Peer Effects on Self-regulated Study: Evidence from Randomly Assigned Classrooms in South Korea

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Self-regulated study significantly affects human capital accumulation and cognitive and noncognitive development; thus, developing such abilities is important for adolescents. The current literature offers little evidence on how peers affect students' self-regulated study. Through examining a random assignment of peers across classrooms within schools in South Korea, this article investigates the effects of peers' self-regulated study on individual students' self-regulated study. We apply a school fixed effect coupled with an instrumental variable approach in a regression analysis to identify the causal relations. Results show that students increase their self-regulated study time in response to their peers' self-regulated study time. The effects are statistically significant for the subsamples of coeducational schools, urban schools, public schools, high schools, and lower academic achievement. Our findings confirm the presence of peer effects on self-regulated study and suggest policy implications regarding school management, such as classroom organization, to enhance the educational environment.

I. Introduction

The existing literature has often recognized the importance of peer effects on adolescents (Zimmerman, 2003; Epple and Romano, 2011; Sacerdote, 2011). Peer culture is characterized by conformity to achieve social acceptance within peer groups, which regulates adolescents' behavior through the desire to conform to social norms (Corsaro and Eder, 1990). Research has increasingly focused on peers' characteristics, such as gender (Han and Li, 2009; Lavy and Schlosser, 2011; Gong, Lu, and Song, 2021) and race (Angrist and Lang, 2004) to examine how these traits

affect adolescent developmental features and cognitive and noncognitive outcomes (Gaviria and Raphael, 2001; Eisenberg, Golberstein, and Whitlock, 2014; Xu, Zhang, and Zhou, 2020; Kang, 2023).

Classmates are a good proxy for peer groups that significantly influence adolescents (Burke and Sass, 2013). Particularly, classmates are an important social network among Korean adolescents as they spend most of their time in school within the same classroom (Lim and Meer, 2017). Different from the United States and other countries, where students rotate their classrooms by academic subject, Korean students have a physical homeroom classroom with the same classmates, where they remain throughout each day of the school year. Given the amount of time spent together, classmates have many chances to build intimate relationships and influence each other.

Scholars have paid increasing attention to how classmates, as a peer group, can affect students' outcomes and behaviors, particularly academic achievement (Kang, 2007; Bifulco, Fletcher, and Ross, 2011; Carman and Zhang, 2012; Hermansen and Birkelund, 2015; Xu, Zhang, and Zhou, 2022), obesity (Lim and Meer, 2017; Luo and Pan, 2020), private tutoring (Kim, Jang, and Kim, 2022a; Pan, Lien, and Wang, 2022), and juvenile delinquency (Lundborg, 2006; Ali and Dwyer, 2009; Kim and Fletcher, 2018). Several studies have shown that peer effects can be extended to a long term (Bietenbeck, 2020; Lei, 2022).

Research on the extent to which classmates influence each other in terms of daily time use is limited. How time is allocated and spent can significantly affect adolescents' cognitive and noncognitive development, including academic achievement and even labor market performance (Levin and Tsang, 1987; Stinebrickner and Stinebrickner, 2004; Babcock and Marks, 2011; Grave, 2011). Particularly, a factor that should not be overlooked is the effects of peers on self-regulated study (Doumen, Broeckmans, and Masui, 2014). Self-regulated study can positively affect adolescents' deep cognitive process (Vermunt, 2005), self-efficacy, self-discipline (Pajares and Miller, 1994; Bandura, 1997; Jung, Zhou, and Lee, 2017), motivation, and volition (Pintrich and De Groot, 1990; Zimmerman, Bandura, and Martinez-Pons, 1992; Dweck, 1999, Eccles and Wigfield, 2002; Diefendorff, 2004). Cumulative evidence confirms the importance of students' self-regulated study in various contexts, showing that it has the power to induce adolescents' cognitive and noncognitive development (Dolton, Marcenaro, and Navarro, 2003; Stinebrickner and Stinebrickner, 2008; Metcalfe, Burgess, and Proud, 2011; Bratti and Staffolani, 2013).

