Why Peers Matter: How Friendship Network Affects Academic Performance

Abstract:

Social relationships affect behavior and performance. Based on the student friendship questionnaire surveys conducted in high school sample classes, this article examines the influence of the network position of individual students within the class on their academic performance. Our research shows that the more popular students are in class, the better academic performance he or she can get in the exams. However, the number of friends a student filled out in the survey seemingly have little correlation with their scores. In addition, this paper tests the heterogeneous impact of the social network on school performance and further attempts to analyze the relevant mechanisms. In this way, we provide a rigorous empirical study to prove that difference in the direction of social network relationships affects behavioral performance, which indicates that students can promote the accumulation of human capital from an early stage through constructing effective social network in their daily life.

Key words: social network analysis, friendship network, student achievement

1. introduction

As Jackson said, a person's social position determines his destiny. High school students study hard and change their destiny through the college entrance examination, which is especially important for families in rural and backward areas. Existing research shows that students' academic performance is affected by many factors, which are the result of the joint action of students, families, schools and peers. But a fact that cannot be ignored is that social networks may also have an impact on students' academic performance. Students have their own social network, and a student's position in the network may determine their academic performance. According to the situational learning theory (SLT), learning is a social situation process in which knowledge is acquired through interaction with others. The interaction between students plays an important role in achieving high-quality learning effects for individuals (Wenger, 2001). Compared with children and adults, adolescents are in a critical period of self-cognitive consciousness development and maturity. Peer relations are more important and have a greater impact on learning performance (Meeus *et al.*, 1994).

As far as senior three students are concerned, their friends are mostly concentrated in the class, and their learning exchanges and daily interactions have a greater impact on their academic performance. Based on the integration of the friendship information of the sample class students, this article describes the structural characteristics of the individual friendship network in the class from different dimensions, focusing on exploring the size of the student peer circle, the central position in the network structure, and the society of interaction with others The effect of distance on their academic performance. On the basis of relevant tests, the study found that the impact of class networks on individual students needs to distinguish the direction of the relationship. Students with good relationships tend to perform better, and whether they are good at communication has little effect on students' academic performance, and through different Qualitative analysis explains possible transmission mechanisms.

The possible marginal contribution of this paper is: In terms of methodology, through the use of social network analysis methods, the micro foundation and macro factors that affect students' academic performance are included in a unified analysis framework, and its feasibility, rationality, effectiveness, and unbiasedness Make theoretical tests and empirical exploration; in terms of analysis and demonstration, conduct a large sample survey on a high school field, measure the social network structure of students in the form of questionnaires, and attach importance to the situational application of relevant theoretical concepts in empirical research, more rigorously Select the econometric model, use instrumental variables to reduce reverse causal effects, and test for possible missing variables to avoid related endogenous issues; in terms of research conclusions, use social network quantitative indicators with different connotations to identify the direction of friendship relations to students The individual's differential influence enhances the explanatory power of the social network analysis method on the factors affecting student performance. Heterogeneity analysis also provides a corresponding empirical basis for the interpretation of related mechanisms.

The structure of this paper is as follows: the second part is a review of relevant literature; the third part is research design; the fourth part is variable selection, model setting and sample description statistical analysis; the fifth part is empirical analysis; the sixth part is different Qualitative analysis and mechanism explanation; the seventh part is the main conclusions and future prospects.

2. literature review

Influencing factors of student performance

In the field of school education, scholars mainly study the factors that affect students' academic performance from the perspectives of student personal characteristics, school atmosphere, class and teacher differences, family conditions, peer interaction (Brophy, 1983; Ames & Archer, 1988; Dishion, 1990; Skinner *et al.*, 1993; Zheng Siming, 2004; Zhao Bihua, 2013; Lu Zhiquan *et al.*, 2013; Zhang Xia, 2018)

Specifically, in terms of personal attribute characteristics, students' gender, age, ability, etc. have a differential impact on academic performance (Wang Chunchao and Xiao Aiping, 2019). Researchers usually use student past performance as an indicator to measure student ability (Frey&Detterman, 2004); In terms of learning environment, Ames (1992) pointed out that the classroom structure will affect students' performance goals and follow-up behaviors; in terms of family conditions, scholars mainly obtain social resources from families (Bourdieu, 1986). Participation (Ho & Willms, 1996; Iarael *et al.*, 2001) and home-school interaction (Pong *et al.*, 2005) and other paths embark on empirical research on family social capital and the conversion to educational capital.

In the empirical research, there are not a few literatures about peer interaction, and most of them focus on discussing the influence of peer characteristics and interaction behavior on student performance. For example, Coolahan *et al.* (2000) explored the relationship between children's peer interaction and the formation of related abilities; Julia (2004) discussed the positive impact of peer performance at the class and age levels on pupils' academic performance; similarly, Contreras et al . (2012) discussed the impact of peer effect on college students' classroom performance; some scholars pointed out that there is a "one takes on the color of one's company" achievement convergence among peers (Antrobus, 1988; Puller, 2008; Lomi *et al.*, 2011) ,and many more.

The above-mentioned research on the influencing factors of student performance or analysis of the influence of student-related characteristics on academic performance along the traditional path ignores the social network location and structural differences brought by individual interaction; or only from the macro-environment level (Kindermann *et al.* , 1996), ignoring the specific mechanism of interaction within the student group, lacking a "bridge" to effectively communicate the micro-theoretical framework and the macro-interaction effect.

This paper considers the effects of students' learning environment, and combines the individual characteristics and family characteristics of the students through social network analysis to explore the influence of the position and structural characteristics of the students in the class's internal friendship network on their academic performance. From the qualitative perspective, the possibility transmission mechanism is elaborated, which effectively avoids the construction of the theoretical framework of "missing one another".

Social network analysis methods

As a quantitative research method to study the interaction relationship of actors in social networks from a structural perspective (Freeman, 2011), social network analysis (SNA) analyzes the social interaction relationship by indexing and graphically The normative analysis of attributes and relationship structures provides a theoretical paradigm for quantitative analysis of the location and structure of the social network where actors are located. (Sun Lixin, 2012).

In terms of network scale, in addition to studying the relationship structure in the overall network relationship, SNA is also widely used to quantify the correlation characteristics of the location of individual social networks (Freeman *et al.*, 1979). The size of the personal network, the degree of being central in the network, the distance to the social network that interacts with others, and the strength of the relationship are common indicators that characterize social network relationships.

SNA based on individual perspective is also widely used in the field of student performance factors analysis. In view of the relatively complex social network relationship acquisition and conversion into a matrix form, many scholars use social software or online learning platforms to obtain online interactive data of students for related research (Chung & Paredes, 2014). In the study of offline interaction between students, scholars generally use the social measurement method created by Moreno in the 1930s as a method of questionnaires for students to nominate peers to identify individual peer network relationships (Cadima *et al.*, 2012) .

Regarding the relationship between the social network relationship of students and their academic performance, most studies have concluded that the two show a significant positive relationship (Chung *et al.*, 2009; Hommes *et al.*, 2012; Poldin, 2016). Furthermore, Wang Chunchao and Xiao Aiping (2019) identified the causal mechanism that the highly central students in the class have a significant impact on the performance of surrounding students through random experiments.

The research methods of social network in the above literature are mostly separated from the traditional analysis path. In the process of exploring the relationship between the quantitative indicators of social network and student performance, there is little systematic control of the individual, family and environmental variables of the student, and there is a large bias in the estimation results; Most of the relevant indicators of centrality are selected to measure the structural characteristics of students' position in social networks, ignoring the rich information contained in other dimensions; in terms of network relationships, most of the literature regards friend relationships as

two-way relationships, and does not consider non- Symmetry affects differences.

Based on relevant research, this paper is aimed at the group of high school students with a stable network structure, using their class as the basis for delimiting the network boundary, and using the indicators of different dimensions of social network to control the individual network characteristics of students under the control of relevant variables. To quantify and distinguish the directional differences of friendship relations, study the impact of students' social network structure on their academic performance, and explore possible transmission mechanisms through heterogeneity analysis to form a complete analytical framework.

3. Research Design

3.1 Survey target

This research was conducted in a first middle school in Shandong Province. There are five divisions in each grade of the high school. A competitive incentive mechanism is adopted among the divisions, and the progress and teaching plans of the classes within the divisions are promoted in a unified manner. According to the pilot program for comprehensive reform of the college entrance examination issued by the General Office of the Shandong Provincial People's Government, Shandong Province officially implemented the linguistic extracurricular examination and selected the examination system for the remaining three subjects starting from the fall 2017 high school entrance freshmen (the freshmen for the 2020 college entrance examination). Considering that students select courses and reorganize classes at the beginning of the fall semester of the second year of high school, the author chooses a group of senior three students with a stable social relationship network as the research object, and selects five classes as samples according to the combination of courses selected by the school. Classes (hereinafter referred to as classes A to E).

3.2 Questionnaire design

To obtain students' network relationships and family information, the author has designed two questionnaires. The first questionnaire (hereinafter referred to as the questionnaire (1)) surveys the social network relationships within the class for the student group, and the second questionnaire (hereinafter referred to as the questionnaire (2)) surveys the family social capital of students and their parents . The design ideas of the two questionnaires are shown in Table 1. For details, please refer to *Appendix* I and *Appendix* II.

Table 1 Questionnaire (1) Design Idea: Identify Student Social Network

	Content	Question number	Description
Personal characteristics	Name	A1	Identify students
	Place of residence	A2	
	Accommodation status	A3	
Social network	Social position	A7 A8	Obtain students' social network relationship through naming method and positioning method
	Friend information	B1-B4	
	Academic resources	B5	
	Emotional support	B6-B8	
	Answer questions	B10 B11	
overall evaluation	Learning Status	A4-A6	Self-assessment of learning status and quantitative scoring of influencing factors
	Influence factor	B9 C1-C7	

Table 2 Questionnaire (2) Design Idea: Determine Student Attribute Information

	Content	Question number	Description
Personal characteristics	Name	A1	Identify students
	Place of residence	A2	
	Accommodation status	A3	
Family characteristics	Parent occupation	B1 B2	Measure the family social resource score
	Number of children	B3	
	Number of electronic devices	B4	
	Monthly disposable income	B5	
	Family social position	B6	
Social closure	Parental involvement	C1-C3	Investigate the role of family social capital
	Intergenerational closure	C4-C5	
Learning Status	Online entertainment	B7	Estimate the degree of student holiday effort and influencing factors
	Influence factor	D1	
Social network	Emotional support	D2 D3	Students who do not fill in the questionnaire (1) and fill in the invalid need to fill in this part
	Answer questions	D4 D5	

3.3 Questionnaire issuing and recycling process

The questionnaire is issued in two stages due to the differences in the survey objects.

