

# Analysis of the Factors Influencing Junior High School Students' Academic Performance and the Construction of a Prediction Model

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**Abstract:** Academic performance is a critical factor in determining the future academic path and the possibility of social class mobility of junior high school students. Exploring the influencing factors of academic performance and predicting them can help provide empirical evidence for a comprehensive and objective evaluation of students' academic performance. Using CEPS 2014-2015 data, we analyze the influencing factors of junior high school students' performance based on the I-E-O model, use a nomogram to predict the likelihood of students' achievement of excellent results, and visualize and analyze the important factors. It was found that, in terms of psychological characteristics, students' and their parents' educational expectations had a much greater impact on academic performance. Additionally, students' motivation and persistence significantly influenced their academic performance. In terms of demographic characteristics, we found notable differences between boys and girls, with girls outperforming boys academically. In terms of student involvement, time spent on school homework and in cram schools has a significant impact on academic performance, but the impact of attending cram schools is negative. Finally, in terms of school characteristics, the level of school per student expenditure had a significant effect on achievement.

*Best Evidence in Chinese Education* 2025; 21(2):2009-2037.

DOI: 10.15354/bece.25.or026

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*How to Cite:* Yan, S. Z., & Li, W. H. (2025). Analysis of the factors influencing junior high school students' academic performance and the construction of a prediction model. *Best Evidence in Chinese Education*, 2025, 21(2): 2009-2037.

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**Keywords:** *Junior High School Students, Academic Performance, Prediction Model, Educational Expectation*

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**Conflict of Interests:** *None*

**Funding:** *No funding sources declared.*

**AI Declaration:** *The author affirms that artificial intelligence did not contribute to the process of preparing the work.*

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## **Introduction**

**A**CADEMIC performance is a key indicator of students' knowledge acquisition and learning outcomes, reflecting both individual progress and the effectiveness of educational systems (Huang et al., 2016). Variations in academic performance among students from different backgrounds often reveal disparities in educational resource distribution and structural inequities, reflecting regional differences in education quality and access. Junior high school marks a critical stage in compulsory education, shaping adolescents' self-identity and social development, while also determining future educational and career paths through the streaming mechanism based on high school entrance exam results. For junior high school students, academic performance is essential, serving as a core measure of individual developmental potential and educational efficacy. High academic performance fosters confidence and motivation, encouraging deeper engagement with learning, which contributes to long-term educational success, career opportunities, and the development of high-quality human capital vital for societal sustainability.

## **Literature Review**

Internal student factors can directly affect academic performance, and educational expectations are one of the important factors. Students' educational expectations, encompassing both short-term (e.g., exam performance) and long-term academic goals, directly influence academic achievement through bidirectional relationships with performance outcomes (Pinquart & Ebeling, 2020a; Pinquart & Ebeling, 2020b). Empirical evidence confirms significant positive correlations between students' self-educational expectations and academic performance, with cross-lagged analyses demonstrating reciprocal causation (Sanders et al., 2001; Pinquart & Ebeling, 2020b). Closely related to students' self-educational expectations, parents' educational expectations are also one of the most important factors affecting students' performance. It substantially predicts academic performance through dual mechanisms: active involvement in educational activities and psychological transmission of competence beliefs, which students internalize as personal behavioral standards (Yamamoto & Holloway, 2010). In addition to educational expectations, students' learning motivation is an important influence on academic performance. While both educational expectations and learning motivation influence academic behaviors, they constitute distinct psychological effects. Educational expectations reflect future-oriented beliefs about educational attainment, whereas learning motivation drives goal-directed actions through cognitive activation (Yamamoto & Holloway, 2010; Moreira-Morales & Garc á-Loor, 2024). Specifically, learning motivation comprises intrinsic

(task-inherent satisfaction) and extrinsic (external reward-driven) dimensions, both significantly predicting academic performance through behavioral engagement (Entwistle et al., 1974). According to Hull's formula, academic performance derives from the multiplicative interaction of motivational drive and study habits (Eysenck, 1957), with educators frequently attributing academic failures to deficiencies in these components (Entwistle et al., 1974). A SEM study showed that both internal and external motivation of students are significantly and positively correlated with academic performance and are important influences on academic performance (Nauzeer & Jaunky, 2019).

In addition to internal student factors, school characteristics, as key external factors, significantly influence learning outcomes. Researchers have examined various aspects of the school environment, including climate, location, facilities, division, and classroom conditions, to assess their impact on academic performance. Physically, classroom environment, location, and facilities remarkably affect student achievement (Iwuagwu, 2016); moreover, researchers have found that schools with more greenery show higher exam success rates, whereas barren landscapes negatively affect performance (Kweon et al., 2017). Psychologically, a positive and supportive school climate enhances academic performance, while a negative climate harms students' well-being and achievement (Podiya et al., 2025). Positive social relationships and a sense of belonging at school increase academic self-efficacy as well, which in turn improves performance (Zysberg & Schwabsky, 2020).

The factors affecting academic performance certainly do not stop there, and a review of existing research on students' academic performance reveals that there is a wealth of research in this area, covering a wide range of topics. Domestic studies have focused on individual student traits, school characteristics, and teacher attributes, offering insights into current performance trends and their determinants. However, these studies often analyze influences through a single dimension, such as extracurricular tutoring (Guan, 2022) or family-school cooperation (Zhang et al., 2020), after controlling for demographics, limiting findings to specific causal factors, and failing to reflect the complexity and diversity of academic performance. Additionally, most studies focus on university students, with insufficient attention to junior high school populations.

In 1977, Astin proposed the Input-Environment-Outcome (I-E-O) model to analyze how higher education influences student development (Astin, 1977). The model categorizes educational processes into three components: Input (students' pre-enrollment background and social experiences), Environment (educational experiences and institutional characteristics), and Output (changes in students' cognitive, skills, and value domains) (Zhang et al., 2020). It posits that student learning and competence development result from the interaction between pre-enrollment inputs and environmental factors during education. In 1984, Astin expanded the model by introducing the

theory of Student Involvement, a key aspect of Environment, which measures the physical and mental energy students invest in their education, reflected in time spent, participation in activities, and engagement with faculty and peers (Astin, 1984). Studies have found that greater student involvement positively affects academic performance (Bao & Zhang, 2012). Although the I-E-O model was developed for higher education, its framework applies broadly, as both higher and basic education involve similar developmental processes shaped by Input, Environment, and Outcome. Therefore, drawing on the I-E-O model and using national survey data, this study examines ninth-grade junior high school students to better understand the factors influencing academic performance and to expand research on this population.