In the Korean-specific educational context, policies promoting the self-motivation of student learning are crucial to the government's education strategy, which pursues the normalization of public education to equip students with intellectual tools by building self-belief and self-regulatory capabilities (Hong and Park, 2012); here, self-regulated study can play a significant role (Kim, 2019).

This article examines the effects of peers' self-regulated study on individual students' engagement in self-regulated studying. Uncovering peer effects is methodologically challenging because the estimation framework may suffer from a self-selection issue, an omitted variable bias, and a reflection problem.[1] To address these concerns, we applied a school fixed effect with an instrumental variable (IV) approach by exploiting random classroom assignments within a school in South Korea. First, we adopted a school fixed effect in the regression analysis, which circumvents an endogenous sorting problem across classrooms and captures unobserved environmental factors that influence individual and peer self-regulated study. Second, an IV estimation was combined with the school fixed effect to control for the bidirectional relationship between individuals and their peers. We adopted peers' household education cost as the IV for peers' average self-regulated study time. The mechanism for this correlation is based on the inference that self-regulated study is closely related to the home education environment and parents' educational interests in their children. A battery of tests was conducted to confirm the validity of the IV. Finally, we controlled for a set of characteristics for students, family, and homeroom teachers to reduce the risk of an omitted variable bias.

South Korea provides an advantageous setting to examine the causal linkage of peers' self-regulated study on individuals. First, self-regulated studying can be an effective tool for normalizing Korea's public education. South Korea is characterized by its extraordinary commitment to education, and the excessive dependence on private tutoring has become a social problem. Parents and adolescents seek admission to prestigious colleges during secondary education, and the heavy reliance on shadow education raises concerns about the role of formal public education. According to the 2021 Private Education Expenditure Survey by Statistics Korea, approximately 76% of students use private tutoring, and the total amount of private tutoring expenses is 23.4 trillion won, which is about 1% of the total GDP. Concerns have been raised about this social phenomenon as excessive private tutoring can adversely affect adolescents' psychological health and well-being, financially burden households, and widen educational inequality among different socioeconomic backgrounds. As a means of addressing the side effects of shadow education (Ryu and Kang, 2013; Choi and Choi, 2016; Kim, Jang, and Kim, 2022b), the advantages and possibilities of self-regulated studying are increasingly gaining attention (Chang and Yang, 2002; Jeon, Cho, and Cho, 2010; Jeong, 2003; Rhee and Kwaug, 2010; Kim, 2011; Kang and Park, 2015; Kim, 2019). In this sense, analyzing the role of peers' effect on individuals' self-regulated study time can provide useful policy implications regarding school and class management. Second,

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[1] A reflection problem arises when a researcher seeks to predict the behavior of an individual by the behavior of the group of which the individual is a member, making the direction of influence unclear (Manski, 1993; Epple and Romano, 2011).

the school environment in South Korea provides an advantageous condition for identifying the causal relationship. The random allocation of students to classrooms within a school, particularly when entering middle and high school, allows a classroom to maintain its homogeneity across student and family characteristics. This quasi-experimental circumstance enables us to isolate peer effects from other confounding effects (Kang, 2007; Lim and Meer, 2018; 2020; Kim, Jang, and Kim, 2022a).

Using samples from 7th grade (the first grade in middle school) and 10th grade (the first grade in high school) students from the Gyeonggi Education Panel Study (GEPS), we found that a student's self-regulated study time increases when classmates averagely spend considerable time on self-regulated studying. In addition, we found the effects to be heterogeneous according to school and individual type, and that statistically significant results were evident for the subsamples of coeducational schools, urban schools, and public schools, high schools, and lower academic achievement.

The remainder of this study is organized as follows. Section 2 introduces the data and variables. Section 3 explains the empirical strategy. Section 4 presents the estimation results. Section 5 concludes the study.

