

Prospective Prediction of Low Self-reported Academic Performance Among Adolescents Using Explainable Machine Learning: A Multi-school Longitudinal Study

Liyan Zhao^{1,*}, Dongping Li²

¹School of Education, Chengdu College of Arts and Sciences, Chengdu, China

²School of Psychology, Central China Normal University, Wuhan, China

Email address:

zeenaly@sina.com (Liyan Zhao), lidongping@mail.ccnu.edu.cn (Dongping Li)

*Corresponding author

Abstract

Low academic performance during adolescence may constrain educational development, yet schools have limited evidence on which psychosocial and contextual factors can inform timely support. Few longitudinal prediction studies test whether models transfer across schools. Guided by ecological systems theory, this study examined whether baseline characteristics across individual, family, peer, school, and behavioral contexts could prospectively predict low self-reported academic performance among adolescents. The baseline sample comprised 1,365 students from four Chinese secondary schools. Of these, 1,079 students (79.0%; 51.5% boys; mean age = 14.52 years, SD = 1.58) completed the third-wave assessment and formed the analytic sample. Low self-reported academic performance was operationally defined as a third-wave mean score of 2 or lower across ratings of Chinese, mathematics, English, and overall academic performance; 195 students (18.1%) met this criterion. Sixty-seven first-wave ecological indicators served as predictors. Prior academic performance was excluded from the primary analysis to assess psychosocial and contextual information alone. Five machine-learning algorithms were evaluated using nested stratified 10-fold cross-validation, with all preprocessing and hyperparameter tuning conducted within the training folds. Leave-one-school-out validation assessed transportability across school settings. Regularized logistic regression achieved the strongest overall performance and showed moderate prospective discrimination (AUC = 0.717, PR-AUC = 0.398, sensitivity = 0.682, specificity = 0.643, Brier score = 0.132). Because 18.1% of students met the operational criterion, the PR-AUC was notably higher than the corresponding no-skill reference value of 0.181. School-specific held-out AUCs ranged from 0.684 to 0.730, whereas the pooled leave-one-school-out AUC was 0.686, indicating preliminary cross-school transportability accompanied by some loss of discrimination. Activation control, conscientiousness, educational stage, classmate relationships, family economic status, parent-child relationships, neuroticism, and competence-need satisfaction were among the most strongly weighted predictors, with predictive information distributed across ecological levels. Adding prior academic performance in a sensitivity analysis increased the AUC to 0.812, underscoring the importance of previous performance for prospective prediction. Overall, multi-context baseline information provided moderate discrimination of subsequent low self-reported academic performance. Explainable machine learning may help schools recognize students who could benefit from additional academic support, but it should complement rather than replace professional educational judgment. In practice, schools may combine prior academic performance with information on self-regulation, peer relationships, and family contexts to provide timely, differentiated support. Independent validation using objective achievement measures and

further assessment of calibration and decision thresholds are required before broader application.

Keywords

Academic Performance, Adolescents, Ecological Systems Theory, Explainable Machine Learning, Longitudinal Prediction, Cross-school Validation