All along, the “scores-only theory” has led schools and parents to overemphasize written examination results, neglecting process evaluation and overall quality assessment. This manner could cause student disengagement and psychological stress, both closely linked to academic performance. Effectively evaluating academic performance and identifying its key influencing factors have thus become critical issues. Using data from the China Education Panel Survey (CEPS), this study examines junior high school students' academic performance from input and output perspectives and develops a predictive model to provide empirical insights for improvement.

## **Methods**

### ***Data Source***

The data utilized in this study are derived from the China Education Panel Survey (CEPS). The CEPS is a large-scale, nationally representative longitudinal survey designed and implemented by a top-tier university in China with an outstanding academic reputation. This survey aims to analyze how factors such as family, school, community, and broader social structures collectively influence individual educational outcomes. It also seeks to deeply uncover the role and mechanisms of these educational outcomes throughout an individual's life course, thereby providing a reliable empirical basis for the formulation of educational public policy and for academic research in related fields.

To ensure the national representativeness of the sample, CEPS employed a multi-stage probability proportional to size (PPS) sampling design. Using the population's average education level and the proportion of the migrant population as stratification variables, this method first randomly selected 28 county-level units nationwide as survey sites. Subsequently, 112 schools were randomly drawn from these selected county-level units. Finally, 438 classes were sampled from these schools, and all students in the chosen

classes were included in the sample. The baseline survey, conducted in the 2013-2014 academic year, comprised approximately 20,000 students.

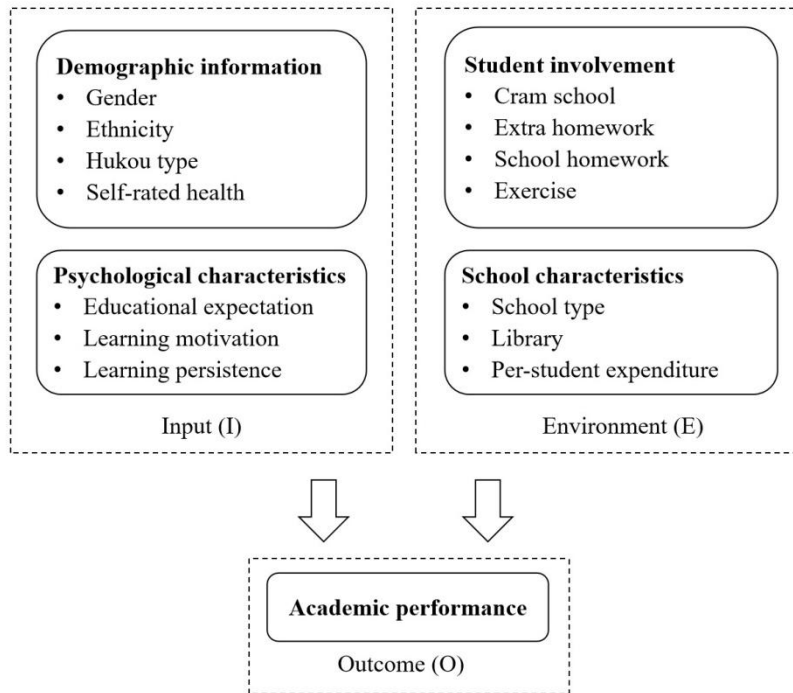
CEPS employs questionnaire surveys as its primary data collection method, targeting a wide range of respondents including students, parents, homeroom teachers, main subject teachers, and school administrators. The content of the questionnaires is tailored to each respondent group: the student questionnaire focuses on basic information, academic growth, physical and mental health, and social-behavioral development; the parent questionnaire centers on the home educational environment, perspectives on school education, and educational expectations for their children; the teacher questionnaire concentrates on educational philosophies, daily teaching practices, work-related stress, and job satisfaction; and the school administrator questionnaire is primarily concerned with the school's basic information, educational mission, teaching facilities, and daily instructional management.

CEPS is a thirty-year longitudinal survey, with its baseline survey launched in the 2013-2014 academic year. It began tracking two cohorts of students, who were then in the seventh and ninth grades. These students were surveyed annually during their middle school years, and follow-ups are planned at multiple subsequent time points after their graduation, with the final survey scheduled for completion in 2043. This study uses data from the first follow-up wave conducted in the 2014-2015 academic year. This wave targeted the baseline cohort of 10,279 seventh-grade students, of whom 9,449 were successfully re-interviewed, resulting in a high follow-up rate of 91.9%. Because CEPS has not released new data since 2015, this wave constitutes the most recent dataset available. For this research, variables were selected from the student, parent, and school administrator questionnaires. After data cleaning, a total of 5,998 valid cases were obtained. Concurrently, in strict compliance with ethical and legal standards, CEPS ensures the confidentiality of all identifiable information, such as county (district), school, and administrative codes, to effectively protect respondent privacy.

## ***Description of the Variables***

### **Dependent Variable**

The dependent variable in this study is student academic performance. The data for this variable consist of student midterm examination scores from the fall 2014 semester, which were provided directly by the surveyed schools.



**Figure 1. Indicator System Based on the IEO Model.**

These are administrative data, not self-reported variables. Specifically, the data include the raw scores for three subjects—Chinese, Mathematics, and English—and the corresponding maximum possible score for each subject. (The CEPS survey exclusively covers academic performance in these three core subjects).

As Chinese, Mathematics, and English are core subjects in middle school (and notably, these three subjects have the same maximum score in the high school entrance examination in most provinces), they were assigned equal weight to comprehensively reflect student academic performance. The raw scores from these three subjects were directly summed to create a raw total score. To eliminate inter-school differences, this study then conducted a within-school standardization of the students' total scores. On a school-by-school basis, the arithmetic mean of all students' total scores was calculated, with this school-level mean serving as a benchmark for each school's academic level. Finally, based on the individual student's score and their school's mean score, a core binary variable was generated to represent the student's performance level relative to their in-school peer group. If a student's total score was higher than the school mean, the variable was assigned a value of 1; conversely, if the score was equal to or lower than the mean, it was assigned a value of 0.

## Independent Variables

The independent variables are the influences related to students' academic performance, with a total of 14 variables divided into two dimensions, Input and Environment, and four sub-dimensions. See **Figure 1** for details.

### Input Dimension

Input variables refer to students' pre-institutional characteristics and are divided into two sub-dimensions: personal background and psychological characteristics. Personal background includes Gender, Ethnicity, Hukou type, and Students' self-rated health. Psychological characteristics include students' self-educational expectations, parental educational expectations, learning motivation, and learning persistence.