II. Data and Variables

The GEPS has provided representative samples of students in Gyeonggi Province since 2012.[2] Students were sampled via a two-stage cluster sampling design. A total of 3,541 fourth-grade students from 85 elementary schools, 4,051 first-grade students from 63 middle schools, 3,361 first-grade students from 49 general high schools, and 881 first-grade students from vocational high schools in Gyeonggi Province were randomly selected. Then, two classrooms were randomly drawn from within each school, and students in the chosen classrooms were surveyed. The GEPS also interviewed parents, homeroom teachers, principals, and schools.

This study examined students in the 1st grade of middle school (corresponding to 7th grade) and general high school (corresponding to 10th grade) in 2012.[3] We focused on the 1st year students of each school level because although schools generally rely on random allocation of students to classrooms, this is especially the case when schools do not have considerable information about students advancing

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[2] Gyeonggi Province is the most populated local district among 17 provincial governments and accounts for about 25% of the total population in South Korea (approximately 13.93 million residents as of 2022).

[3] General high school students tend to prepare for college entrance exams, whereas vocational high school students usually get a job after graduation. Thus, self-regulated study may be more pertinent to general high school students.

to higher-level education.[4] From the raw data, we excluded students from multicultural families, students without class information, and students who did not

[**Table 1**] Descriptive statistics

Variable	Mean	SD	Min	Max
Dependent variable				
Self-regulated study	76.746	72.868	0	750
Private tutoring	59.177	65.283	0	600
Spending time with friends	67.762	75.652	0	630
Leisure	115.467	90.828	0	720
Independent variable				
Peers' self-regulated study	74.493	23.579	13	185
IV				
Peers' education cost	64.234	22.231	16.667	129.833
Control variable: Student and family characteristics				
Male	0.504	0.500	0	1
BMI	19.959	3.041	12.903	37.924
Academic performance	50.448	8.283	28.178	73.018
Household income	482.257	528.807	0	9,999
Married	0.893	0.309	0	1
Owned house	0.630	0.483	0	1
Number of children	2.132	0.664	0	18
Birth order	1.568	0.659	0	6
Father's schooling	0.453	0.498	0	1
Mother's schooling	0.310	0.462	0	1
Control variable: Homeroom teacher characteristics				
Male	0.225	0.417	0	1
Age	0.271	0.444	0	1
Teaching experience	0.397	0.489	0	1
Post-graduate degree	0.376	0.484	0	1
Obs.	6,499			

Note: The dependent variable unit of measurement is minutes per day. Academic performance is the average value of Korean, English, and math test normalized scores. The education cost and household income units are 10,000 won per month. Father's and mother's schooling are measured as a dummy variable, equal to 1 if parents attended a four-year university program, and 0 otherwise. The age of the homeroom teacher is categorized as 1 for 40s and above, and 0 otherwise. Teaching experience equals to 1 for more than 10 years, and 0 otherwise.

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[4] Focusing on the 1st year of the panel data is also advantageous in that it can avoid the issue of attrition. As the main purpose of this study is to examine peer effects, we need to secure a sufficient number of peers within the class. In 2012, which is the first year of the survey, all students in two classrooms within the same school are identified, enabling us to observe sufficient pupils. However, as students advance to the next grade, the number of classmates observed in the data decreases sharply. In the next section, we use a balancing test to confirm the existence of randomly assigned classrooms by comparing the effects of peers' self-regulated study on students' family and homeroom teacher characteristics with and without the school fixed effect.

