated with emotional well-being, resilience, and reduced psychopathology. Research suggests that individuals with higher levels of self-compassion exhibit lower levels of anxiety, depression, shame, and stress while demonstrating greater emotional regulation and psychological flexibility (Meiri et al., 2024; Meiri & Aldawsari, 2024; Seabra et al., 2023). The capacity to respond to personal challenges with kindness rather than self-condemnation may be particularly important for adolescents who experience frequent academic or social setbacks.

The potential relevance of self-compassion for adolescents exposed to bullying and victimization has been increasingly recognized. Studies indicate that self-compassion may buffer the harmful emotional effects of negative peer experiences by reducing self-blame and fostering adaptive coping strategies (Múzquiz et al., 2022). Narrative reviews have similarly suggested that self-compassion interventions may help reduce the psychological consequences of bullying and cyberbullying while promoting healthier interpersonal functioning (Aledeh et al., 2024). Related evidence from mindfulness-based approaches demonstrates that acceptance, emotional awareness, and compassionate self-regulation contribute to reductions in anxiety and stress among adolescents and

marginalized populations (Serenity et al., 2023; Sun et al., 2022). Furthermore, self-compassion has been linked to improved well-being in individuals facing developmental and family-related challenges, indicating its broad protective value across diverse contexts (Agoglia, 2022; Finardi et al., 2022). For students with learning disabilities, self-compassion may serve as an important internal resource that mitigates the emotional consequences of academic struggles, rejection experiences, and peer victimization.

Despite substantial advances in understanding adolescent mental health, several important gaps remain in the literature. Much of the existing research has focused on traditional statistical approaches that assume linear relationships among variables. However, psychological phenomena such as social anxiety are often influenced by complex, nonlinear interactions among multiple risk and protective factors. Recent developments in machine learning offer new opportunities to address these complexities. Machine learning approaches can identify intricate patterns within data, improve predictive accuracy, and provide insights into variable importance that may not be detectable using conventional analytical methods. Educational and psychological researchers have increasingly adopted machine learning techniques to predict mental health outcomes, behavioral difficulties, and victimization experiences (Qiu et al., 2024). These approaches are particularly valuable when examining multidimensional constructs influenced by interacting cognitive, emotional, and social factors.

Among machine learning algorithms, CatBoost has emerged as a powerful gradient-boosting technique capable of handling complex datasets while minimizing overfitting and improving predictive performance. CatBoost offers advantages in modeling nonlinear relationships and interactions among predictors, making it particularly suitable for psychological research involving multiple interrelated variables. Although machine learning methods have been increasingly utilized in educational and mental health research, relatively few studies have applied these techniques to understand social anxiety among students with specific learning disabilities. Moreover, the combined contributions of rejection sensitivity, peer victimization, and self-compassion remain insufficiently understood within this population. Given that these variables represent theoretically meaningful interpersonal risk factors and intrapersonal protective resources, examining their relative importance through an advanced predictive framework may provide valuable guidance for prevention and intervention efforts.

The present study sought to address these gaps by employing a CatBoost machine learning model to predict social anxiety among Chilean students with specific learning disabilities based on rejection sensitivity, self-compassion, and peer victimization, while also examining the relative contribution of each predictor to model performance.

2. Methods and Materials

2.1. Study Design and Participants

The present study employed a cross-sectional predictive modeling design to investigate the extent to which rejection sensitivity, self-compassion, and peer victimization contribute to the prediction of social anxiety among students with specific learning disabilities. The study was conducted in Santiago, Chile, during the 2025–2026 academic year. The target population consisted of secondary school students who had been formally diagnosed with specific learning disabilities by educational psychologists and school support services in accordance with national educational assessment guidelines. Participants were recruited from public and private educational institutions that offered specialized educational support programs for students with learning disabilities. A total of 428 students participated in the study. Inclusion criteria included being between 13 and 18 years of age, having a documented diagnosis of specific learning disability, enrollment in a regular educational program, and the ability to comprehend and complete self-report questionnaires independently. Students with intellectual disabilities, autism spectrum disorder, severe psychiatric disorders, or significant sensory impairments were excluded to ensure the homogeneity of the sample. Prior to participation, informed consent was obtained from parents or legal guardians, and assent was obtained from the students.