Gender is a binary nominal variable. The data were sourced from the 'Personal Background' module of the student questionnaire and represent a single-item measure self-reported by students during the 2013-2014 baseline survey. As gender is a stable attribute, it did not require repeated measurement; therefore, this information was not collected again in the 2014-2015 follow-up survey. The complete gender information was obtained by merging the baseline data with the follow-up data using the unique student identification code (variable name: ids). The original coding for this variable, "1=male, 2=female," was used without modification.

Data on ethnicity were also sourced from the 'Personal Background' module of the student questionnaire, representing a single-item measure self-reported by students in the 2013-2014 baseline survey. Due to its stability, this question was not repeated in the follow-up survey; the ethnicity information for students was obtained by merging the datasets. The original variable was a multi-category nominal variable with eight categories (1=Han, 2=Mongol, 3=Manchu, 4=Hui, 5=Tibetan, 6=Zhuang, 7=Uygur, and 8=Other). To avoid the potential interference of small-sample categories in the statistical analysis, this study transformed it. The original eight categories were consolidated into a binary nominal variable, with the coding scheme 0=Ethnic minority (including Mongol, Manchu, and other groups) and 1=Han.

The student's hukou (household registration) type is a single-item measure self-reported by students in the 2013-2014 baseline survey. This information was obtained by merging the baseline and follow-up data using the student ID. The original variable was a four-category nominal variable with the following codes and meanings: 1=Agricultural hukou, 2=Non-agricultural hukou, 3=Resident hukou (a type issued in some regions to all residents, without distinguishing between agricultural and non-agricultural status), and 4=No hukou. Based on this study's focus on the traditional ur-

ban-rural hukou disparity, the original variable was recoded. Considering that the “Resident hukou” is a product of hukou system reforms aimed at reducing this binary distinction and is more closely aligned with the non-agricultural hukou in terms of public services and social rights (urban attributes), “2=Non-agricultural hukou” and “3=Resident hukou” were merged to form the urban hukou category, which was assigned a value of 2. The “1=Agricultural hukou” category was retained as is. Furthermore, the “4=No hukou” category was excluded from the analysis due to its ambiguity and extremely small proportion. The resulting transformed variable is a binary nominal variable.

Data on self-rated health were derived from the ‘Physical and Mental Health’ module of the student questionnaire. The corresponding original question was: “Which one of the following best describes your general health condition AT PRESENT?” This is a single-item, self-reported measure. The variable was originally a five-category ordinal variable (1=Very poor, 2=Not very good, 3=Moderate, 4=Good, 5=Very good). For this study, it was recoded into a three-category ordinal variable with the following structure: the ‘Very poor’ (1) and ‘Not very good’ (2) categories were merged into ‘poor’ and assigned a value of 1; the ‘Moderate’ (3) category retained its original meaning but was reassigned a value of 2; and the ‘Good’ (4) and ‘Very good’ (5) categories were combined into ‘good’ and assigned a value of 3. The transformed variable is thus a three-category ordinal variable.

Data on students’ self-educational expectations were sourced from the ‘Academic Development’ module of the student questionnaire. The variable is a single-item, self-reported measure based on the question: “What is the highest level of education you expect yourself to receive?” The original variable was a 10-category ordinal scale: (1) Drop out now, (2) Graduate from junior high school, (3) Go to technical secondary school or technical school, (4) Go to vocational high school, (5) Go to senior high school, (6) Graduate from junior college, (7) Get a bachelor degree, (8) Get a Master degree, (9) Get a Doctor degree, and (10) I don’t care. Based on a hierarchical logic of ascending educational expectations, this study simplified the variable into a three-category ordinal measure. The first category, “1 = Secondary Education and Below,” includes the original codes 2 through 5. The “Drop out now” (1) and “I don’t care” (10) options were also assigned to this category because they largely reflect low educational expectations. The second category, “2 = University Degree,” represents the foundational level of higher education and combines the original codes for “Graduate from junior college” (6) and “Get a bachelor degree” (7). The third category, “3 = Post-graduate Degree,” corresponds to the advanced level of higher education and includes the original codes for “Get a Master degree” (8) and “Get a Doctor degree” (9).

The raw data for parental educational expectations were derived from the 'Family Education' module of the parent questionnaire. This variable is a single-item, self-reported measure based on the question: "What is the highest level of education do you expect this child to receive?" The original coding and the meanings of the categories for this variable were identical to those for student self-educational expectations. For the analysis, this study applied the same consolidation and simplification logic to parental educational expectations as was used for the student self-educational expectations variable.

Data on learning motivation were derived from a sub-item within a scale in the student questionnaire's 'Physical and Mental Health' module, which begins with the prompt: "How much do you agree with each of the following statements about your experiences in GRADE 7?" It is a single-item, self-reported measure corresponding to the specific statement: "I would try my best to finish even the homework I dislike." The variable was originally a four-point Likert-type ordinal variable, with the following codes and meanings: 1=Strongly disagree, 2=Somewhat disagree, 3=Somewhat agree, and 4=Strongly agree. To simplify the analysis, this study merged and transformed it. The categories '1=Strongly disagree' and '2=Somewhat disagree,' which had smaller sample proportions, were combined into 'Not really agree' and assigned a value of 1. The '3=Somewhat agree' category retained its original meaning, with its code adjusted to 2, and the '4=Strongly agree' category was recoded to 3. The transformed variable is a three-category ordinal variable.

Data on learning persistence were also sourced from the student questionnaire's 'Physical and Mental Health' module. It is a single-item, self-reported measure from the same scale as the learning motivation variable, corresponding to the specific statement: "I would try my best to finish my homework, even if it would take me quite a long time." As a four-point Likert-type ordinal variable, its original coding and meanings were identical to those of the 'learning motivation' variable. The logic used for its consolidation and transformation was also the same as that applied to 'learning motivation', resulting in a three-category ordinal variable.

## Environment Dimension

Environmental variables reflect learning resources and influence inside and outside school, central to the educational process. It's divided into two sub-dimensions: student involvement and school characteristics. Student involvement includes weekly hours spent on school homework, cram school attendance, extra homework (assigned by parents or cram school), and Exercise. School characteristics include School type, Availability of library, and Per-student Expenditure.

Regarding school characteristics, three variables were included: school type, whether the school has a library, and per-student expenditure. All three items were sourced from the 'Basic Information of the School' module of the school administrator questionnaire.