[**Figure 1**] Density distribution of individuals' and peers' self-regulated study
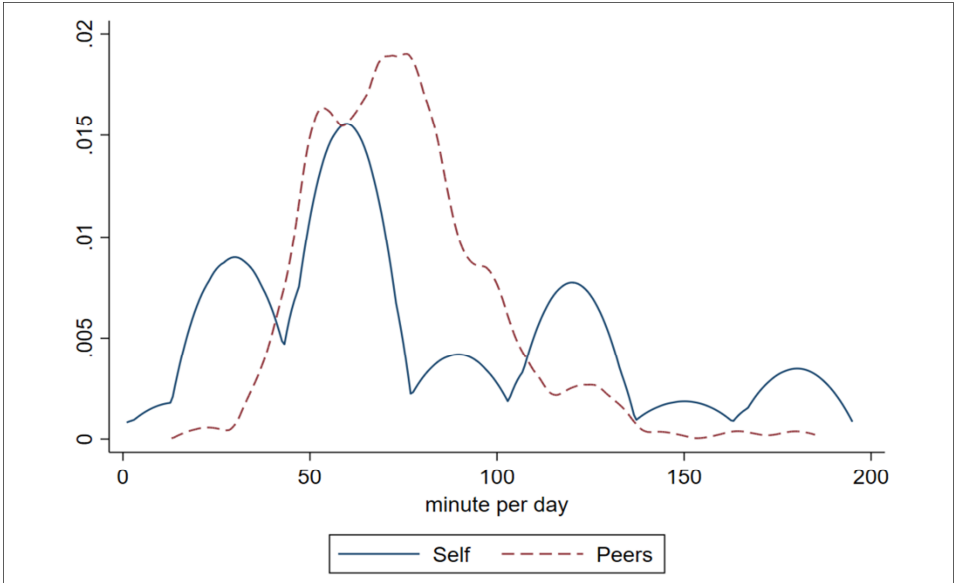
Note: This figure is calculated based on the values of the 0 to 99 percentile ranges.

respond to the survey questions that this study applied in the regression analysis. Through this procedure, we were able to include a total of 6,499 students: 3,545 at middle school and 2,954 at general high school.[5]

Table 1 shows the descriptive statistics, and Figure 1 presents a density distribution of individuals' and peers' self-regulated study time.[6] In the case of students' daily time allocation, the average self-regulated study time was 76 min per day, private tutoring time was 59 min per day, spending time with friends was 67 min per day, and leisure time was 115 min per day. The peers' self-regulated study time was 74 min per day, and the peers' average monthly education cost was about 640,000 won. The gender was evenly split, with an average BMI of 20. Academic performance, which is the averaged normalized scores for Korean, English, and math, was approximately 50.488, with a standard deviation of 8.283. The average household monthly income was 4.82 million won, and the average education costs accounted for about 13% of the monthly household income. Around 89% of students reported being from married families, and 63% of students live in their own houses. On average, the surveyed families have two children, and the father's

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[5] The results do not qualitatively change when we included students who do not respond to all questions.

[6] Students were directly surveyed in the time-use questionnaire by filling out two-digit hours and two-digit minutes. O the basis of this information, we converted them into total minutes per day. The time-use questionnaire is different from other questionnaires (such as private tutoring costs) as it is directly reported by students, not their parents. It can be more accurate because students experience all 24-hour routines and have precise information.

educational background is higher than that of their mothers. In the case of homeroom teacher characteristics, a higher proportion of female teachers was observed, and about 40% of teachers has more than 10 years teaching experience.

III. Estimation Design

3.1. Empirical Strategy

To examine the causal effects of peers' self-regulated study on that of individuals, we applied a regression analysis as follows:

$$Y_{ics} = \alpha + \beta \overline{Y}_{-ics} + \gamma X_{ics} + \delta_s + \varepsilon_{ics} \text{ ,}$$

where i denotes a student, c is a class, and s is a school. Y_{ics} is student i's time allocation for daily activities, of which we mainly focused on self-regulated study time. $\overline{Y}_{-ics}$ is the average time allocation of student i's classmates, excluding student i. X_{ics} includes the characteristics of the student, family, and homeroom teacher explained in the descriptive statistics.[7] δ_s is the school fixed effect. ε_{ics} is the error term. Standard errors are clustered at the level of school.

β is intended to capture the influence of peers on the individual. However, this coefficient may be biased due to endogeneity issues; that is, individual students and peers can simultaneously affect each other's self-regulated study time, which is often referred to as the reflection problem (Manski, 1993). In addition, the unobserved school environment, which influences individual students and peers, may spuriously drive the results.