In mid-January 2020, the author distributed a paper version of the questionnaire (1) to the students in the sample class and recycled it on the spot. A total of 285 questionnaires were distributed, 245 of which were valid questionnaires containing accurate personal identification information and clear answers to social network relationships. The survey recovery rate was 73.13%.

At the beginning of February 2020, the questionnaire (2) originally scheduled to be issued by the Council of Academicians was changed to online due to the impact of the epidemic. After preliminary data cleaning and sorting, the author combined with the senior high school students' school status information to determine the actual number of students surveyed in each sample class. Those who are deemed to be invalid questionnaires in the first stage and students who have not completed the questionnaires need to answer additional questions about the social network relationship information in questionnaire (1). The author issues electronic questionnaires to the same student group and its parents through student social groups, parent communication groups and other channels, with a payback period of one week. At this stage, 335 questionnaires were distributed and 313 valid questionnaires were recovered. The survey recovery rate was 93.43%.

See *Appendix (3)* for the details of the questionnaire distribution and recovery of each sample class.

3.4 Reliability and validity of the questionnaire

3.4.1 Reliability test

Given that the questionnaire topics are mostly subjective, it is difficult to use the internal consistency coefficient to test. The author chooses to use test-retest reliability to test whether there is a significant difference in the time dimension of the questionnaire measurement results.

In the second stage of questionnaire issuance, the author randomly selects about 10% of the students in the sample to fill in the social network questions of questionnaire (1) again, and uses Stata commands to convert the answers to the two questions in questionnaire (1) B8 and B11 into continuous variables. , To get the internal correlation coefficient (Intraclass Correlation Coefficient, ICC), respectively 0.84 and 0.79. This shows to a certain extent that the questionnaires for measuring students' social relations have stability over time, and students' social relations networks are less affected by daily random disturbances.

3.4.2 Validity test

We could check the accuracy of the questionnaire questions from the level of content validity to reflect the measured things (Qilaibin *et al.*, 2003).

This study takes students in sample classes as the main body and studies the factors that affect students' academic performance from two perspectives: students' social network relationship and family social resources. Among them, the social network topic uses a fixed-line free nomination method to determine student peer relationships. This idea is used by large-scale survey projects such as the United States Comprehensive Social Survey (1984, 2004) and the Taiwan Social Change Survey (1997, 2017 respectively) to determine individual cores. The network structure has a certain degree of authority; the topic of family social resources draws on the idea of the "National Youth Science and Technology Literacy Survey" (2009), and explores it from two perspectives of network resources and social closure, which is representative. From the point of view of qualitative analysis, the essential characteristics of the questionnaire questions have been verified by predecessors, which largely fit the research theme.

4. Variable selection, model setting and sample description statistical analysis

4.1 Illustration of the class's overall social network

There are two sources for the data in this article, one is to obtain the students' social network and family information data through the questionnaire survey method, and the other is the student's achievements and related personal data. After integration and cleaning, through the qualitative analysis method, the overall social network panorama of the class can be portrayed.

Specifically, in the questionnaire (1), we asked the friendship network of students in their class:

Please write down five students who have a good relationship with you in this class (if there are less than five students, you don't need to list them completely.

(1) _____ *(2)* _____*(3)* _____*(4)* _____ *(5)* _____

problems	*(1)*	*(2)*	*(3)*	*(4)*	*(5)*
A. How often do you interact with him (her) on average every week? (please fill in the specific value) (if less than one, please specify this to one)					
B. How long have you known him (her)?					

Converting the obtained answers into the matrix of student relationships in the class, combined with personal attribute information, we can get the friendship network of each of the five sample classes.

Taking class A as an example, with the help of UCINET and NETDRAW software (Borgatti *et al.*, 2002), considering the gender variables of students, we get Figure 1:

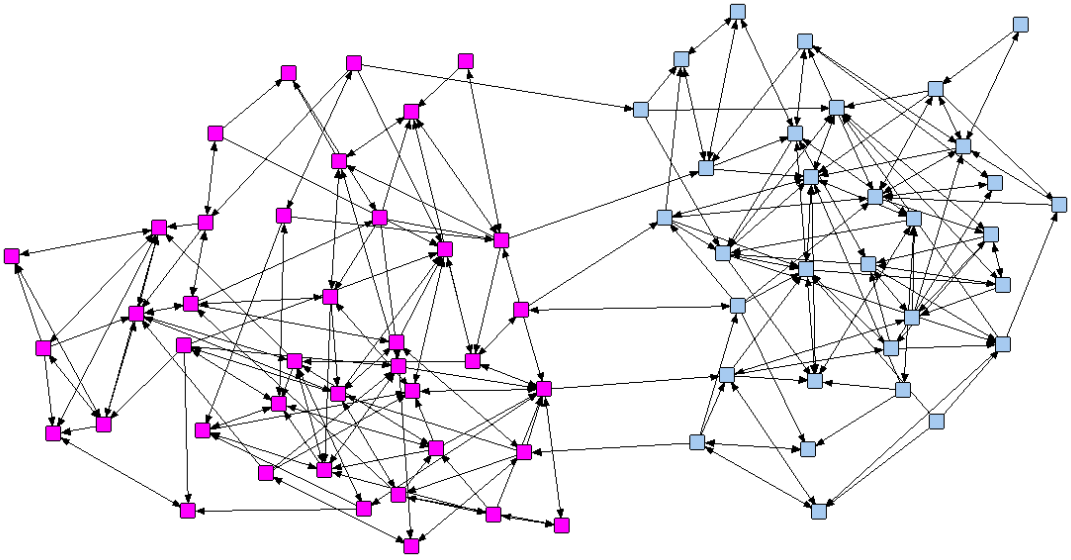


Figure 1 the whole friendship network in class A

Note: The node represents the sample student individual (ego), the fuchsia node represents the girl, and the light blue node represents the boy; the line between the dots represents the intimate friendship between the students, and the arrow direction represents the individual student as the other party is a friend ; The shape of the network can be adjusted at will, and the position of the individual in the image does not represent the student's actual network status.

As can be seen from the image, the Class A friendship network is a component, the whole is more "unity", and there is no isolated point ignored by others. At the same time, students tend to have better relationships with classmates of the same gender. The communication between boys and girls is only connected by 6 relationship lines, and the relationship density is low.

If we use a dark red line to represent a reciprocal relationship (both parties in the relationship call each other as friends), a bright blue line represents a non-reciprocal relationship (the relationship node is only the issuer or recipient of the relationship), and the thickness of the line segment represents the strength of the relationship It can be found that the reciprocal relationship of girls is relatively widely distributed and the relationship intensity is higher, and the reciprocal relationship of boys is relatively dense and intimate. (See Figure 2)

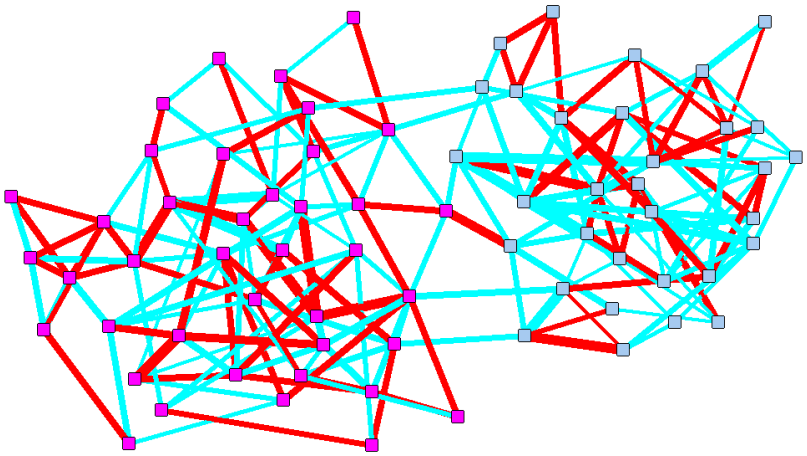


Figure 2 The relationship between class A relationship strength and reciprocity

From the above qualitative analysis, we can see that there is a certain correlation between students' academic performance and friendship network structure. which may be affected by personal attributes such as gender. This laid an intuitive foundation for subsequent variable selection and model setting.

4.2 Variable selection

4.2.1 Explained variable

This article uses the final exam results of the fall semester 2019 to measure students' academic performance. Taking the differences in the difficulty of different combinations of subjects into account, we selected the average score of the Linguistics and English subjects (hereinafter referred to as "main subject") as the variable to be explained. *A* (4) shows the overall school, the sample classes and the distribution of results within the sample classes. The distribution of results is similar and representative.

4.2.2 Core explanatory variables

The core explanatory variable in this paper is the relevant index to quantify the position of students' friendship network in the class.

As a collection of actor/ego interactions in a certain field, social networks build a theoretical framework for understanding the nature and characteristics of individual interactions. In terms of its manifestation, scholars generally use nodes to represent actors in the network, and lines between nodes to indicate the existence of interactive relationships between actors (Carrington, 1991).It can be seen from Figure 3 that the source of the peers of the students in the sample class is mostly classmates. Constructing a class internal friendship network to a large extent represents the students' real interpersonal interactions, and it has more explanatory power to discuss related issues.