School type is a single-item measure self-reported by the principal. The variable was originally a five-category nominal variable with the following codes and meanings: (1) Public school, (2) Private school subsidized by the government, (3) Ordinary private school, (4) Private school for children of migrant workers, and (5) Other. Because this study's primary aim is to investigate the difference in impact between public and private schools on student achievement, this variable was recoded. Specifically, categories 2 through 4 were merged to form the 'private school' category, which was assigned a value of 0. The 'public school' category (1) was kept unchanged. The transformed variable is a binary nominal variable. Additionally, among the 112 schools in the sample, none were classified as 'Other' (5).

Whether the school has a library is a single-item measure self-reported by the principal, derived from a sub-item under the scale "Does your school have the following facilities?". The original variable was a three-category ordinal variable: (1) No, (2) Yes, but need to be improved, and (3) Yes, and well equipped. For this study, categories 2 and 3 were merged to form the "has a library" category, which was assigned a code of 2. The "No" category remained unchanged. The transformed variable is a binary nominal variable.

Per-student expenditure was a self-reported item completed by the principal, representing objective administrative statistical data. The corresponding original question was: "How much fiscal appropriation per student has your school received THIS YEAR?". The variable was originally a continuous variable, taking non-negative values (unit: Yuan/student) with a range of 0 and above. For this study, the data were recoded into a three-category ordinal variable with the following codes and meanings: 1=Low funding (<800 Yuan), 2=Medium funding (800-1,800 Yuan), which represents the primary distribution range of the data, and 3=High funding ( $\geq$ 1800 Yuan).

Data on the weekly time students spent on school homework, cram school, and extra homework were all derived from the 'Academic Development' module of the student questionnaire. They were sub-items under the scale asking, "How much time ON AVERAGE EVERYDAY did you spend on the following extra-curricular activities?". The corresponding original items were: 'Doing homework assigned by teacher,' 'Taking cram school courses (related to schoolwork),' and 'Doing homework assigned by parents or cram school.' The time spent was measured separately for weekdays and weekends. The response options for the weekday scale were: (1) 0 hours, (2) Less than 1 hour, (3) About 1-2 hours, (4) About 2-3 hours, (5) About 3-4

hours, and (6) More than 4 hours. The response options for the weekend scale were: (1) None, (2) Less than 2 hours, (3) About 2-4 hours, (4) About 4-6 hours, (5) About 6-8 hours, and (6) More than 8 hours. Because the original options represented interval data, the midpoint of each interval was taken and multiplied by the corresponding number of days. The resulting values for weekdays and weekends were then summed to calculate the total weekly time spent (unit: hours).

Data on students' physical exercise were obtained from the 'Physical and Mental Health' module of the student questionnaire. This was a self-reported, two-part measure corresponding to the question: "How often do you do physical exercise? Usually [ ] days a week, [ ] minutes a day." Existing research indicates that "ensuring two hours of daily physical activity for middle school students" is a national-level reform goal that is being vigorously promoted but has not yet been fully realized, and that insufficient exercise among students remains a common phenomenon (Liu & Shan, 2025). Based on this, we concluded that some students' self-reported daily exercise durations (e.g., over 150 minutes) likely deviated significantly from the prevalent reality. Therefore, to ensure data validity and the robustness of the analysis, this study treated cases reporting more than 150 minutes of daily exercise as outliers and excluded them. Subsequently, for the remaining valid sample, the 'days of exercise per week' was multiplied by the 'minutes of exercise per day,' and the result was converted into hours to generate the total weekly physical exercise duration. The transformed variable is a continuous variable with non-negative values.

## ***Methods of Analysis***

Data cleaning was carried out via Stata 17 to retain relevant variables, recode categorical variables, and remove outliers. Statistical analysis was performed using SPSS 26.0; chi-square tests were applied to categorical variables related to student background, psychological and school characteristics, while one-way ANOVA was used for continuous variables on student involvement, with significance set at  $p < 0.05$ . Variables with  $p < 0.05$  were entered into binary logistic regression to assess their association with academic performance. Multicollinearity was assessed using the variance inflation factor (VIF), with  $VIF < 5$  indicating acceptable independence among predictors. Based on logistic regression results, a nomogram was constructed using R 4.4.2 to visualize the prediction model and improve interpretability. Model performance was evaluated using ROC curves, area under the curve (AUC), and calibration curves.

**Table 1. Effects of Input Characteristics on Academic Performance.**

Category	N	High score achiever	Percentage	$\chi^2$	p value
Gender				273.078	<0.001
Male	3,024	1,408	46.56		
Female	2,974	2,013	67.69		
Ethnicity				0.954	0.329
Han	5,430	3,108	57.24		
Minority	568	313	55.10		
Hukou type				12.958	<0.001
Rural	3,182	1,746	54.90		
Urban	2,816	1,675	59.48		
Self-rated health				4.603	0.1
Poor	387	215	55.56		
Fair	1,749	964	55.12		
Good	3,862	2,242	58.05		
Self-educational expectation				785.385	<0.001
Secondary Education & Below	1,160	289	24.91		
University Degree	3,058	1,757	57.46		
Postgraduate Degree	1,780	1,375	77.25		
Parental education expectation				702.429	<0.001
Secondary Education & Below	723	129	17.84		
University Degree	3,222	1,771	54.97		
Postgraduate Degree	2,053	1,521	74.09		
Learning motivation				183.38	<0.001
Not really agree	1,197	491	41.02		
Fair	2,536	1,459	57.53		
Strongly agree	2,265	1,471	64.94		
Learning persistence				192.135	<0.001
Not really agree	1,251	518	41.41		
Fair	2,476	1,414	57.11		
Strongly agree	2,271	1,489	65.57		
Total	5,998	3,421	57.04		

## Results

### *Differences in Junior High School Students' Academic Performance on Inputs*

The result showed that of the 5,998 students, 3,421(57.04% of the total) had academic performance above the average of their schools.