2.2. Measures

Data collection was carried out using a battery of standardized psychological instruments with established psychometric properties. Social anxiety was assessed using the Social Anxiety Scale for Adolescents (SAS-A), originally developed by La Greca and Lopez (1998). This instrument consists of 22 items, including 18 substantive items and 4 filler items, designed to evaluate fear of negative evaluation, social avoidance and distress in new situations, and generalized social avoidance and distress. Responses are recorded on a five-point Likert scale ranging from 1 (not at

all) to 5 (all the time), with higher scores indicating greater levels of social anxiety. Numerous studies have demonstrated satisfactory validity and reliability of the scale across adolescent populations, including students with educational and psychological challenges.

Rejection sensitivity was measured using the Rejection Sensitivity Questionnaire (RSQ), developed by Downey and Feldman (1996). The instrument evaluates anxious expectations and concerns regarding interpersonal rejection through a series of hypothetical social situations. Participants indicate both their level of anxiety concerning possible rejection and their expectations of acceptance in each situation. Composite scores are calculated according to the developers' scoring procedures, with higher scores reflecting greater rejection sensitivity. Previous research has consistently reported strong internal consistency, construct validity, and predictive validity for the RSQ across diverse adolescent and educational populations.

Self-compassion was assessed using the Self-Compassion Scale (SCS) developed by Neff (2003). The scale comprises 26 items distributed across six dimensions: self-kindness, self-judgment, common humanity, isolation, mindfulness, and over-identification. Participants respond on a five-point Likert scale ranging from 1 (almost never) to 5 (almost always). After reverse-scoring negatively worded items, higher total scores indicate greater self-compassion. The SCS has been extensively validated in international studies and has demonstrated satisfactory psychometric properties among adolescent and student populations. Previous research has confirmed the scale's reliability, factor structure, and criterion-related validity.

Peer victimization was measured using the Multidimensional Peer Victimization Scale (MPVS), developed by Mynard and Joseph (2000). This instrument consists of 16 items assessing four dimensions of peer victimization, including physical victimization, verbal victimization, social manipulation, and attacks on property. Responses are recorded on a three-point scale reflecting the frequency of victimization experiences. Higher scores indicate greater exposure to peer victimization. The MPVS has demonstrated adequate reliability and validity in adolescent samples and has been widely used in studies examining social adjustment, emotional functioning, and school-related psychosocial outcomes.

2.3. Data Analysis

Data collection was conducted in classroom settings under the supervision of trained research assistants and school counselors. Participants completed the questionnaires anonymously during designated assessment sessions lasting approximately 40 to 50 minutes. All responses were screened for completeness prior to analysis. Missing data were minimal and were addressed using multiple imputation procedures. Descriptive statistics were initially computed to summarize demographic characteristics and study variables. Prior to predictive modeling, data preprocessing procedures included standardization of continuous variables, assessment of outliers, examination of multicollinearity using variance inflation factors, and evaluation of distributional properties. Pearson correlation analyses were conducted to examine preliminary associations among the study variables.

The primary analytical approach involved the implementation of the CatBoost machine learning algorithm, a gradient boosting framework specifically designed to handle complex nonlinear relationships and interactions among predictors while minimizing overfitting. Social anxiety scores served as the target variable, whereas rejection sensitivity, self-compassion, and peer victimization constituted the predictor variables. The dataset was randomly divided into training and testing subsets using an 80:20 ratio. Hyperparameter optimization was conducted through grid search procedures combined with five-fold cross-validation on the training dataset to identify the optimal model configuration. Model performance was evaluated using multiple metrics, including coefficient of determination (R^2), root mean square error (RMSE), mean absolute error (MAE), and mean absolute percentage error (MAPE). Feature importance analysis was subsequently performed to determine the relative contribution of each predictor to the model's predictive accuracy. In addition, SHAP (Shapley Additive Explanations) values were calculated to provide interpretable insights into the direction and magnitude of the relationships between predictor variables and social anxiety outcomes. All statistical analyses and machine learning procedures were conducted using Python programming language and relevant machine learning libraries, with statistical significance evaluated at the 0.05 level.