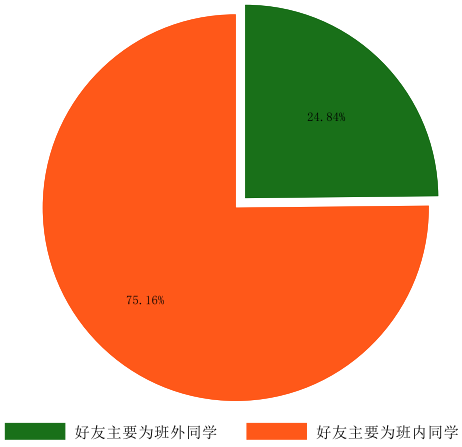


Figure 3 Main sources of student friends

Combining the quantitative analysis ideas of scholars such as Freeman *et al.* (1979), this article describes the interaction between students in the class from three perspectives: network scale, network centrality and node distance.

As the most basic indicator for describing an individual's social network, the individual network size measures the quantitative relationship between the node and other nodes in the network, and we express it in degrees. Among them, the indegree (indegree) represents the number of relationships that the node "received" (received), reflecting its popularity in the network; the outdegree (outdegree) means that the node "initiated" (initiate) to other nodes The number of relationships reflects its activity in the network.

Network centrality (network centrality) is the most common quantitative category in SNA, reflecting the centrality of nodes in the network location. According to the actual situation of the research problem, this paper uses the central distance of the local feature vector as the quantitative index to measure the centrality, so as to more appropriately measure the influence of the student's position in the small circle where he is.

The node distance characterizes the functional characteristics of the social network structure. In view of the asymmetry characteristics of the network relationship studied in this paper, the average reciprocal distance between nodes is used as an indicator to measure the difficulty of students to exchange information resources with other students.

In order to distinguish the directionality of the peer relationship, the internal degree, internal local feature vector centrality distance and internal average reciprocal distance are classified as "inward" social network indicators, and correspondingly, the remaining three items are classified as "outward" social network indicators. The names of friends nominated by class students form the internal friendship relationship matrix of the class, and with the help of related software, relevant index values are obtained.

4.2.3 Control variables

Referring to the previous literature and actual surveys, this article takes the individual characteristics of students and family characteristics as control variables.

a. Individual effects

In terms of individual characteristics, combined with the practice of previous literature and the actual situation of the surveyed subjects, this article mainly considers the differences between students' personal abilities (Hommes, 2012) and gender (Tianheng, 2019). Among them, we use the average score of the main subject of the junior high school to increase the secondary school examination (hereinafter referred to as the "high school entrance examination") to measure personal ability; gender is a dummy variable, the girl is assigned a value of 0, and the boy is assigned a value of 1.

b. Family effect

In terms of family characteristics, combined with previous literature, this paper weights the sample student income percentile and family network resource score (divided into the parental occupational power score and the parental occupational resource score) to obtain the family social capital score.

The meaning and description of the main variables in this article are shown in Table 3.

Table 3 Meaning and description of main variables

	Variable name	Variable definitions	Description
Explained variable	Final grades of the main subject	(Chinese score + math score + English score)/3	Fixed distance 1-150
Core explanatory variable	Internal degree	Number of peer relationships "received" by students	Fixed distance
	External degree	Number of peer relationships "sent" by students	Fixed distance
	Centrality within local feature vector	"Receiving" the centrality position in the local network of peer relationships	Fixed distance
	Local feature vector outer centrality	The centrality position in the local network of "issued" peer relationships	Fixed distance
	Inward average reciprocity distance	The social distance from other people in the network of "receiving" peer relationships	Fixed distance
	Average outward reciprocity distance	The social distance from other people in the "issued" peer relationship network	Fixed distance
Control variable	gender	Dummy variables, 0 for girls and 1 for boys	classification
	Social capital score	1/3 month disposable income percentile +1/3 father professional reputation score +1/3 father professional power score	Fixed distance, 1-100
	The average score of the main subject	(Chinese language scores in the senior high school entrance exams + math scores in the high school entrance exams + English scores in the high school entrance exams)	Fixed distance, 1-120

4.3 Model building

To explore the influence of students' social network structure on their academic performance, combined with students' personal characteristics and family characteristics, this paper constructs a multiple linear regression model, the equation is as follows:

$$y_i = \alpha + \beta x_{1i}^{network} + \gamma \sum x_{2i}^{control} + \varepsilon_i \qquad (1)$$

Among them, i represents sample student individual; y_i is student i's academic performance indicator; $x_{1i}^{network}$ is student i class network indicator; $\sum x_{2i}^{control}$ represents student i 's personal and family characteristics indicator, at the individual level is Gender, past academic performance, family level is the weighted score of social capital; ϵ_i is the random error term.

Substituting different groups of social indicators into the model for multiple collinearity tests, the variance inflation factor (VIF) is significantly less than 10, indicating that there is no obvious collinearity problem between the main variables. Table 4 presents the test result of the network scale with social network index.

Table 4 Multicollinearity test

variable	VIF	1/VIF
Internal degree	1.05	0.95
External degree	1.05	0.95
gender	1.06	0.95
Social capital score	1.01	0.99
Entrance examination results	1.07	0.94
average value	1.05	0.95

4.4 Descriptive statistics of the sample

Table 5 is the descriptive statistics of the relevant variables of the sample group.

Table 5 Descriptive statistics of samples

Variable meaning	Mean	Standard deviation	Minimum	Maximum	Sample size
Explained variable					301
Final grades of the main subject	102.2	11.29	65.83	125.2	301
Core explanatory variable					301
Internal degree	3.236	1.92	0	10	301
External degree	3.256	1.696	0	6	301

Centrality within local feature vector	11.09	8.362	0	49	301
Local feature vector outer centrality	10.99	6.977	0	25	301
Inward average reciprocity distance	15.36	7.525	0	27.88	301
Average outward reciprocity distance	14.88	7.677	0	29.51	301
Control variable					
gender	0.404	0.491	0	1	301
Social capital score	102.2	11.29	65.83	125.2	301
The average score of the main subject	80.27	9.776	0	100.3	301

Note: The sample of students who have not taken the final exam has been eliminated here; some students filled out six students with good relationships when answering the questionnaire (1) B8, so the maximum external degree exceeds the theoretical maximum (5); centrality and society The distance indicators are standardized according to the class size.

5. Analysis of empirical results

5.1 Analysis of regression results

Figure 4 visually shows the scatterplot of key explanatory variables and explained variables. It's obvious that there may be a positive correlation between the two.

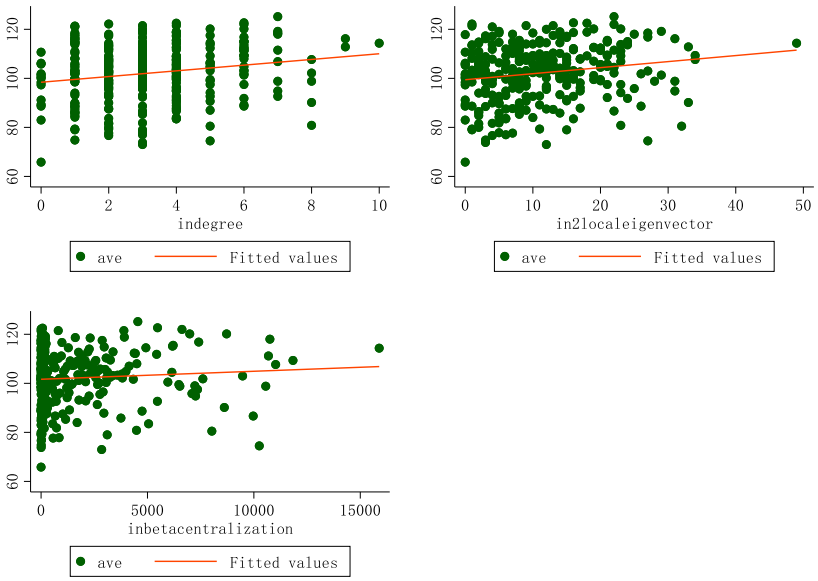


Figure 4 Scattered distribution and fitted straight line graph of "inward" social network

indicators and final grades

Next, we use rigorous measurement results to verify. Table 6 shows the OLS regression results of students' academic performance on related social network indicators. Columns (1) to (5) in the table represent the impact of different types of social network indicators on academic performance.

Table 6 The influence of social network indicators on students' academic performance

	Explained variable: student's average grade at the end of the main subject		
	(1)	**(2)**	**(3)**
External degree	-0.158		
	（0.47）		
Internal degree	0.867***		
	（2.89）		
External feature vector centrality		-0.007	
		(0.07)	
Inner feature vector centrality		0.164**	
		（2.07）	
Average reciprocal distance			0.055
			（0.64）
Average reciprocal distance			0.190**
			（2.2）
gender	6.015***	6.107***	5.871***
	（5.33）	（5.37）	（5.2）
Entrance examination results	1.171***	1.190***	1.170***
	（59.3）	（71.59）	（62.03）
Social capital score	0.080**	0.080**	0.073**
	（2.42）	（2.39）	（2.18）
R-squared	0.992	0.991	0.992
Sample size	192	192	192

*Note: The sample data of the students who did not take the final exam, the family information is obviously missing, and the social network indicators cannot be calculated did not enter the regression process; t statistics in parentheses; ***, **, and * represent 1%, 5%, Significant at the 10% level.*

5.1.1 The influence of social network indicators on academic performance

From the statistical results, the "inward" social network relationship indicators (internal degree, internal feature vector centrality and internal average reciprocal distance) have a significant positive effect on students' final exam scores, and "outward" social network relationship indicators (The external degree, the centrality of the external feature vector and the external average reciprocal distance) affect the direction indefinitely and the effect is not significant.

Specifically, in the regression results in column (1), the regression coefficient of the student's internal degree is 0.867, and it is significant at the 1% level, indicating that under the control of the student's personal characteristics, the more popular the student is in the class, the higher the score The higher; other "inward" social network indicators also verify this conclusion.

Regarding the relationship between "outward" social network indicators and academic performance, the regression results cannot indicate that there is a significant correlation between the two. Compared with the "inward" social network indicator, the corresponding regression coefficients are generally small and insignificant, and even have a negative relationship, which means that the number of friends nominated by a student does not indicate the level of his grades and the presence of students who are busy with communication. With the possibility of a decline in grades.