In terms of demographic characteristics, girls' academic performance (67.7%) is better than boys' (46.6%), and the difference is statistically significant ( $\chi^2 = 273.078$ ,  $p < 0.001$ ). This result indicates that gender is one of the factors that significantly affects students' performance. The percentage of Han Ethnicity and ethnic minority students who performed better than the school average was 57.24% and 55.10%, respectively. From the results, ethnicity is not a significant influence on academic performance. In terms of Hukou type, urban household register students outperformed rural household register students with a significant difference ( $\chi^2 = 12.958$ ,

**Table 2. The Impact of School Characteristics on Academic Performance.**

Categorization	N	Numbers of above-average	Percentage	$\chi^2$	p value
School type				9.517	0.002
Private	410	204	49.76		
Public	5,588	3,217	57.57		
Library				0.011	0.915
No	902	513	56.87		
Yes	5,096	2,908	57.06		
Per-student expenditure				16.609	< 0.001
Low	2,209	1,187	53.73		
Medium	2,751	1,608	58.45		
High	1,038	626	60.31		

$p < 0.001$ ). The highest percentage of students who perceived themselves as physically good achieved good grades (58.10%), followed by those who perceived themselves as physically poor and fair (55.60% and 55.12%, respectively), but there was no significant difference in grades between students with different health conditions ( $p = 0.1$ ). In terms of psychological characteristics, students' and parents' educational expectations have a significant effect on students' academic performance, with higher educational expectations being associated with better academic performance. Students' learning motivation and persistence are also significant influences on academic performance; the stronger the learning motivation and persistence, the better the students' academic performance. The details are shown in **Table 1**.

### ***The Impact of School Characteristics on Students' Academic Performance***

Regarding school characteristics, the proportion of students with above-average academic performance was significantly higher in public schools (57.57%) than in private schools (49.76%) ( $\chi^2 = 9.517$ ,  $p = 0.002$ ). In terms of school material resources, whether a school had a library was not significantly associated with student academic performance ( $\chi^2 = 0.011$ ,  $p = 0.915$ ). In fact, the proportion of students who achieved above-average scores was nearly identical in schools with libraries (57.06%) compared to schools without them (56.87%). Per-student expenditure had a significant effect on academic performance ( $\chi^2 = 16.609$ ,  $P < 0.001$ ), with students' academic performance gradually improving as per-student expenditure increased, as shown in **Table 2**.

Regarding student involvement, this study found that the amount of time students spent per week writing school and extra homework, attending cram school, and exercising all had a significant effect on students' academic

**Table 3. The Impact of Student Involvement on Academic Performance.**

Categorization	Square sum	Degrees of freedom	Mean square	F	p value
Sch_ homework	48.122	32	1.504	6.310	<0.001
Extra_ homework	19.316	32	0.604	2.482	<0.001
Cram_ school	23.076	30	0.769	3.173	<0.001
Exercise	50.513	109	0.463	1.923	<0.001

**Table 4. Descriptive Analysis of Student Engagement (N = 5,998).**

Categorization	Min	Max	Mean	SD
Sch_ homework	0	40.5	16.07	8.390
Extra_ homework	0	40.5	4.14	6.144
Cram_ school	0	40.5	4.30	7.535
Exercise	0	17.5	2.30	2.148

performance ( $p < 0.001$ ). The effect of hours of writing school homework on academic performance was relatively high ( $F = 6.310$ ), followed by hours of cram school ( $F = 3.173$ ) and extra work ( $F = 2.482$ ), and exercise had the smallest effect ( $F = 1.923$ ), but still had a significant effect on performance (see **Table 3** for details). In addition, we used descriptive statistics to analyze student involvement, and the results are presented in **Table 4**. The results showed that students spent the longest amount of time per week on school homework, with an average of 16.07 hours per week, followed by attending cram school and writing extra homework. In contrast, students exercise an average of only 2.30 hours per week, dramatically less than the time spent on academics.

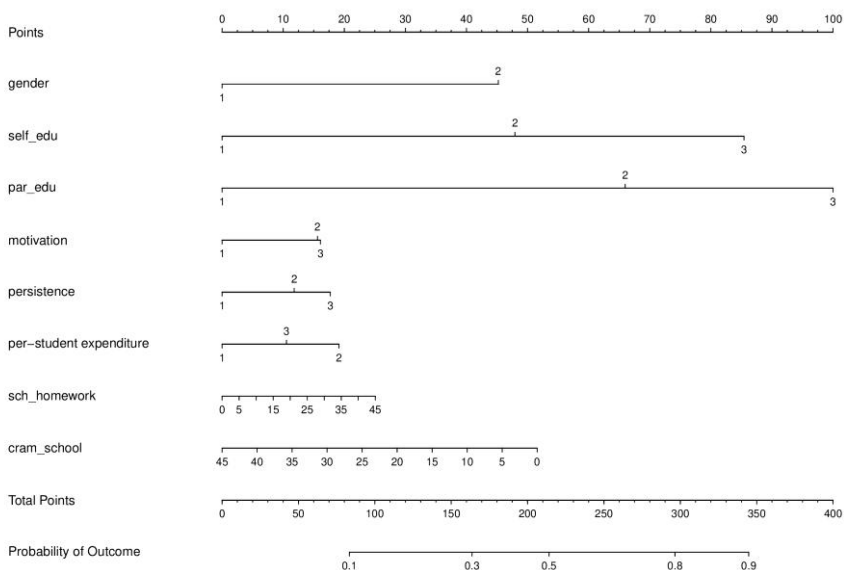
### ***Logistic Regression Analysis of Factors Affecting Academic Performance***

Binary Logistic regression analyses were conducted using the statistically significant factors from the univariate analyses as independent variables and students' academic performance as the dependent variable. In order to mitigate potential bias in the results due to high correlation between variables, VIF was used to check the data for multicollinearity. The results showed that the VIF values of all the variables in this study were less than 5 (range 1.019 - 2.147), proving that there is no problem of multicollinearity among the variables.

Table 5. Logistic Regression Results.

Independent Variable	B	SE	Wald $\chi^2$	p Value	OR	95%CI	
						Lower Limit	Upper Limit
Intercept	-2.876	0.173	277.671	<0.001	0.056	0.040	0.079
Exercise	-0.015	0.014	1.172	0.279	0.985	0.958	1.012
Extra_homework	-0.007	0.006	1.483	0.223	0.993	0.982	1.004
Cram_school	-0.016	0.005	12.286	<0.001	0.984	0.976	0.993
Sch_homework	0.010	0.004	7.807	0.005	1.011	1.003	1.018
Gender							
Female	0.756	0.060	160.300	<0.001	2.129	1.894	2.393
Male							
Hukou type							
Urban	-0.097	0.063	2.386	0.122	0.908	0.803	1.026
Rural							
Self-educational expectation							
Secondary Education & Below							
University Degree	0.809	0.090	81.000	<0.001	2.245	1.882	2.677
Postgraduate Degree	1.450	0.107	184.118	<0.001	4.262	3.457	5.255
Parental educational expectation							
Secondary Education & Below							
University Degree	1.114	0.118	89.633	<0.001	3.046	2.419	3.836
Postgraduate Degree	1.692	0.128	174.621	<0.001	5.428	4.224	6.976
Motivation							
Not really agree							
Fair	0.260	0.095	7.482	0.006	1.297	1.076	1.563
Strongly agree	0.273	0.114	5.776	0.016	1.314	1.052	1.642
Persistence							
Not really agree							
Fair	0.200	0.095	4.444	0.035	1.221	1.014	1.470
Strongly agree	0.304	0.114	7.149	0.007	1.355	1.085	1.694
Per-student expenditure							
Low							
Medium	0.339	0.066	26.531	<0.001	1.404	1.234	1.598
High	0.215	0.088	5.991	0.014	1.240	1.044	1.473
School type							
Public	0.209	0.118	3.149	0.076	1.232	0.978	1.552
Private							