3. Findings and Results

A total of 428 students with specific learning disabilities participated in the study. The sample consisted of 238 males (55.6%) and 190 females (44.4%). Participants ranged in age from 13 to 18 years, with a mean age of 15.41 years ($SD = 1.52$). Regarding educational level, 136 students (31.8%) were enrolled in lower secondary education and 292 students

(68.2%) were enrolled in upper secondary education. The most frequently reported learning disability was dyslexia (46.7%), followed by dyscalculia (21.7%), dysgraphia (12.4%), and mixed learning disabilities (19.2%). All participants had received a formal diagnosis from educational psychologists and were enrolled in educational support programs at the time of data collection.

Table 1

Descriptive Statistics and Correlations Among Study Variables

Variable	Mean	SD	1	2	3	4
1. Social Anxiety	52.83	11.47	—			
2. Rejection Sensitivity	12.91	3.68	.69**	—		
3. Self-Compassion	78.44	14.62	-.61**	-.47**	—	
4. Peer Victimization	24.57	7.53	.65**	.58**	-.42**	—

Table 1 presents the descriptive statistics and bivariate correlations among the study variables. The findings indicated that students reported moderate to high levels of social anxiety ($M = 52.83, SD = 11.47$). Rejection sensitivity demonstrated a strong positive correlation with social anxiety ($r = .69, p < .01$), suggesting that students who were more concerned about interpersonal rejection tended to experience higher levels of social anxiety. Peer victimization also exhibited a substantial positive association with social anxiety ($r = .65, p < .01$), indicating that experiences of

bullying, exclusion, and peer aggression were related to increased social fears and avoidance behaviors. In contrast, self-compassion was significantly and negatively associated with social anxiety ($r = -.61, p < .01$), implying that students with greater levels of self-kindness, mindfulness, and self-acceptance experienced lower levels of social anxiety. Significant associations were also observed among the predictor variables themselves, although none exceeded thresholds indicative of problematic multicollinearity.

Table 2

CatBoost Model Performance Indicators

Performance Metric	Training Set	Testing Set
R^2	0.861	0.812
RMSE	4.21	5.08
MAE	3.17	3.94
MAPE (%)	7.12	8.46

The predictive performance of the CatBoost model is presented in Table 2. The model demonstrated excellent predictive capability across both the training and testing datasets. On the testing dataset, the model accounted for 81.2% of the variance in social anxiety scores ($R^2 = .812$), indicating a high degree of explanatory power. The relatively low RMSE (5.08) and MAE (3.94) values further confirmed the accuracy of predictions generated by the

model. The small discrepancy between training and testing performance metrics suggested minimal overfitting and demonstrated that the model generalized effectively to unseen data. These findings support the suitability of CatBoost as a robust machine learning approach for predicting social anxiety among students with specific learning disabilities.

Table 3

Relative Feature Importance in the CatBoost Model

Predictor	Importance (%)
Rejection Sensitivity	41.82
Peer Victimization	34.67
Self-Compassion	23.51

The feature importance analysis revealed that rejection sensitivity was the most influential predictor of social anxiety, accounting for 41.82% of the model's predictive contribution. This finding indicates that concerns about social rejection and expectations of interpersonal exclusion played a central role in determining social anxiety levels among students with specific learning disabilities. Peer victimization emerged as the second most important predictor, contributing 34.67% to the overall model. This

result highlights the substantial impact of negative peer experiences on social-emotional functioning within this population. Self-compassion contributed 23.51% of the model's predictive power and demonstrated a protective role against social anxiety. Although its contribution was smaller than those of rejection sensitivity and peer victimization, self-compassion remained a meaningful predictor and substantially improved overall model performance.