5.1.2 The impact of students' personal and family characteristics on students' academic performance

In terms of control variables, students' gender, personal ability, and family social capital scores all have a significant impact on academic performance. Under the condition that other conditions remain unchanged, the average academic performance of boys is about 6 points higher than that of girls, which is related to factors such as the knowledge structure of high school subjects and the field of gender expertise (Wu Lan, 2002); students' original basic abilities and knowledge Accumulation is also highly related to the current academic performance of students; in terms of family social capital, the family's economic strength and social network resources at a significant level of 5% have a positive effect on students' academic performance, which is related to related research (Zhao Yandong , 2012) consistent conclusions. It is worth noting that compared with other factors, students' exogenous family conditions have a smaller impact on student performance, indicating that in the high school stage of "on the hero" by scores, intergenerational resources have not been fully converted into students' educational capital. Family conditions are not the main reason for differences in student performance.

5.2 Heteroscedastic analysis

The above OLS regression is based on assumption that ε_i has the same variance in equation (1). If the heteroscedasticity problem occurs, the efficiency of the model estimation effect will be reduced, and the prerequisite for using the t test in the subsequent robustness test cannot be met.

Taking the first set of regression equations as an example, Figure 6 shows the scatter plot of the internal degrees and the residuals of the corresponding regression model. It can be found that the residual values are concentrated around the value 0, and are evenly distributed up and down. Inspection confirmed.

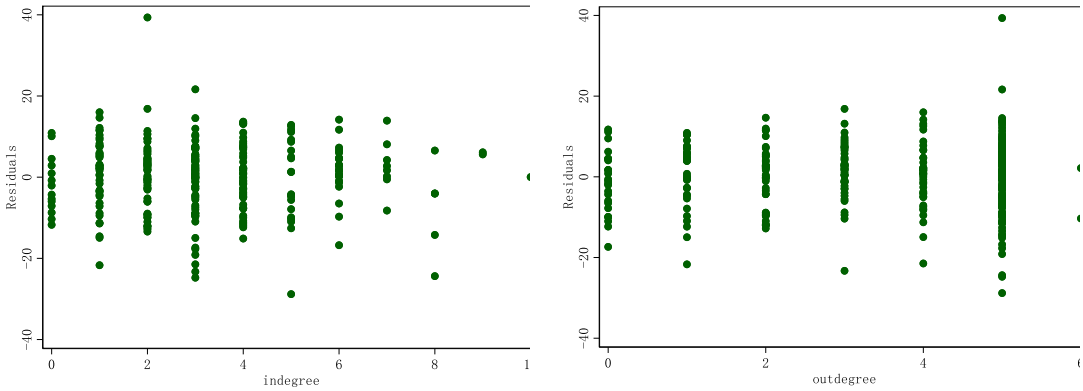


Figure 5 Scatterplot of internal and external degree regression residuals and final scores

5.3 Reverse causality test

From the regression of OLS, we can see that there is a significant correlation between the location of students' social networks and their academic performance, but it is impossible to make a causal inference between the two. While the social network of students affects their academic performance, it may also happen that the better the student's performance, the stronger the attraction to his peers, thereby occupying a more favorable social network position. In dealing with the endogenous nature of social networks, instrumental variable methods are commonly used (Giorgi *et al.*, 2010; Lavy, 2012; Giorgi *et al.*, 2014).

Among them, Giorgi *et al.* (2010) adopted the peer performance of student peers as instrumental variables, but this idea does not apply to the context of this article. This article builds structural information on students' social networks based on a stable class friendship network. Actors in the social network know each other and influence each other, only with different levels of familiarity. That is to say, the friend of the student companion is also a friend of the student himself, but his status in the student's own heart is not very high, and it is not listed in the student's nominated peer list. As such, the peer performance of student peers is not an exogenous indicator and is not suitable for the test of reverse causality.

Based on relevant research, the author uses the student's peer centrality as the instrumental variable of the key explanatory variable. According to the theory of social

network homogenization, the higher the peer centrality, the larger the social network size of the students themselves. At the same time, the size of the peer's centrality does not directly affect the student's academic performance, which can better reduce the endogenous problem that the student's performance affects the scale of the network.

The internal and external central degrees of the local feature vectors of the students' peers are averaged and used as instrument variables for the internal and external degrees of the students, respectively. From the regression results in the first stage of Table 7, we can see that there is a significant positive correlation between the original indicators and the instrumental variables.

Comparing the columns in Table 7(3)(4), we can see that using the instrumental variable method and OLS to regress the final grade on the internal degree index, the regression results obtained are less different, and are all significant positive coefficients; the external degree index is There is also an insignificant negative relationship between academic achievements. From this, we have reason to deduce that the problem of reverse causality is not prominent in the context of this research. Using the OLS regression model is effective, and the position of the students' friendship network within the class does affect their academic performance.

Table 7 Reverse causality test

	The first stage regression results		**Second stage regression results**	
	(1)	(2)	(3)	(4)
	Internal degree	**External degree**	**Average grade (IV)**	**Average grade (OLS)**
Peer centrality	0.212***	-0.0345***		
	(0.01)	(0.01)		
Peer center	-0.030***	0.232***		
	(0.01)	(0.01)		
Internal degree			0.825***	0.742***
			(0.32)	(0.27)
External degree			-0.292	-0.166
			(0.35)	(0.31)
gender	-0.012	-0.051	3.658***	3.645***
	(0.12)	(0.10)	(1.06)	(1.06)
Entrance examination results	0.00	0.01	0.758***	0.758***
	(0.01)	(0.01)	(0.05)	(0.05)
Social capital score	-0.003	-0.002	0.029	0.029
	(0.00)	(0.00)	(0.03)	(0.03)
Constant term	1.131**	0.550	37.43***	37.28***
	(0.50)	(0.43)	(4.52)	(4.51)
R-squared	0.76	0.77	0.44	0.44
Sample size	292	292	292	292

*Note: t statistics are in parentheses; ***, **, and * indicate significant at 1%, 5%, and 10% levels, respectively.*

5.4 Robustness test

This article uses the following two methods to test whether the regression coefficients of key variables are stable.

5.4.1 Replace key explanatory variables

Referring to the practices of scholars such as Wang Chunchao and Xiao Aiping (2019), this paper examines the robustness of different types of social network indicators to explain the significance of the dependent variables and the correlation between the variables.

As shown in Table 8, the correlation coefficients between social network indicators are all significantly positively correlated. Combining the regression results, we can conclude that social network indicators, especially "inward" social network indicators, are robust to the positive interpretation of student achievement.

Table 8 Social network index Pearson correlation coefficient matrix

	External degree	External degree	External feature vector centrality	Internal feature vector centrality	Inward average reciprocity distance	Average outward reciprocity distance
External degree						
Internal degree	0.219***					
External feature vector centrality	0.863***	0.367***				
Inner feature vector centrality	0.335***	0.870***	0.513***			
Inward average reciprocity distance	0.718***	0.235***	0.782***	0.380***		
Average outward reciprocity distance	0.242***	0.691***	0.437***	0.768***	0.525***	
Moderate	0.603***	0.775***	0.596***	0.703***	0.484***	0.560***

*Note: ***, **, and * are significant at the levels of 1%, 5%, and 10%, respectively.*

5.4.2 Random group regression

In ascending alphabetical order of student names, we randomly divided the data into two groups for regression. Based on the seemingly unrelated regression (SUE), the regression coefficient difference between groups was tested, and the empirical p-value of the inter-group degree was 0.8977, and the empirical p-value of the inter-group

degree was 0.1179. The 1% and 5% significant levels cannot reject the null hypothesis that there is no difference in regression coefficients between groups, so the key explanatory variables in the model in this paper do not have significant differences between classes.

Table 9 Regression results of robustness test and missing variable test

	Explained variable: final grade		
	Robustness test for random group regression		Endogenous test for missing variables
	(1)	(2)	(3)
Internal degree	0.767**	0.809**	0.800***
	(1.99)	(2.21)	(2.89)
External degree	0.49	0.741*	0.22
	(1.11)	(1.83)	(0.72)
gender	2.709*	4.530***	3.571***
	(1.73)	(3.30)	(3.38)
Entrance examination results	0.595***	0.962***	0.775***
	(8.27)	(12.59)	(13.92)
Social capital score	0.03	0.03	0.03
	(0.57)	(0.78)	(0.99)
Residual difference			0.18
			(0.98)
Constant term	47.660***	22.776***	35.301***
	(7.82)	(3.50)	(7.15)
R-squared	0.38	0.55	0.44
Sample size	146.00	146.00	292.00
Empirical p-value:			
Inter-group degree	0.8977		
Between groups	0.1179		

*Note: Robust standard errors are in parentheses; ***, **, and * indicate significant levels at 1%, 5%, and 10%, respectively.*

5.5 Missing variable test

In previous studies, many scholars pointed out that student performance and peer relationship will be affected by the class and school environment (Sacerdite, 2001), and some researchers use hierarchical linear model (HLM) to explore different Influencing factors of student performance in the environment (Raudenbush *et al.*, 2001; Wang Haigang *et al.*, 2007).

In this measurement model, unobservable school and class factors (such as class culture, teacher teaching style, school discipline management rules, etc.) are classified as ε_i, if these factors affect both the social network structure of students and their academic performance Achievements, there are missing important variables in the model settings of this paper, which leads to endogenous problems, so we need to test whether there are missing variables.

Combining the research framework of Goldsmith & Pinkham and other scholars (2013), the author reduces the random error term ε_i in equation (1) to the student-specific error term and the school-level error term, resulting in (2):

$$y_i = \alpha + \beta x_{1i}^{network} + \gamma \sum x_{2i}^{control} + \varepsilon_{if}$$

$$\varepsilon_{if} = \mu_i + e_{if} \qquad (2)$$

Among them, f represents the fixed effect of the school and the class environment, and the remaining symbols have the same meaning as above; under the theoretical framework of this article, the content of the relationship between peers such as information transfer, resource circulation and emotional support are all through the class internal society The network plays a role, so $x_{1i}^{network}$includes the influence of individual characteristics and academic performance of students' peers, so the residual term of peer effect is not listed in equation (2).