We applied a school fixed effect with an IV approach to address this problem.[8] First, we controlled for school fixed effects δ_s to capture the selection and

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[7] The following is a list of variables: student characteristics (gender, BMI, and academic performance), family characteristics (household income, marital status, housing type, number of children, birth order, and parents' educational level), and teacher characteristics (gender, age, teaching experience, and educational level)

[8] A similar empirical strategy can be found in seminal literature, such as Kang (2007); Lim and Meer (2018); Luo and Pan (2020); Kim, Jang, and Kim (2022a); and Pan, Lien, and Wang (2022). Specifically, Kang (2007) applied the mean science score of peers as the IV for the mean math score of peers. Lim and Meer (2018) adopted peers' BMI with peers' number of siblings. Luo and Pan (2020) used four peer family traits (peer number of siblings, health status of peer parents, education of peer mothers, and education of peer fathers) as the IV for peer BMI. Kim, Jang, and Kim (2022a) instrumented peers' private tutoring for the proportion of classmates with married parents, the average birth order of classmates, and the proportion of classmates with parents who own a house. Similarly, Pan, Lien, and Wang (2022) applied peers' parental education and health condition as the IV for peers' shadow education participation.

environmental confounding effects. Given that students are randomly allocated to classes within the same school, the school fixed effect enabled us to utilize quasi-random variations in peer composition. Moreover, it can control for unobserved environmental factors that influence individuals' and peers' self-regulated study.

Second, we instrumented peers' self-regulated study with peers' education cost. We focused on peers' education cost as the IV for peers' self-regulated study for the following inferences. First, we sought to identify several IV candidates that affect peers' self-regulated study (commonly referred to as a relevance condition) and do not directly affect individuals' own self-regulated study (widely referred to as an exclusion condition). This approach required that we pay attention to peers' household environmental factors. Next, we considered that information that is observable and obtainable from individual students would be difficult to meet the exclusion condition. The reason is that factors with these characteristics can directly affect self-regulated study. For example, whether peers receive shadow education is relatively easy to observe in terms of how it influences individual self-regulated study, making it difficult to satisfy the exclusion condition. Parental educational background could be used as a useful IV if the dataset provides information on which university they graduated from. However, the dataset did not provide specific university names.

On the basis of these inferences, we adopted peers' education cost as the IV. First, peers' education cost is closely related to peers' study time because the cost of education implies parents' interest in their children's education. Based on the literature which documents parental influence as an important determinant of the intergenerational persistence (Bisin and Verdier, 2001; Chowdhury, Sutter, and Zimmermann, 2022), parents' interest on education may affect their children's study time through interactions within the family. Second, the education "cost" is more private information compared to factors such as private tutoring "participation." Third, we observed peers' average education cost from the survey results by parents, not students, which is difficult for individual students from other families to observe directly. Overall, a household's average education cost presents a good indicator for the IV, as it is related to a child's learning environment and activities within the household. In addition, peers' education costs are private information depending on the family's financial status, making it difficult to directly affect each individual student's self-regulated study.

3.2. Validity of Empirical Strategy

Before conducting the main estimation, we performed two tests to check our empirical strategy's validity. First, we examined whether students were randomly assigned to classrooms in our samples. The random assignment of peers across classes within the same school is significant to our identification strategy. At the

beginning of each school year, students are assigned to classes based on random criteria, such as a lottery system. Due to social norms for achieving equity in education and an established tradition of the government's equalization policy, segregating students into different classrooms by academic abilities and family backgrounds has been traditionally rejected (Kang, 2007; Lim and Meer, 2017). Once assigned, students stay in the same classroom all year round; thus, individual and family characteristics of students should be similar across classes within a school at the beginning of the school year. This approach is important for examining the influence of peers on individual students. If students had been segregated into classrooms based on their individual and family traits, such as test scores or household income, then the examined effects would have reflected this sorting rather than the causal effect.

The balancing test results in Table 2 show the relationship between peers' self-regulated study and family- and teacher-level characteristics, with and without the school fixed effect. If deviations from the school fixed effect are not correlated with variations in family and teacher characteristics, then the balancing tests may support our assumption that the school fixed effect combined with the random assignment of students to classes account for any systematic selection. In actuality, we found that peers' self-regulated study is generally uncorrelated to family and homeroom teacher traits after controlling for the school fixed effect.