Table 4

SHAP-Based Directional Effects of Predictors on Social Anxiety

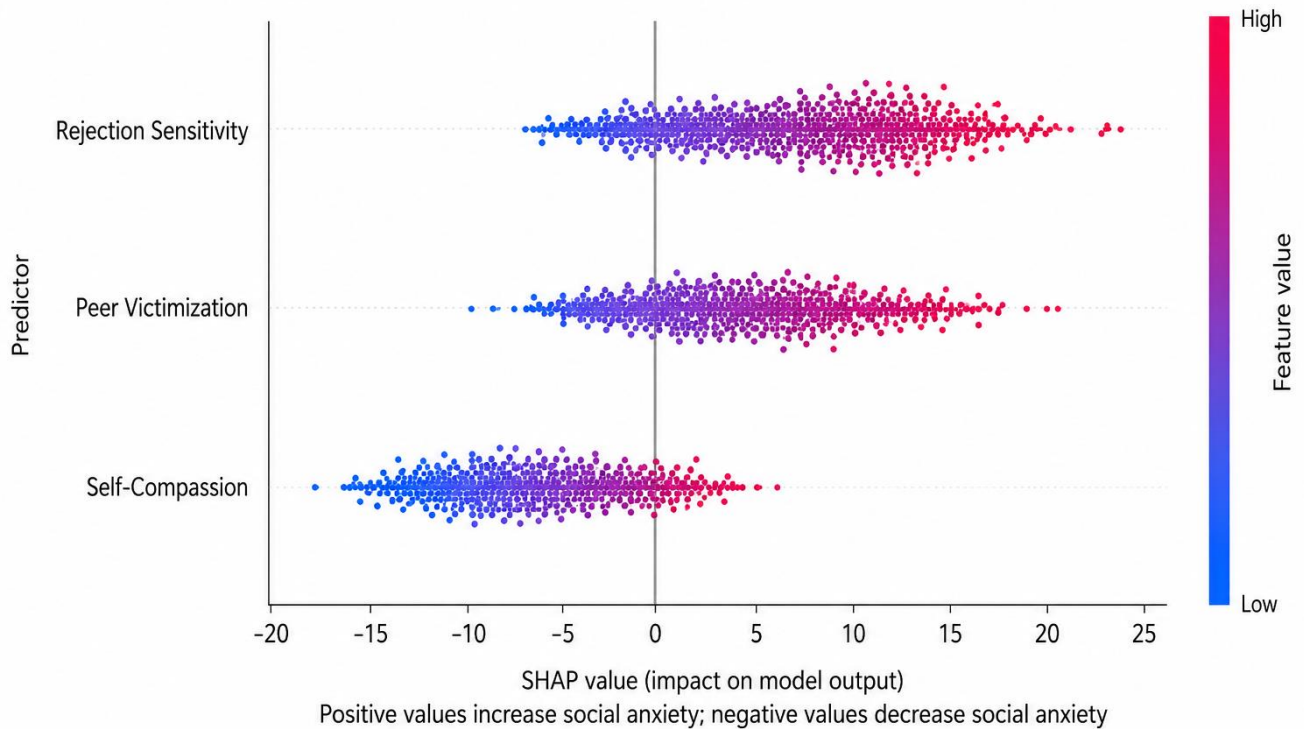
Predictor	SHAP Direction	Average SHAP Value	Interpretation
Rejection Sensitivity	Positive	+6.42	Higher values increase social anxiety
Peer Victimization	Positive	+5.71	Higher values increase social anxiety
Self-Compassion	Negative	-4.86	Higher values decrease social anxiety

The SHAP analysis provided a detailed interpretation of the relationships between the predictors and social anxiety outcomes. Higher levels of rejection sensitivity consistently increased predicted social anxiety scores, with an average SHAP contribution of +6.42 points. Students who expected rejection in social interactions demonstrated substantially elevated model predictions for social anxiety. Peer victimization also exerted a strong positive influence, contributing an average increase of 5.71 points in predicted social anxiety scores. Students reporting frequent

victimization experiences showed markedly higher levels of predicted social anxiety. In contrast, self-compassion exerted a negative influence on social anxiety, reducing model predictions by an average of 4.86 points. Students with stronger capacities for self-kindness, emotional balance, and self-acceptance tended to exhibit substantially lower levels of social anxiety. Collectively, the SHAP findings confirmed that social anxiety among students with specific learning disabilities is shaped by both risk factors and protective psychological resources.