If the school and class environment have similar effects on students, that is, there is no endogenous problem, the e_{if} in equation (2) should be similar between different students. Correspondingly, in the regression results, the absolute value of the residual difference$|\widehat{\varepsilon_{\iota f}} - \widehat{\varepsilon_{jf}}|$only reflects the difference between individual students $\widehat{\mu_\iota}$. It can be known from the application conditions of OLS that the regression coefficient ρ in equation (3) is not significant and tends to 0 at this time.

$$y_i = \alpha + \beta x_{1i}^{network} + \gamma x_{2i}^{control} + \rho|\widehat{\varepsilon_{\iota f}} - \widehat{\varepsilon_{jf}}| + w_i \qquad (3)$$

Therefore, the original hypothesis and the alternative hypothesis for the endogenous test based on the measurement model conditions in this article are:

H_0: There is no significant correlation between the residual difference and the explanatory variable (learning performance), that is, ρ=0.

H_1: There is a significant correlation between the residual difference and the explanatory variable (learning performance), that is, ρ≠0.

According to the above ideas, the author randomly divides the data into two groups

according to the student's student ID. And I obtain the estimated residual error by regression. According to the formula (3), the estimated residual is regressed to obtain a regression coefficient of 0.18 (see Table 7 (3) column), which is not significant at the 10% level. Combining the scatterplot of the final grade and the difference between the residual items (Figure 6), we cannot reject the original hypothesis that the environmental factors at the school and class levels will not have a differential impact on student performance, so there is no unconsidered learning environment The endogenous problems caused by factors, the variable estimation coefficients of the econometric model constructed by equation (1) are unbiased (unbiased) estimators.

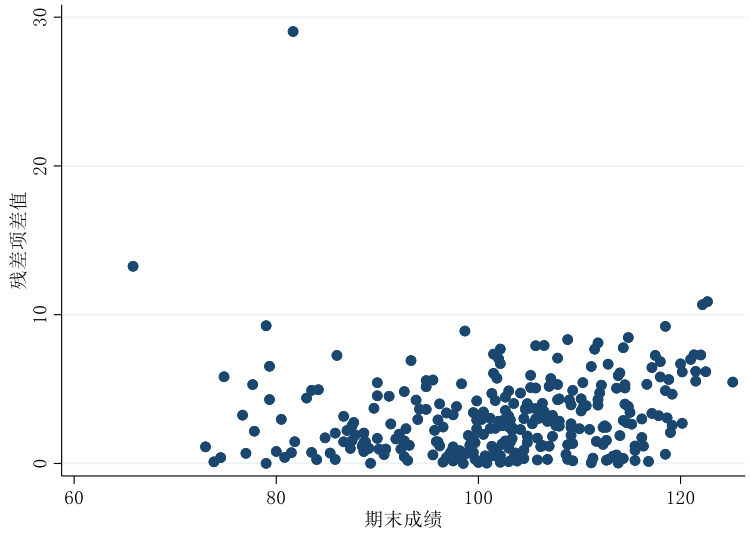


Figure 6 Scatterplot of residual items and final results

6. Heterogeneity analysis and mechanism explanation

From the above empirical analysis, we can see that social network relationships with different connotations, especially the "inward" social network indicators are significantly positively correlated with students' academic performance, and related tests prove the credibility, robustness and unbiasedness of this conclusion. The model has Strong explanatory power.

On this basis, this part considers the individual differences of students, and deeply explores the impact of social network indicators on different student groups.

(1) The impact of social network indicators on students of different grades

Sort the students' grades from high to low and divide the average grades of the students' final exams into A, B, and C grades by tertile. The distribution of grades in each class is shown in Figure 7.

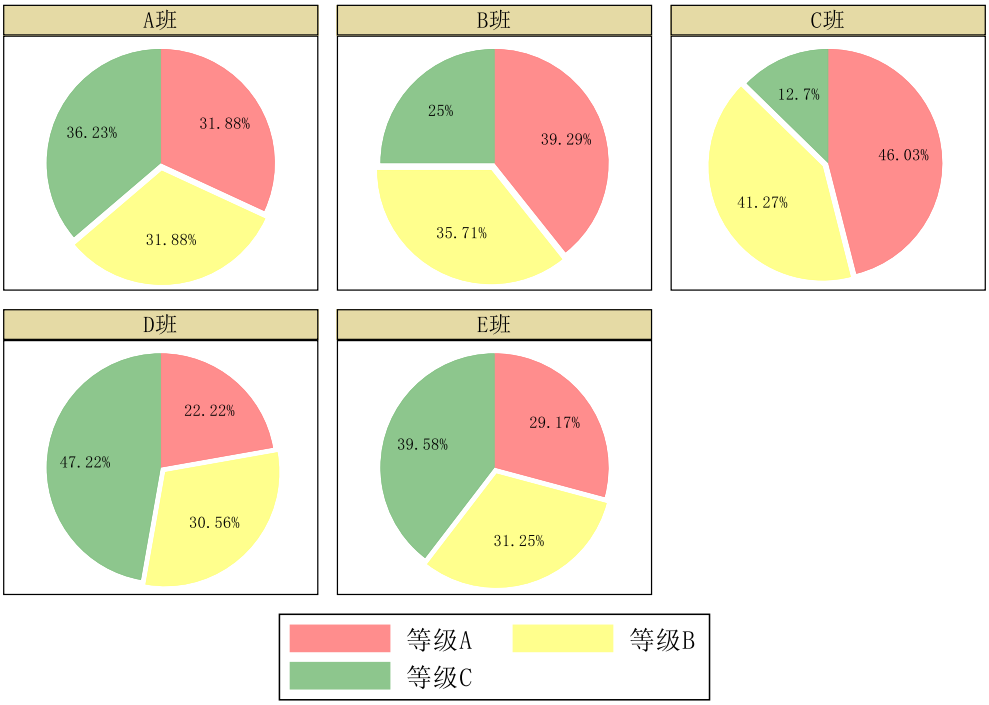


Figure 7 Distribution of grades of sample classes

By performing hierarchical group regression on social network indicators, we get the regression results in Table 10.

Table 10 The influence of social networks on students with different grades

	Explained Variable: Average Final Exam Results								
	The first set of social network indicators			The second set of social network indicators			Third Social Network Index		
	Class C	Class B	Class A	Class C	Class B	Class A	Class C	Class B	Class A
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Internal degree	0.259	0.321**	0.284						
	(0.37)	(0.15)	(0.20)						
External degree	0.431	0.261*	0.131						
	(0.38)	(0.16)	(0.26)						
Internal local feature vector				0.121	0.0662*	0.0557			
				(0.09)	(0.04)	(0.06)			
External local feature vector				0.122	0.0699	0.0387			
				(0.10)	(0.04)	(0.07)			
Average reciprocal distance							0.166*	0.0758**	(0.02)
							(0.10)	(0.04)	(0.07)

							(0.12)	0.0978**	0.03
Average reciprocal distance							(0.09)	(0.04)	(0.07)
	69.93***	91.40***	87.01***	69.23***	92.42***	87.01***	69.95***	91.82***	87.22***
	5.549	3.173	5.481	(5.68)	(3.13)	(5.58)	5.496	3.187	5.459
R-squared	0.206	0.173	0.268	0.22	0.18	0.25	0.211	0.153	0.259
Sample size	98	102	92	98.00	102.00	92.00	98	102	92

*Note: All regressions above control the individual and family characteristics of the students; robust standard errors are in parentheses; ***, **, and * indicate significant levels at 1%, 5%, and 10%, respectively.*

Overall, the impact of social network indicators on academic performance is less than the regression results in Table 5. The decrease in the social network effect is mainly due to the reduction in the size of the regression sample after grouping, and the difference in the performance of students in the group. Correspondingly, the power of related variables to explain the difference in academic performance will decrease.

For middle-level students, although the impacts measured by different social network indicators are different, their network scale, average reciprocity distance, and centrality indicators pointing to students all have a significant impact on their grades. Students with higher or lower grades There is no such significant social network effect, which shows that students' learning performance in the middle reaches is more likely to be affected by the location of the social network, which is consistent with the findings of Carman and Zhang (2012). Chunchao Wang and Aiping Xiao (2019) interpreted this heterogeneity result in related research as that middle school students have better learning habits and higher quality of lectures than poor students, which makes it easier to obtain academic progress, but it cannot be explained. Why there is no relevant mechanism for top students and poor students, so it needs to be further tested.

6. Analysis of heterogeneous student attribute and related mechanisms

From the above, we can find that the network relationship within the class has a heterogeneous impact on students of different learning levels, and students whose academic performance is in the middle reaches the level of the most affected by their own social network structure. So, do the students' individual characteristics and family characteristics have similar characteristics? In the case of controlling other variables, we grouped the gender of students, the scores of the entrance examinations and social capital scores to conduct a quantitative analysis of the size of the social network. The

regression results are shown in Table 11.

Table 11 The influence of social network scale on students with different characteristics

	Explained variable: final grade							
	Schoolgirl	**Boys**	**Entrance examination level C**	**Entrance examination level B**	**Entrance examination level A**	**Social capital C**	**Social capital B**	**Social capital A**
	(1)	**(2)**	**(3)**	**(4)**	**(5)**	**(7)**	**(8)**	**(9)**
External degree	0.43	0.09	0.20	1.327**	0.02	0.63	0.59	0.998*
	(0.38)	(0.49)	(0.60)	(0.59)	(0.55)	(0.52)	(0.54)	(0.51)
Internal degree	0.35	1.353***	1.798***	0.63	0.883*	0.71	0.85	0.32
	(0.35)	(0.43)	(0.58)	(0.49)	(0.45)	(0.46)	(0.52)	(0.43)
Entrance examination results	0.923***	0.614***				0.879***	0.581***	0.873***
	(0.08)	(0.08)				(0.10)	(0.08)	(0.09)
Social capital score	0.01	0.04	(0.02)	0.07	0.04			
	(0.04)	(0.05)	(0.06)	(0.06)	(0.05)			
gender			3.46	5.385***	0.89	1.96	3.553*	5.683***
			(2.09)	(1.97)	(1.83)	(1.89)	(1.90)	(1.60)
Constant term	26.40***	48.99***	87.56***	100.8***	105.9***	29.17***	54.53***	25.11***
	(6.34)	(6.21)	(3.36)	(2.66)	(2.48)	(8.73)	(7.08)	(7.09)
R-squared	0.47	0.46	0.11	0.11	0.06	0.47	0.38	0.58
Sample size	177.00	115.00	102.00	94.00	96.00	99.00	98.00	95.00

*Note: Robust standard errors are in parentheses; ***, **, and * indicate significant levels at 1%, 5%, and 10%, respectively*

6.1 Gender differences and mechanism explanation

The data are grouped and regressed according to gender. From the columns in Table 9(1)(2), we can see that for each additional peer in the relationship network that points to the individual, on average, boys' academic performance is 1.35 points higher than that of girls, and it is significant at the 1% level. . We can explain such differences in the size of social networks with differences in relationship strength between different genders.