The logistic regression analysis revealed that in terms of student involvement, the weekly time spent on exercise and extra homework had no significant effect on academic performance. Attending cram school had a significant negative impact. School-assigned homework was the only variable in the student involvement dimension that positively influenced academic performance; for each additional hour spent on school homework, the odds of performing above the school average increased by 1.1%. Regarding personal background, gender differences were significant, with female students significantly outperforming male students. The effect of hukou type on academic performance was not significant. With respect to psychological characteristics, the student's own educational expectations, parental educational expectations, learning motivation, and learning persistence all had a significant impact on academic performance. Among these, the student's own and parental educational expectations were the

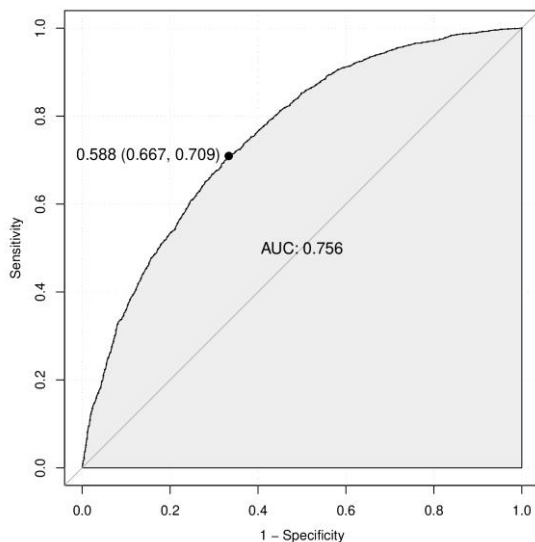


**Figure 2. Nomogram.**

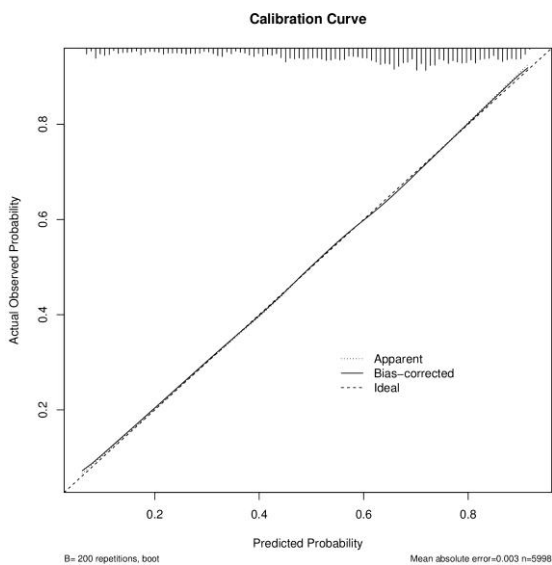
strongest predictors of academic performance, with their odds ratios (ORs) being substantially greater than 1 and significantly higher than those of other independent variables. The regression results are detailed in **Table 5**.

### ***Predictive Modelling of Academic Performance of Junior High School Students***

A Nomogram prediction model was developed based on the factors affecting students' academic performance, the details of which are shown in **Figure 2**. The names of the variables are displayed on the left side; each variable corresponds to a line segment, and the scale of the line segment indicates the range of scores of the variable. The larger the range of scores, the greater the impact of the variable on the predicted results of the model, and the more important the variable is. Individual scores on each variable are summed to obtain the TOTAL POINT, which represents the total score of an individual in the model. The probability that a student's academic performance is higher than the school average is obtained by plotting the Total Point against the Prob of outcome axis. According to the nomogram, the significance of the predictor variables is: parental education expectation > self-education



**Figure 3. ROC Curve.**



**Figure 4. Calibration Curve.**

expectation > cram school > gender > school homework > per-student expenditure > learning persistence > learning motivation.

The results of the ROC curve test showed that the average AUC value was 0.756, and the sensitivity and specificity were 0.709 and 0.667, respectively. These results indicate that the model is effective in predicting

students' academic performance, and the predictions are within acceptable limits (Mandrekar, 2010). The specific details of the ROC curve are shown in **Figure 3**. The calibration curve fluctuates around the ideal curve and almost overlaps with the ideal curve, which fully indicates that the model predicts well and is repeatable. The mean absolute error (MAE) is 0.003, and the lower error rate once again indicates the prediction accuracy of the model, details of which are shown in **Figure 4**.

## Discussion

Based on the Input-Environment-Outcome (I-E-O) theoretical framework, we utilized nationally representative large-scale survey data to investigate the influence of multidimensional factors on the academic performance of ninth-grade students. The findings indicate that the formation of academic performance is a complex process involving the synergistic effect of multiple factors. A student's individual and psychological characteristics serve as the internal drivers influencing academic performance. At the same time, the educational environment in which students are situated, and their academic involvement within it, also have a significant impact on their academic performance.

Slightly more than half of the total number of students in this study, 57.04%, performed above the school average. Overall, students' academic performance tended to be better than average. In terms of the distribution of the number of students with high and low academic performance, this result is also in line with the reality that 50% of students enter regular senior secondary schools under the mechanism of '50-50 streaming in the high school entrance examination'.

### *The Dominant Role of Educational Expectations*

This study found that both parental and student self-educational expectations significantly and positively predict academic achievement, with the role of parental expectations being more critical. Higher levels of expectation are associated with a greater probability of achieving high academic performance, a finding that is consistent with existing research (Fishamn, 2022). Furthermore, according to the results from the nomogram model and the regression analysis, the importance of parental educational expectations for student achievement is slightly greater than that of student self-expectations, highlighting the crucial role played by external family expectations.