Figure 1

SHAP Summary Plot of Predictor Contributions to Social Anxiety in the CatBoost Model



The SHAP summary plot provided a visual representation of the magnitude and direction of each predictor's contribution across all participants. The figure demonstrated that rejection sensitivity occupied the highest position on the plot and displayed the widest distribution of SHAP values, confirming its dominant role in predicting social anxiety. Peer victimization exhibited the second-largest range of SHAP values, indicating considerable influence on model predictions across participants. Self-compassion showed an inverse pattern, with higher values associated with negative SHAP scores and lower predicted social anxiety levels. The distribution of SHAP values further illustrated substantial heterogeneity among students, suggesting that individual differences in psychological vulnerability and resilience significantly influenced social anxiety outcomes. Overall, the figure reinforced the importance rankings obtained from the feature importance analysis and provided additional evidence that rejection sensitivity, peer victimization, and self-compassion collectively constitute powerful determinants of social anxiety among students with specific learning disabilities.

4. Discussion

The present study employed a CatBoost machine learning approach to predict social anxiety among students with specific learning disabilities based on rejection sensitivity, self-compassion, and peer victimization. The findings demonstrated that the proposed model achieved a high level of predictive accuracy, explaining more than 80% of the variance in social anxiety scores. Furthermore, rejection sensitivity emerged as the most influential predictor, followed by peer victimization and self-compassion. The SHAP analyses additionally revealed that rejection sensitivity and peer victimization exerted positive effects on social anxiety, whereas self-compassion demonstrated a protective and negative association with anxiety symptoms. These findings provide important insights into the psychological and interpersonal mechanisms underlying social anxiety among students with learning disabilities and contribute to a growing body of research emphasizing the importance of both vulnerability and resilience factors in adolescent mental health.

One of the most notable findings of the present study was the dominant role of rejection sensitivity in predicting social anxiety. Students who reported greater expectations of

rejection and stronger emotional reactions to potential social exclusion demonstrated substantially higher levels of social anxiety. This finding is theoretically consistent with cognitive-interpersonal models of anxiety, which propose that individuals who anticipate criticism, humiliation, or rejection are more likely to perceive social situations as threatening and therefore develop avoidance behaviors and heightened anxiety responses. Rejection sensitivity creates a cycle in which adolescents become hypervigilant to signs of social disapproval, interpret ambiguous interactions negatively, and consequently reinforce their fears of social evaluation. Such processes are particularly relevant for students with learning disabilities because they often encounter situations that may challenge their social confidence, including academic difficulties, negative peer comparisons, and experiences of misunderstanding by classmates and teachers. Research examining psychosocial outcomes among students with learning disabilities has consistently documented elevated levels of emotional vulnerability and social difficulties, suggesting that repeated experiences of perceived inadequacy may contribute to maladaptive expectations regarding interpersonal acceptance (SoĀanci & Kulesza, 2023). Similarly, investigations of anxiety among neurodivergent and functionally disabled youth have emphasized the importance of interpersonal stressors and social belonging in shaping emotional adjustment (Sutherland, 2025). The present findings therefore suggest that rejection sensitivity may represent a core cognitive-emotional mechanism through which social experiences influence anxiety among students with learning disabilities.

The results also revealed a strong positive relationship between peer victimization and social anxiety. Students who experienced greater levels of bullying, exclusion, teasing, and peer aggression demonstrated significantly higher levels of social anxiety, and peer victimization emerged as the second most important predictor within the machine learning model. This finding is highly consistent with previous literature demonstrating the detrimental psychological consequences of bullying and victimization. Numerous studies have shown that victimized adolescents experience increased anxiety, depression, loneliness, and social withdrawal as a consequence of repeated exposure to hostile peer interactions (Ahmed et al., 2022; Harsono & Febriyana, 2026; K. et al., 2023). Victimization communicates powerful social messages regarding acceptance and belonging, often leading adolescents to perceive social environments as unpredictable and threatening. Over time, these experiences

may foster fear of evaluation, avoidance of peer interactions, and heightened concern regarding future rejection. Longitudinal evidence further supports the notion that victimization contributes to enduring emotional difficulties rather than merely reflecting preexisting psychological vulnerabilities (Hui et al., 2026; Shen et al., 2025). The current findings extend this literature by demonstrating that peer victimization remains a powerful predictor of social anxiety specifically among students with learning disabilities.