The compelling IV should be closely related to peers' self-regulated study, and it should not affect individuals' own self-regulated study other than through peer influence. Although other channels cannot be dismissed, Figure 2, which presents the scatter plot of self-regulated study and peers' education cost, provides indirect evidence to support our inferences. The correlation between peers' self-regulated study and peers' education cost is positive, and the size is approximately 0.5281. However, the correlation between individuals' self-regulated study and peers' education cost decreases to 0.1723.

In addition, we investigated whether the IV—peers' education cost—was correlated with predetermined attributes of the family and homeroom teacher. We acknowledge that no formal method can verify the exclusion restriction of the IV, and the exact transmission channel remains uncertain. However, we could anticipate that if the IV is exogenous, it would not have a significant correlation with observable variables. Therefore, we may indirectly confirm the exogeneity condition by analyzing the relationship between the IV and observable variables. This examination provided useful information on the validity of the IV (Altonji, Elder, and Taber, 2005). Indeed, the final column in Table 2 demonstrates that the IV is not directly associated with these characteristics, suggesting that it is possible to satisfy the IV assumptions.[9]

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[9] Still, our IV strategy has a limitation in that it does not consider the possibility in which one

[Figure 2] Scatter plot of self-regulated study and peers' education cost
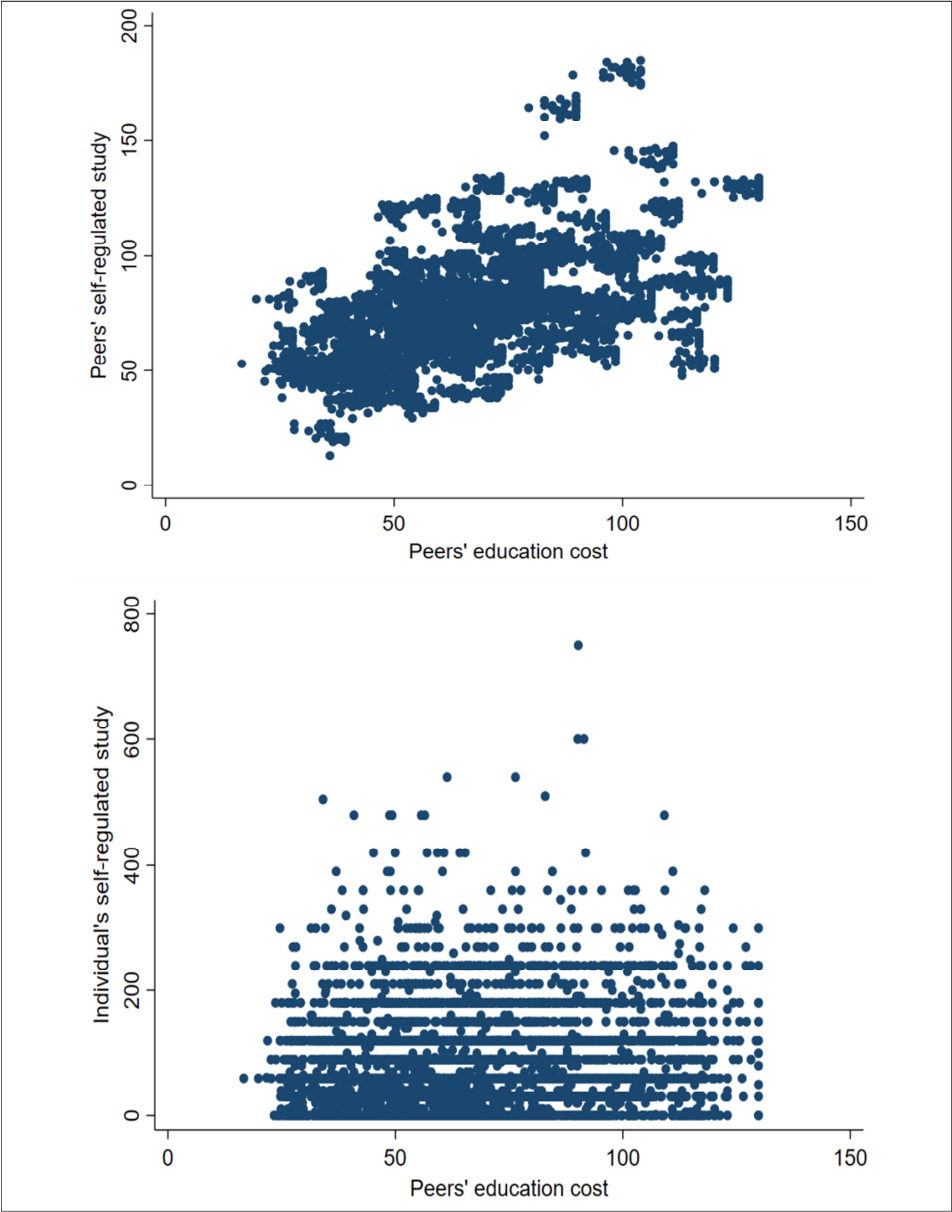
Note: The X-axis unit of measurement is 10,000 won per month, and the Y-axis unit is minutes
    per day. The correlation of the upper figure is 0.5281, and the lower figure is 0.1723.