Taking class A as an example, combining the recognition time and communication frequency of students and peers, we weighted to obtain a distribution table of relationship strength between genders (see Table 12). Compared with girls, boys have a higher density of friendship networks and more exchanges between same-sex groups. Such a "small group" network structure is more conducive to sharing learning resources, communicating information, and providing emotional support among peers (Leavitt, 1951 ; Coleman, 1988; Haythornthwaite, 2002).

Table 12 Distribution of relationship strength between genders in Class A

	Schoolgirl	Boys	sum
Schoolgirl	57.5%	2.7%	60.2%
Boys	1.4%	67.0%	68.4%

6.2 Ability difference and mechanism explanation

In column 11 (3) (4) (5) of Table 11, the author divides the average grades of the senior high school entrance examinations into groups by tertile and finds that the influence of the scale of social networks on student performance shows a “polarized” distribution trend, namely Students with high learning ability and low learning ability can benefit significantly from their "popular" friendship network. The popularity of middle-ability students has no significant effect on their achievements. The more friends, the lower the achievement. Happening.

The author divides the student's internal and external degrees into three levels: high, medium and low, and compares different ability groups. It can be seen intuitively from Figures 8 and 9 that students with intermediate abilities prefer to make friends, with high external degrees accounting for twice as much as groups with lower abilities; but at the same time, their "received" friend relationships are relatively Less, this constitutes an asymmetric network relationship structure. Based on this, we have reason to speculate that the "inward" social network indicators of middle-ability students have no significant impact on academic performance because they receive relatively few friendships and have no significant effect at a small sample size; , They may spend more time and energy in dealing with interpersonal relationships, but they do not get the corresponding positive feedback of friendship, which leads to the situation that the more "issued" friend relationships, the lower the score.

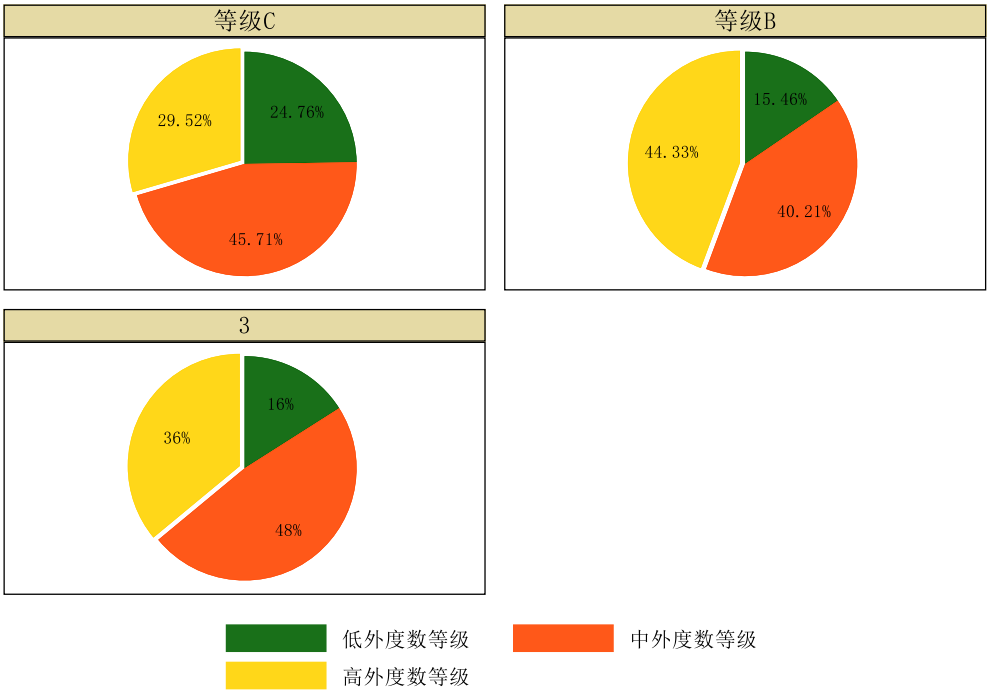


Figure 8 Distribution of degrees outside degrees of different grades

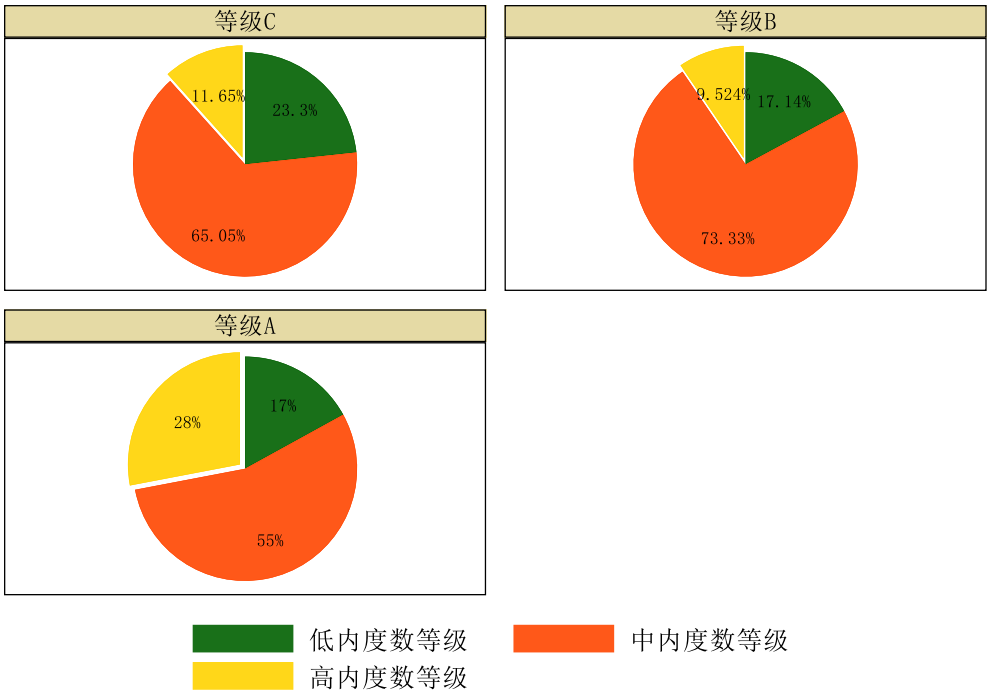


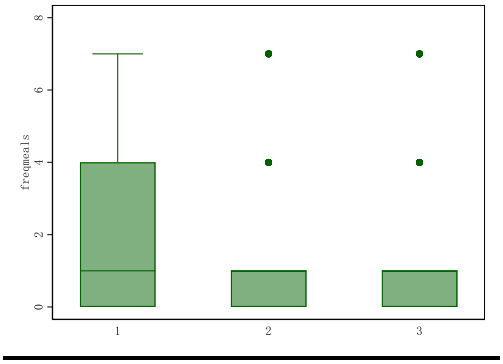
Figure 9 Distribution of degrees within different grades

6.3 Differences in family conditions and mechanism explanation

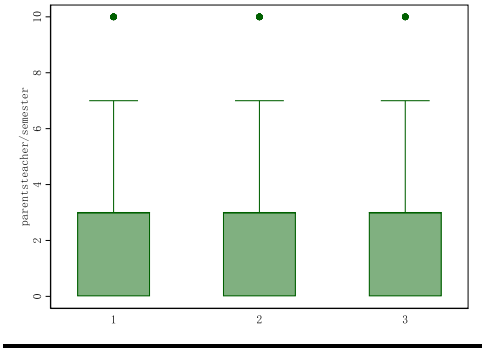
Regression is made on the grouping of social capital grades to obtain the columns in Table 9(7)(8)(9). In different groups, the size of social networks has no significant

effect on student performance.

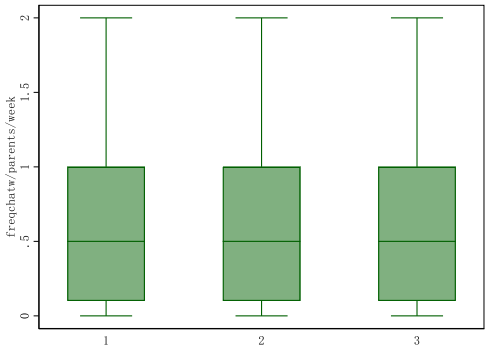
According to the theory of social closure, the author can study the impact of family social capital on children's learning from the perspectives of parental involvement and home-school interaction (Zhao Yandong and Hong Yanbi, 2012). The author embodies it as the frequency of weekly meals delivered by parents to students, the frequency of parents' active suggestions to the school in the fall semester of 2019, and the frequency of weekly communication between parents and students. Account for these four indicators. It can be seen from Figure 10 that in this survey group, there is no significant difference between the student groups of different family conditions, which is consistent with the findings of Dijkstra *et al.* (2004) and other studies. This shows to a certain extent that in high school, compared with the peer effect of students, differences in family conditions have little effect on children's achievements; family social capital has not been completely converted into student education capital, and the intergenerational class has not solidified , The local social class is more mobile.