The significance of peer victimization is particularly understandable when considering the educational experiences of students with learning disabilities. Research indicates that students with special educational needs frequently encounter lower peer acceptance, greater stigmatization, and higher rates of bullying than their typically developing peers (Li, 2025). Educational difficulties may increase visibility within peer groups and create opportunities for negative labeling, exclusion, or ridicule. Studies focusing on children with communication and learning challenges have documented strong associations between victimization experiences and social adjustment difficulties (García et al., 2021). Likewise, Marini et al. emphasized that perceived integration within peer groups functions as a protective factor against victimization among children with learning disabilities (Marini et al., 2023). The present findings reinforce these observations by suggesting that victimization not only affects social functioning but also contributes directly to anxiety symptoms. Furthermore, broader analyses of school and peer cultures suggest that educational environments play a crucial role in determining whether students experience inclusion or marginalization, thereby influencing mental health outcomes (Gordon & Levesque, 2025). Consequently, interventions designed to reduce bullying and promote peer acceptance may represent important avenues for preventing social anxiety among students with learning disabilities.

Another important finding concerned the protective role of self-compassion. Higher levels of self-compassion were associated with lower levels of social anxiety, and self-compassion contributed meaningfully to the predictive performance of the CatBoost model. This result aligns with a substantial body of evidence suggesting that self-compassion promotes emotional resilience and psychological well-being. Individuals who treat themselves with kindness during times of difficulty are less likely to engage in excessive self-criticism, rumination, and negative self-evaluation, all of which are central cognitive processes

associated with anxiety disorders. Self-compassion allows adolescents to interpret failures and social setbacks within a broader and more balanced perspective, thereby reducing the emotional impact of adverse experiences. Previous research has demonstrated negative associations between self-compassion and a variety of psychological difficulties, including shame, distress, anxiety, and depressive symptoms (Meiri et al., 2024; Meiri & Aldawsari, 2024; Seabra et al., 2023). The present findings suggest that similar protective processes may operate among students with learning disabilities, helping them navigate academic and interpersonal challenges more effectively.

The observed protective effect of self-compassion is also consistent with studies examining bullying and victimization. Research has shown that self-compassion moderates the relationship between negative peer experiences and emotional distress by reducing self-blame and promoting adaptive coping strategies (Múzquiz et al., 2022). Narrative reviews have similarly highlighted the potential value of self-compassion training within schools as a means of mitigating the harmful effects of bullying and cyberbullying (Aledeh et al., 2024). Furthermore, mindfulness-based and acceptance-oriented interventions, which share conceptual similarities with self-compassion, have demonstrated effectiveness in reducing anxiety and enhancing emotional regulation among adolescents (Serenity et al., 2023; Sun et al., 2022). Studies involving parents and families facing developmental challenges have likewise emphasized the importance of compassionate self-relating as a foundation for psychological adjustment and well-being (Finardi et al., 2022). Taken together, these findings support the interpretation that self-compassion functions as a resilience factor capable of buffering the psychological consequences of academic struggles, social rejection, and peer victimization.

The collective pattern of findings can be understood within broader developmental and psychosocial frameworks. Social anxiety among students with learning disabilities appears to emerge through interactions between external social experiences and internal psychological processes. Peer victimization represents an external stressor that communicates rejection and exclusion, whereas rejection sensitivity reflects an internalized expectation that such rejection will continue to occur. Self-compassion, in contrast, serves as an adaptive internal resource that reduces vulnerability to these stressors. This interpretation is consistent with contemporary perspectives emphasizing the interplay between social contexts and emotional regulation

processes in the development of psychopathology (Bemmouna & Weiner, 2023). It also aligns with evidence linking adverse interpersonal experiences to subsequent emotional and behavioral difficulties (Hesselink, 2023). By identifying both risk and protective factors, the present study contributes to a more comprehensive understanding of social anxiety among students with learning disabilities.