This finding aligns with the classic Wisconsin Model of Status Attainment, which posits that educational expectations, as a key sociopsychological variable, serve as the core mediator linking family socioeconomic background to an individual's ultimate educational achievements

(Sewell et al., 1969). Our study demonstrates that this model remains applicable within the Chinese educational context. However, this study also finds that when we incorporate the practical application of these expectations, specifically the weekly time spent in cram school, into the model, this factor exhibits a significant negative effect on academic performance. This indicates that merely holding high expectations is insufficient. How these expectations are translated into concrete educational behaviors is key to moderating their ultimate effect. This finding thereby adds a new interpretive dimension to the Wisconsin Model's application in contemporary China.

Specifically, the positive influence of high parental educational expectations is effective because, through high-quality interaction and support, these expectations are effectively internalized by students and transformed into autonomous self-expectations (Piquart & Ebeling, 2020a). According to Self-Determination Theory, the positive influence of high parental expectations is realized when these expectations are conveyed in a supportive, understanding, and encouraging manner. In such a context, students feel their autonomy is respected and are thus more likely to integrate external goals as intrinsic motivation, fostering greater learning persistence and self-efficacy. This process of internalization aligns parental and student expectations, synergistically driving academic success. However, this study's finding that weekly time spent in cram school negatively impacts academic performance illustrates an alienated pathway for the transmission of expectations. When high parental expectations fail to be internalized through effective family communication and emotional support, and are instead transformed into a form of external, coercive behavioral control, the positive effect can be diminished or even reversed. In such cases, an 'expectation gap' emerges between the parents' high expectations and the students' actual feelings, abilities, or willingness (Cheng et al., 2022). An expectation gap transforms educational expectations from a motivational goal into an oppressive source of external control, negatively affecting academic performance through several mechanisms. First, the expectation gap directly undermines a student's learning autonomy, shifting learning from intrinsic exploration to passive coping, which in turn weakens learning motivation (Li & Hu, 2021). Second, persistent pressure and the negative feedback that may accompany failure to meet high expectations can erode a student's academic self-efficacy, making them feel that they can never satisfy their parents, regardless of their efforts. Finally, long-term psychological stress, academic burden, and negative emotions significantly increase the risk of academic burnout, leading students to cognitively and emotionally disengage from learning, which results in a substantial negative impact on their academic achievement (Cheng et al., 2022). Therefore, the influence of educational expectations on the academic achievement of middle school students is not a simple linear positive relationship but rather a complex process characterized by dynamic interplay.

While high expectations from parents and students are undoubtedly valuable psychological capital for academic success, the realization of their positive effects hinges on the manner of their transmission and application. Only when the communication of these expectations maintains and promotes a student's autonomy and intrinsic motivation, thereby achieving high-quality internalization, can they serve as a catalyst for academic development. Conversely, they will erode a student's learning motivation, be detrimental to their physical and mental well-being, and ultimately impede academic progress.

### ***The Negative Impact of Cram Schools on Academic Performance***

The influence of student involvement on academic performance presents a contradiction: although the time spent completing school homework is positively associated with high academic performance, the duration of participation in cram school shows a significant negative association. This seemingly conflicting result indicates that the sheer 'quantity of time invested' is not the key to academic success; rather, the nature of that engagement may play a more crucial role. We argue that school homework and cram school courses are fundamentally different in how they affect student learning autonomy. From the perspective of Self-Determination Theory (SDT), school homework, as an extension of the school curriculum, is typically designed by teachers in accordance with the syllabus. Its content is synchronized with the pace of instruction, and its difficulty is often within the student's zone of proximal development, which helps students consolidate knowledge and effectively satisfies their need for competence. In contrast, cram school courses are often arranged by parents and are more representative of external control rather than an autonomous choice by the student. These courses frequently aim to "teach ahead" or "raise the bar," and their learning content may exceed the student's current cognitive abilities, leading to persistent frustration and undermining their sense of competence. This passive participation can thwart the student's need for autonomy. Even if a student is intrinsically motivated, such a controlling learning context may lead to inefficient, surface-level learning, thereby negatively impacting academic achievement. As existing research has indicated, excessive extracurricular tutoring intensity is closely associated with students' psychological stress and academic burnout (Fu et al., 2023).

Additionally, although descriptive statistics indicate that students' physical exercise time (mean = 2.30 hours/week) is severely constrained by numerous academic activities, the multiple regression model reveals that, within the analytical framework of this study, exercise duration was not a direct predictor of academic achievement ( $p = 0.279$ ). Therefore, the nega-

tive effect of cram school is not primarily realized through the indirect pathway of crowding out time for physical exercise, but is more likely to stem from its direct impact on learning psychology and the learning process. Specifically, although existing research has indicated an association between attending cram school and negative emotions such as an aversion to learning (Li & Liu, 2022), this study finds that learning motivation and learning persistence remain among the most critical psychological characteristics for achieving high performance. In other words, the negative impact of attending cram school may not be that it simply and completely destroys students' motivation to learn; rather, it likely operates through other mechanisms while their motivation is still present. For example, the intensive, test-oriented training in cram school may hinder the development of students' deep learning and critical thinking skills (Guill et al., 2022). Even if a student is motivated to complete assignments, their learning efficiency and ultimate outcomes could be substantially compromised by a shift toward surface-level learning.

### ***Indirect Effects of Hukou and School Type***

In the univariate analysis, hukou type and school type were initially found to be significantly associated with academic achievement. However, when micro-level variables such as individual student characteristics, the psychological characteristics, and specific school resources were incorporated into the binary logistic regression model, the predictive effects of these two variables were no longer significant. This does not suggest that hukou type and school type have no impact on academic performance. Instead, it reveals that their influence is indirect: after the inclusion of more substantive micro-level variables, their effects are mediated by these variables.