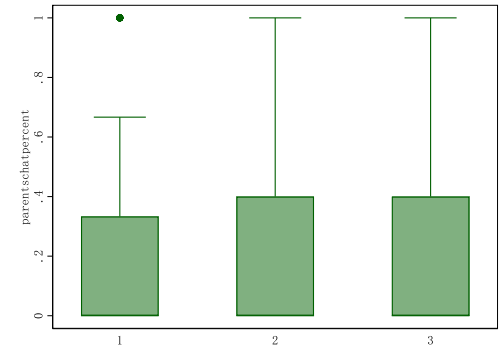
a. How often parents send meals to students every week



b. Frequency of parents proactively giving opinions to the school



c. Weekly frequency of communication between parents and students



d. Students encountering learning annoyances and actively seek out the proportion of parents

Figure 10 Distribution of social closure indicators of different families

7. Main conclusions and future expectations

7.1 Main conclusions and related suggestions

This paper explores the influence of students' position in the class network on their academic performance by constructing a sample class overall friendship network relationship, while controlling related variables. The study found that there is a differential relationship between the two, and students' academic performance is significantly positively correlated with the "popularity" of their friendship networks in the class. Students "accept" one more friendship relationship in the friendship network, which means that their academic performance improves by 0.867 points; the friendship relationship "sent out" by students does not have a similar significant correlation, and even the more friends they make actively, the higher the student achievement. Low situation.

Specifically, the location of social networks has a heterogeneous effect on students with different characteristics. In terms of grades, students studying midstream are most affected by their class network location. In terms of gender, the position of social networks has a greater impact on boys. In terms of ability level, the popularity of students with intermediate ability has no significant effect on their scores, and even the more friends, the lower the score. The possible mechanism is that the group's asymmetric friendship network makes its interpersonal interactions show unequal pay and benefits, so that it has no significant impact on academic performance, or even a negative relationship; in terms of family conditions, different family backgrounds There is no significant difference in the degree of influence of student social network scale on their academic performance. This shows to a certain extent that regardless of the conditions, parents in this area pay more attention to their children's education. Family advantages with high social capital levels are not obvious, and education still exists as a mechanism for the "upward" flow channel of ordinary families.

Therefore, the social network structure of the student's class has a differentiated impact on the student's performance, and as a medium for emotional support and a channel for sharing learning resources, it has a more profound impact on the student's academic performance and future development. In other words, the peer effect is not only reflected in the exogenous influence brought by the companion's own ability and performance, but also in the endogenous effect brought by the network structure of the individual student. This expands new ideas for us to understand the relationship between student interpersonal interaction and human capital accumulation.

For students, maintaining a stable and effective interpersonal relationship and concentrating on their studies has the problem of trade-offs in limited time and energy. How to effectively divide the two weights requires students to have a further understanding of their social network location needs. Based on the findings of this study, students should engage in effective peer interaction, focus on learning while actively participating in class activities, and enhance their own appeal, so as to form a virtuous circle with academic performance and achieve a "win-win" situation.

For class and school administrators, when formulating relevant regulations or disciplinary standards, not only should the current and future benefits brought by the accumulation of human capital of students be considered, but also the attention should be paid to the interaction of the class network constructed behind the system for student interaction Structured influence. From the perspective of behavioral economics, the interpersonal interaction of students is not entirely in exchange for learning resources or information. As a "social person", students also have more complex social preferences such as altruism, trust, and reciprocity. Appropriate attention to the needs of students' interpersonal interaction is not only a vivid expression of the "education-oriented" education concept, but also a low-cost solution to effectively improve students' overall academic performance under the framework of structured rules.

7.2 Limitations of this article and future expectations

In terms of research objects, the data in this article mainly comes from the sample class students in the high school survey. After relevant tests, the impact of the learning environment on student performance has a homogeneous character, and there are no significant differences between classes. Although this article has conducted internal and external validity tests on relevant indicators, due to the differences in regional and school policies, whether the relevant conclusions are universal or not requires further testing.

In terms of sample size, affected by the epidemic situation and the adjustment of the relevant teaching arrangements of the surveyed high school, this article only surveyed the relevant data of more than 300 students for relevant analysis. In the process of heterogeneity analysis, the small sample size makes the individual differences within the group low. The variable regression coefficient is not significant, which does not mean that the variable does not correlate with the explained variable, and a large estimation error may occur. When conditions permit, the author will expand the types of research high schools and appropriately expand the sample size of the survey to make the sample more representative.

In terms of analysis framework, this paper chooses linear regression model as the basis of econometric analysis, and tests the rationality, effectiveness and unbiasedness of model selection. This kind of analysis is based on the characteristic that the learning environment effect of the survey group is not different from the individual, thereby eliminating the endogenous problems caused by the environmental effect. If it is used to analyze a larger sample group, that is, when there are differences at the macro level, the problem of chaos at the analysis level may occur. In future research, the author will try to incorporate the idea of multi-layer linear regression model into the analysis framework to make the model construction more general.

In terms of research content, the various social network indicators used in this paper not only represent the position and position of students in the relationship network, but also imply the differential impact of peer characteristics and abilities on it. Although such an idea of constructing indicators has a theoretical basis, in empirical analysis, it is more persuasive and explanatory to split the impact of peer interaction into

endogenous variables (social network location) and exogenous variables (peer characteristics and abilities). In future research, the author will use the spatial autoregressive model to internalize peer characteristics and ability indicators within the existing theoretical framework to explain the influencing factors of student performance under the social network structure more accurately.

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Appendix

Appendix (I)

Questionnaire for high school students' achievements and social network research (offline)

Questionnaire number: [__ __ __]

Hello! I am an investigator of "Studies on High School Students' Achievements and Social Networking". In order to better explore the influencing factors of high school students' performance changes and actively respond to the changes in the college entrance examination reform, we need to understand the current state of learning of high school students and other real conditions. The content of this questionnaire is only used for statistical analysis and suggestions, and the content you fill out will be kept strictly confidential in accordance with the provisions of the "Statistics Law of the People's Republic of China". Your careful filling is very important to the final analysis result, please fill it out according to the actual situation. Thank you for your understanding and cooperation!

January 2020

A. **Personal information**

A1. Your name is_____

A2. Your **current** residence is

1. Urban area (including the situation of township students renting houses in the urban area)

2. Township (please specify the name of the town or street where you live) _____

A3. Your current accommodation status is

1. live on campus

2. Running school Please continue to check: 21 own house 22 rent house 23 other circumstances (please specify) ____

A4. Do you think your current learning status is

1. Very good 2. Fair

3. Very poor 4. Not sure (please specify) _____

A5. How satisfied are you with your current ranking?

1 Satisfied 2 Fair 3 Unsatisfied 4 No feeling (please specify specific mood) _____

A6. Do you think you have much room for improvement in the next study life? (Please indicate the reason after the option)

1. Larger _____

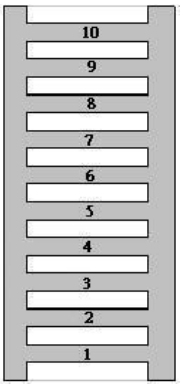
2. Smaller _____

3. Not sure _____

A7. If you compare the class to a "ladder" (pictured) from top (labeled 10) to bottom (labeled 1), you think you are in the position labeled _____. The reason is_____

A8. What do you think the different positions in the "ladder" mean? (Just a short

answer)



B. **Interpersonal relationship**

B1. Do you think the degree of influence of your interpersonal relationship on learning status is

1 Great influence 2 Little influence 3 Almost no influence

4 Unclear (please specify) _____

B2. Your current friends mainly come from

1 Current class 2 Past classmates 3 Family relatives and neighbors

4 Others (please specify) _____

B3. The main contact information between you and your friends is

1 Offline direct communication 2 Network communication software contact 3 Others (please specify) _____

B4. Your parents' attitude towards making friends is (multiple choices)

1 Support making more friends 2 Support making more friends with excellent grades

3 against making more friends 4 against making friends with hard-working students

5 Let it take its course and don't ask 6 Others (please specify) _____

B5. You know _____ people who have college education (and above) (including current scholars).

B6. During this semester, did you talk to _____ people about your learning troubles? (such as fluctuating scores, mentality adjustment, etc.) (please fill in the approximate number)

B7. Please write down the names or titles of the five people who talk to him (her) most frequently about their learning troubles:

(1) _____ (2) _____ (3) _____ (4) _____ (5) _____

problem	(1)	(2)	(3)	(4)	(5)
1. Who is he/she?					
1. (For example, parents, high school classmates, teachers...)					
2. 2. How many years have you known him (her)?					

3. 3. Occupation?					
4. 4. Education level?					
5. If you compare society to the "ladder" above, where do you think your friends are? (Please fill in 1~10 serial number)					

B8. Please write down five classmates who have a good relationship with your class

(1) _____ (2) _____(3) _____(4) _____ (5) _____

problem	(1)	(2)	(3)	(4)	(5)
1. How often do you interact with him (her) on average every week? (Please fill in the specific value)					
1. (Please specify if less than one time)					
2. 2. How many years have you known him (her)?					
3. Which position do you think he/she is in the "ladder diagram" of the class? (Please write the serial number 1~10)					

B9. Who do you think has the most influence on your learning status (effort level, mental status, etc.)?

1 Parents and other family members 2 Teachers 3 Students with good grades around 4 Students with poor grades around

5 Competitors of other classes 6 Examples of worship (please specify) _____ G Others (please specify) _____

Please briefly explain the reasons why this group of people affects you the most _____

B10. In this class, you have _____ classmates/friends who can often ask/answer (please choose one) the questions in the study.

B11. Please list the five students who ask/answer the most (please choose one). (Can be less than five)

_____

_____

C. Overall evaluation

The following questions use a scoring system, with 1 to 5 points between zones, of which 5 points are full points and 1 point is the lowest point.

C1. If you grade the class teacher's concern for you, it is _____.

C2. Score the importance of the class teacher's role in your learning process

by _____.

C3. Score the importance of your teacher's role in your learning process by _____.

C4. Score the importance of the friends you meet in your learning process as _____ points.