An additional contribution of the present study lies in its use of machine learning methodology. Traditional statistical approaches often focus on average effects across populations, whereas machine learning algorithms are capable of identifying complex patterns and nonlinear relationships among variables. The strong predictive performance achieved by the CatBoost model demonstrates the value of advanced analytical techniques for understanding adolescent mental health. Recent educational and psychological research has increasingly adopted machine learning methods to predict behavioral and emotional outcomes, including bullying victimization and mental health risks (Qiu et al., 2024). The current findings support this growing trend and suggest that machine learning approaches may offer valuable tools for identifying students at heightened risk of social anxiety. Such predictive models could ultimately inform early screening initiatives and personalized interventions within educational settings.

5. Conclusion

The findings also have broader implications for understanding mental health among vulnerable youth populations. Research has increasingly emphasized that emotional difficulties among adolescents are shaped not only by individual characteristics but also by social environments and experiences of belonging, acceptance, and inclusion (Weinberg & Cooper, 2025). Students with learning disabilities frequently navigate educational contexts in which both academic and social challenges coexist. The current results suggest that interventions addressing social anxiety should not focus exclusively on symptom reduction but should also target peer relationships, school climate, and self-compassion development. Such a multidimensional approach may be especially effective because it addresses both the environmental and psychological determinants of emotional distress.

The present study possesses several limitations that should be acknowledged. First, the cross-sectional design prevents conclusions regarding causality among the study variables. Although rejection sensitivity, peer victimization,

and self-compassion were significant predictors of social anxiety, causal relationships cannot be established. Second, the use of self-report measures may have introduced response biases, including social desirability and recall bias. Third, the sample consisted exclusively of students with specific learning disabilities from Chile, which may limit the generalizability of the findings to other cultural contexts, age groups, or disability categories. Fourth, although the CatBoost model demonstrated excellent predictive performance, additional psychosocial variables such as family functioning, teacher support, academic self-concept, emotional regulation, and socioeconomic status were not included in the model and may further improve prediction accuracy.

Future research should employ longitudinal designs to clarify the developmental pathways linking rejection sensitivity, peer victimization, self-compassion, and social anxiety. Researchers should also investigate potential mediating and moderating mechanisms that explain how these variables interact over time. Expanding studies to include diverse cultural contexts and different categories of neurodevelopmental and learning-related conditions would improve the generalizability of findings. Future machine learning investigations may benefit from incorporating additional predictors, multimodal data sources, and explainable artificial intelligence techniques to generate more comprehensive predictive models. Intervention studies are also needed to determine whether reducing rejection sensitivity, preventing victimization, and enhancing self-compassion can effectively decrease social anxiety among students with learning disabilities.

The findings suggest several practical implications for educators, school psychologists, counselors, and policymakers. Schools should implement comprehensive anti-bullying programs that promote peer acceptance, inclusion, and respect for individual differences. Early screening procedures may help identify students who exhibit elevated rejection sensitivity and social anxiety before difficulties become severe. School-based interventions should incorporate strategies designed to strengthen self-compassion, emotional regulation, and adaptive coping skills. Teachers should receive training regarding the psychosocial experiences of students with learning disabilities and the importance of fostering supportive classroom climates. Collaboration among educators, mental health professionals, and families may further enhance the effectiveness of prevention and intervention efforts. By addressing both social risk factors and psychological

resilience factors, educational systems can create environments that support emotional well-being and reduce the burden of social anxiety among students with learning disabilities.

Authors' Contributions

Authors equally contributed to this article.

Declaration

In order to correct and improve the academic writing of our paper, we have used the language model ChatGPT.

Transparency Statement

Data are available for research purposes upon reasonable request to the corresponding author.

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Declaration of Interest

The authors report no conflict of interest.

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Ethics Considerations

The study protocol adhered to the principles outlined in the Helsinki Declaration, which provides guidelines for ethical research involving human participants.

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