In the analysis, the effect of hukou type on academic performance exhibited a significant transformation. In the univariate analysis, students with a non-agricultural hukou demonstrated significantly better academic performance than students with an agricultural hukou. However, in the binary logistic regression model that incorporated more control variables, the direct predictive effect of hukou type became non-significant. This shift indicates that hukou type does not directly determine academic performance but more likely operates through more specific mediating pathways. Specifically, from the perspective of family cultural capital, educational expectations demonstrated the strongest predictive power among all independent variables. This points to a pathway for the influence of hukou type. A reasonable explanation is that families with a non-agricultural hukou are typically situated in urban environments with more advantaged socioeconomic status and cultural resources, and this environment may naturally translate into higher educational expectations among family members (Sun et al., 2025). These high

expectations, acting as a potent form of “cultural capital,” not only directly motivate students but also positively influence their “learning motivation and learning persistence,” and these two psychological qualities are also significant predictors in the model. Consequently, when the model directly measures this core driver of educational expectations, a portion of the explanatory power held by hukou, a relatively macro-level background label, is absorbed by these more targeted psychological variables. While educational expectations are the most central of these variables, the model’s other significant predictors, learning motivation and learning persistence, also likely stem from the family environment. Together, they constitute a psychological mediation chain through which hukou type influences academic performance. On the other hand, from the perspective of educational resource allocation, the regression analysis shows that “per-student expenditure” is another significant environmental factor influencing student achievement. China’s long-standing urban-rural dual structure has created vast disparities in educational resources, resulting in significant inequality in accessing financial support between rural schools associated with agricultural hukou and urban schools associated with non-agricultural hukou (Zhao, 2023). Urban schools typically receive higher per-student funding, which translates to higher-quality teachers, better facilities, and richer educational resources. Because this study’s model directly controls for “per-student expenditure” which is the core variable reflecting the school environment, it also accounts for the resource advantages attached to hukou status, rendering the independent effect of hukou type no longer statistically prominent. Therefore, the influence of hukou type on the academic performance of middle school students is indirect; its effect is realized through two pathways: shaping the “family soft environment” and the “school hard environment.” When the model simultaneously controls for both the family soft environment and the school hard environment, the influence of hukou type as a macro-level social identity is no longer significant.

Similarly, the school type variable, which was significant in the univariate analysis, was no longer significant in the binary logistic analysis. This disappearance of significance may be due to the presence of selection bias. The “public school advantage” observed in the univariate analysis may not stem from the “public” status itself, but is rather a combined result of the school’s resource endowments and the student population it serves. Existing research has pointed out that schools of different types have significant differences in their student populations, and a school’s educational effectiveness is largely influenced by the selection mechanisms related to its student quality (Yao, 2023). First, from the perspective of resource endowments, the binary logistic regression model included “per-student expenditure” as a key variable in the analysis. The results show that the level of per-student expenditure has a significant positive impact on students’ academic perfor-

mance, which indicates that the financial resources a school receives are an important factor in student academic development. When the model controls for this variable, which more directly reflects a school's resource level, the general labels of "public" or "private" lose their independent predictive power. In other words, for both public and private schools, being able to obtain adequate resource investment is the key to promoting student academic development, not the nature of their governance. Second, from the perspective of student body composition, this study, proceeding from the 'input' dimension, selected a large number of variables related to students' individual backgrounds, including educational expectations, learning motivation, and persistence. All of these variables were found to be powerful predictors of academic performance. In Chinese educational practice, schools of different types or reputations often attract student groups from diverse backgrounds, a phenomenon known as 'student sorting' (Tan & Zhang, 2025; Yao, 2023). High-quality public schools with strong reputations may naturally attract students who come from families with higher educational expectations and more ample support. Therefore, the advantage of public schools observed in the univariate analysis may simply be a concentrated reflection of the pre-existing advantages of its student population. Consequently, when the multivariate regression model takes these advantageous factors into account, the independent effect of the school type subsequently disappears, its explanatory power having been absorbed by the more substantive variables.

### ***Model Evaluation and Reflection***

Building upon the identification of key factors influencing the academic performance of middle school students, this study further developed a nomogram model with strong predictive performance. In terms of model performance, its AUC was 0.756, with a sensitivity and specificity of 0.709 and 0.667, respectively. This indicates that the model can effectively discriminate between student groups performing above or below the in-school average, demonstrating predictive power within an acceptable range. Furthermore, the model's calibration curve nearly coincided with the ideal curve, and its MAE was only 0.003. This clearly demonstrates a high degree of concordance between the predicted probabilities and the observed frequencies of high achievement, showcasing good calibration performance and thereby enhancing the model's reliability for practical application. The strong performance of the model in this study can be attributed to its precise capture of key influencing factors, particularly through the quantification and successful integration of variables such as student and parental educational expectations, gender, and academic involvement into a unified predictive framework.

Compared to traditional regression equations, the greatest advantage of the nomogram model constructed in this study lies in its intuitive nature

and ease of use. The model transforms complex statistical results into a simple, graphical scoring system, enabling educators without a statistical background to use it with ease. On a practical level, schools and teachers can utilize this nomogram to conduct prospective assessments of student academic performance. By inputting a student's specific information on the various indicators, one can quickly obtain a quantified probability of that student's achievement being above the in-school average. This helps educators identify students who may face academic challenges, thereby allowing for early intervention and the provision of personalized academic support or psychological counseling to achieve targeted instruction.

The model in this study also has certain limitations. On the one hand, there are limitations in the scope of variable selection. Although this study, guided by the I-E-O model, included 14 variables from the 'Input' and 'Environment' dimensions, it may still have overlooked other potentially important factors. These include teacher-level variables such as teaching style, peer effects, and other deeper psychological variables like student self-efficacy and resilience. These unmeasured variables may have constrained the upper limit of the model's predictive accuracy. On the other hand, there are boundaries at the methodological level. First, the model constructed in this study is a predictive model; it reveals correlations between variables and the outcome, rather than strict causal relationships. Second, the model's external validity requires further examination. Although the model demonstrated good internal validation, its generalizability to different regions or types of schools still needs to be verified through further empirical testing.

## **Conclusion and Limitation**

This study systematically investigated the multifaceted factors influencing the academic performance of middle school students and constructed a nomogram model with good predictive performance (AUC = 0.756). The conclusions indicate that psychological capital that originates from the family and is internalized by the student, especially educational expectations, serves as the core driving force that surpasses other variables, highlighting the decisive role of intrinsic motivation in academic achievement. The study also revealed the differential returns of various academic involvement behaviors and elucidated that the influence of macro-structural factors, such as hukou type and school type, is largely realized indirectly through more direct micro-level pathways like family cultural background and actual school resources. Overall, this study not only identified the key predictors of academic performance but also provided deeper insights into the complex interaction among these factors, offering a valuable empirical reference for educational practice and policy interventions.

This study has several limitations. First, the data used were collected from surveys conducted between 2014 and 2015, the most recent available from the CEPS dataset. However, to more accurately and comprehensively investigate factors influencing junior high school students' academic performance, future studies should employ more representative and up-to-date data that reflect changes in the educational context. Second, the study focused exclusively on Grade 9 students. As final-year students, they face unique curricular demands and psychological pressures. Therefore, further research is needed to examine the factors influencing academic performance among students in earlier grades of junior high school.

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*Received: September 16, 2025*

*Revised: October 30, 2025*

*Accepted: November 08, 2025*