C5. Score your relationship with your parents on _____ points.

C6. Score your parents' attention to your study by _____.

C7. Score the importance of your parents' role in your learning process by _____.

D. Suggestions for improvement

D1. Do you want to explain your answer further?

_____

_____

_____

_____

This is the end of the questionnaire. Thank you for your conscientious completion. I wish you a happy winter holiday!

Appendix (2):

Student Achievement and Social Network Research Questionnaire (Online)

Questionnaire number: [__ __ __]

(Volume abbreviation)

February 2020

A. Personal information

Same questionnaire (1)

B. Family Information Questionnaire content B requires the cooperation of your family. If your family is around, please fill in with your family.

B1. What is your mother's occupation?_____

B2. What is your father's occupation?

B3. Excuse me, there are _____ children in your family

B4. There are a total of _____ units (sets) of smartphones (excluding senior mobile phones), computers (desktop computers and laptops) and tablets (for example, ipad, Huawei tablet, Xiaomi tablet, etc.) in your family.

B5. May your family's disposable income be about _____ yuan per month (including your parents' salary income, salary, allowances, subsidies, etc., unit: RMB)

B6. If the society is divided into different social positions, where 1 means the lowest and 10 means the highest, you think your family is in the position of number _____

B7. During this winter vacation, the average time you spend on online leisure activities (including online chat, playing games, watching small videos, reading novels, etc.) is _____ hours (excluding online learning time) (fill in integers))

C. Parent-child interaction

C1. During your school, did your parents send you meals [single choice question] *

1. Yes
2. No _____ (skip to question C3)

If necessary, explain the reason

C2. During the last semester, how often your parents gave you meals

1. Seven times a week and above
2. Two to six times a week
3. Once a week
4. Once every two or three weeks
5. Less than five times a semester

6. Other circumstances _____ (please specify)

C3. During the last semester, your parents took the initiative to talk to you (for example, you shared the joys and worries of school life together) as

1. Twice a week and above
2. Once a week

3. Once every big break
4. Less than five times a semester
5. Hardly talk

C4. During the last semester, your parents took the initiative to communicate with your class teacher or class teacher about your learning situation (for example, by telephone communication, WeChat communication, etc.) (excluding teacher interviews)

1. More than ten times a semester
2. Five to nine times a semester
3. One to four times a semester
4. Basically not actively communicate

C5. In the past year, did your parents take the initiative to submit comments to the school (for example, to explain parents' opinions or suggestions through channels such as the parent's submission issued before the holiday, daily feedback, etc.)

1. Yes
2. No

D. Personal social network

D1. Which of the following groups do you think have the greatest influence on your learning status (effort level, mental status)? (Multiple choices, up to three choices)

1. Parents and other family members
2. Teacher
3. Students with good grades around
4. Students with poor grades around
5. Competing students in other classes
6. Former classmates
7. The role model

This questionnaire ends here, thank you for your careful filling!

Appendix (3)

Questionnaire distribution and recovery schedule

		Number of valid questionnaires	Number of questionnaires issued	Total class size	Response rate	Investigation recovery rate
Questionnaire (1)	Class A	55	60	72	76.39%	91.67%
	Class B	33	42	56	58.93%	78.57%
	Class C	58	63	68	85.29%	92.06%
	Class D	66	70	75	88.00%	94.29%
	Class E	33	50	64	51.56%	66.00%
		245	**285**	**335**	**73.13%**	**85.96%**
Questionnaire (2)	Class A	72	72	72	100.00%	100.00%
	Class B	54	56	56	100.00%	100.00%
	Class C	68	68	68	100.00%	100.00%
	Class D	72	75	75	97.33%	97.33%
	Class E	47	64	64	73.44%	73.44%
		313	**335**	**335**	**93.43%**	**93.43%**

Appendix (4)

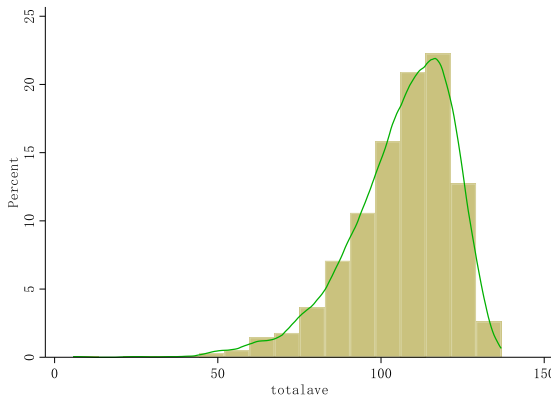


Figure 1 Distribution of the average grades of all major students at the end of the high school

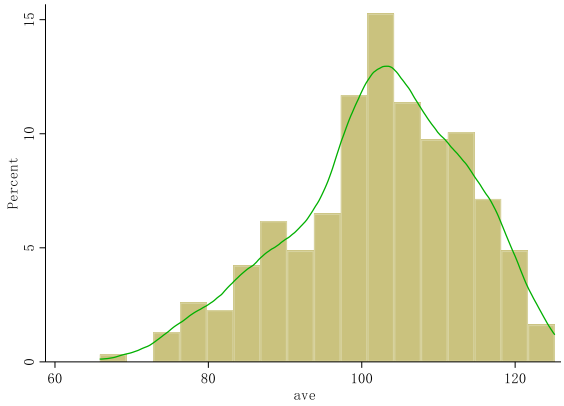


Figure 2 Distribution of the average grades of the main subjects at the end of the sample class

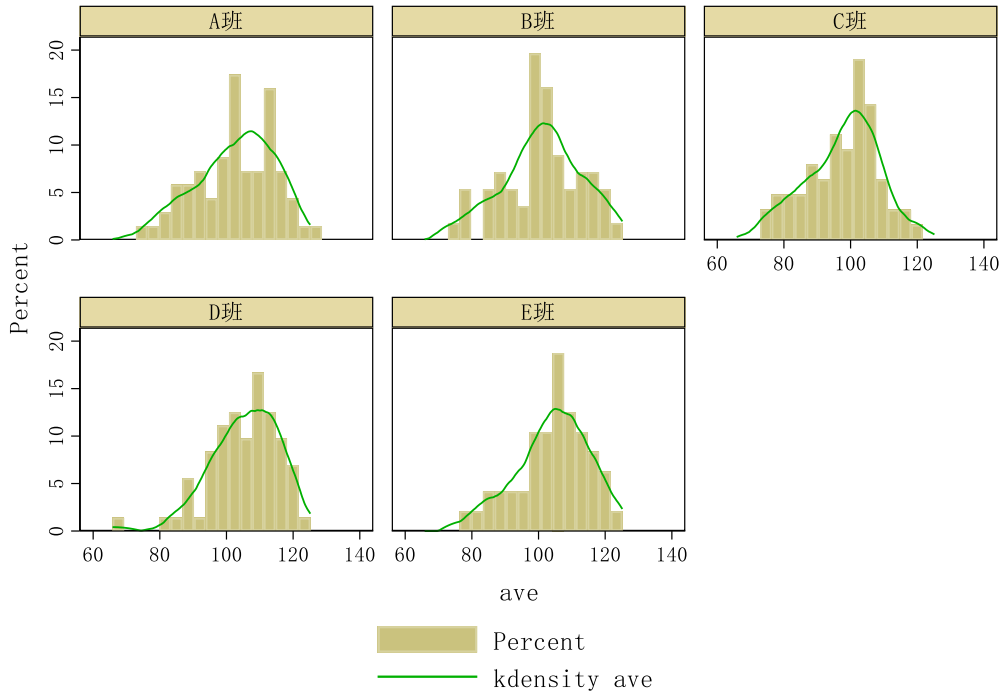


Figure 3 Distribution of average scores of main subjects at the end of each sample class

[1] [US] Matthew Jackson, "Human Network: Social Position Determines Destiny," CITIC Press, Chinese translation in 2019.

[2] School units living between classes and grades.

[3] "Notice of the General Office of the Provincial Government on Printing and Distributing the Pilot Program for Comprehensive Reform of the Admissions for Higher Education Examinations in Shandong Province" (hereinafter referred to as the "Pilot Program"), website link of the Shandong Provincial People's Government: http://www.sd.gov .cn/index.html. Visiting time: March 20, 2020.

[4] During the survey period, some students did not attend school due to leave, so the number of questionnaires issued was less than the total number of class members.

[5] The formula for calculating the survey recovery rate: the number of valid questionnaires / (the number of valid questionnaires + the number of invalid questionnaires + the number of non-response questionnaires) (Floyd, 2004; Feng Xiaotian, 2005). Whether the denominator (sample size) of the investigation recovery rate includes the people who were selected but did not respond is still controversial in the academic world (Hao Dahai, 2007; Feng Xiaotian, 2007a, 2007b). *Appendix* (3) also calculates the effective response rate. The formula is effective response rate = number of valid questionnaires / (number of valid questionnaires + number of invalid questionnaires) for comparison and reference.

[6] Excludes borrowers, transfer students, repeaters and art and sports specialty students who have not been studying in this class for a long time.

[7] The applicant is a student who is enrolled in this class. The completed questionnaire is not less than 120 seconds and the successful questionnaire is regarded as a valid questionnaire. Repeated questionnaires will be counted as a questionnaire based on the last questionnaire.

[8] Corresponding to the number of good friends and learning partners.

[9] Due to space limitations, this article only presents the social network relationship diagram of Class A. The overall network structure of the other four sample classes is similar. If necessary, you can contact the author to obtain the friendship network charts of other classes.

[10] It is defined here as relationship strength = 2/3 * weekly communication frequency + 1/3 * number of years of recognition.

[11] The sample students are of similar age, so the age variable is not included in the analysis framework.

[2] Due to space limitations, this article omits the specific calculation of family social capital score and the process of correlation test. If necessary, you can contact the author for relevant content.

[3] The p-values are 0.92 and 0.53, respectively. This shows that at the significant level of 1% and 5%, the regression model does not have the problem of heteroscedasticity.

[4] The research high school is a boarding school, and many parents will give their children meals on the school open day on weekends to supplement their nutrition.