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parent may influence the behavior of another parent, which can be referred to as a "rate race" in
education. Nonetheless, the school fixed effect term can capture the characteristics of neighborhoods
that affect the interactions between parents, enabling us to partially control for this channel.

[Table 2] Validity of the empirical framework

	Balancing test		IV validity
	Independent variable: Peers' self-regulated study		Independent variable: Peers' education cost
Dependent variable: Family characteristics			
Household income	1.636***	−0.110	−0.790
	(0.283)	(0.603)	(0.702)
Married	0.001***	−0.001*	−0.000
	(0.000)	(0.000)	(0.000)
Owned house	0.002***	0.000	−0.001
	(0.000)	(0.001)	(0.001)
Number of children	−0.001***	0.000	−0.002*
	(0.000)	(0.001)	(0.001)
Birth order	−0.001***	0.001*	−0.002
	(0.000)	(0.001)	(0.001)
Father's schooling	0.004***	−0.000	−0.001
	(0.000)	(0.000)	(0.001)
Mother's schooling	0.003***	−0.000	−0.001*
	(0.000)	(0.000)	(0.001)
Dependent variable: Homeroom teacher characteristics			
Male	0.000	−0.001	0.002
	(0.000)	(0.003)	(0.002)
Age	−0.001***	−0.001	0.003
	(0.000)	(0.002)	(0.003)
Teaching experience	−0.003***	−0.004	−0.001
	(0.000)	(0.003)	(0.003)
Post-graduate degree	−0.002***	−0.002	0.000
	(0.000)	(0.003)	(0.003)
School fixed effect	N	Y	Y

Note: Standard errors clustered at the school level in parentheses, *** $p < 0.001$, ** $p < 0.01$, * $p < 0.05$.

IV. Estimation Results

4.1. Main Results

Table 3 shows the main results. Generally, regressing individual traits based on peers' characteristics leads to a negative bias that is inherent with the random assignment (Guryan, Kroft, and Notowidigdo, 2009; Lim and Meer, 2018). The classroom averages for students' characteristics become balanced across the classrooms when peers are randomly assigned. Thus, for example, if individuals' test score is higher than the average classroom value, then peers' test scores, which exclude the individual, become lower. This leads to a negative correlation between

individual and peers' characteristics.[10] In actuality, we observed that self-studying peers cause a reduction in individual students' self-regulated study without the IV estimation (Column 1).

The IV estimation presents the qualitative different outcomes by correcting the above bias. With only the school fixed effect, a student's self-study time increased by 0.98 min if peers' self-regulated study time increased by 1 min (Column 2). These results are similarly supported when we additionally controlled for student and family characteristics (Column 3) and homeroom teacher traits (Column 4). The coefficients were greater than 0.9 and statistically significant. Throughout the specifications, first-stage F-statistics showed a greater value than 10, which is the standard for satisfying the IV's relevance condition.

Overall, our findings suggest that peers' self-regulated study strongly affects individual students' self-regulated study, and the size of effects is almost a one-to-one transformation.

[Table 3] Main results

Specification	(1) OLS	(2) IV	(3) IV	(4) IV
Peers' self-regulated study	−0.425*	0.983***	1.210***	1.191***
	(0.198)	(0.254)	(0.335)	(0.341)
R^2	0.088	0.050	0.088	0.090
N	6,499	6,499	6,499	6,499
F statistic	-	122.393	113.530	109.964
School fixed effect	Y	Y	Y	Y
Student and family controls	N	N	Y	Y
Homeroom teacher controls	N	N	N	Y

Note: Standard errors are clustered at the school level in parentheses, *** $p < 0.001$, ** $p < 0.01$, * $p < 0.05$.

First-stage F-statistic is based on the Cragg–Donald Wald F-statistic.

We conducted several tests to check the robustness of these results. First, we used the alternative IV (which was composed of peers' education cost and fathers' and mother's schooling) to check whether the results are similar. The coefficient reduced somewhat (0.990) although the magnitude is similar to that of the main result and is still statistically significant. Second, we performed a falsification test by changing the dependent variables to various types of daily activity. If peers' self-regulated study time affects individuals' nonstudy times, then our findings may have originated from a spurious correlation, making the results less reliable. Table 4

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[10] Suppose there are five students, with test scores of 30, 40, 50, 60, and 70, of which the average score is 50. From the perspective of the student who scores 30 (40, 50, 60, 70), the average value of peers' test score is 55 (52.5, 50, 47.5, 45). This example clearly shows the negative correlation between individual and peers' test scores.

shows the falsification test results. Here, we find little statistical evidence that students' engagement in self-study is affected by their classmates when the dependent variable is either private tutoring time, spending time with friends, or leisure time. These findings show that the main result is robustly supported.

[Table 4] Robustness checks

	(1) Alternative IV	(2) Private tutoring	(3) Spending time with friends	(4) Leisure
Peers' self-regulated study	0.990**	−0.370	−0.058	−0.118
	(0.302)	(0.675)	(0.840)	(0.832)
R^2	0.098	0.127	0.164	0.105
N	6,499	6,499	6,499	6,499
F statistic	36.870	109.964	109.964	109.964
School fixed effect	Y	Y	Y	Y
Student and family controls	Y	Y	Y	Y
Homeroom teacher controls	Y	Y	Y	Y

Note: Standard errors are clustered at the school level in parentheses, *** $p < 0.001$, ** $p < 0.01$, * $p < 0.05$.

First-stage F-statistic is based on the Cragg–Donald Wald F-statistic. The dependent variable of Column (1) is self-regulated study, and the IV is composed of peers' education cost and fathers' and mother's schooling. In Columns (2)–(4), the dependent variable is private tutoring, spending time with friends, and leisure, respectively, and the IV is peers' education cost.

4.2. Heterogeneity

Tables 5 and 6 show the heterogeneous results by limiting the samples according to school type (Table 5) and dividing the samples according to individual type (Table 6). Although identifying any exact mechanism is beyond the scope of this study, we provided potential explanations for the heterogeneous results where possible.[11]

School gender composition can have different effects compared with peer effect. We found that the effects of peers' self-regulated study on individuals are significant in coeducational schools, but little statistical significance is observed in single-sex schools (Columns 1 and 2 in Table 5). We inferred that school gender composition

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[11] Here, considering the Korean education environment, we should be cautious in interpreting the results because school characteristics tend to overlap. For example, middle schools are predominantly public and coeducational, whereas high schools are predominantly private and single-sex. Thus, comparing coeducational and single-sex schools can be similar to comparing middle school and high school. Moreover, some of the estimation results have smaller F stats, making it necessary not to overestimate the statistical significance (Lee, McCrary, Moreira, and Porter, 2021).

results in different environments (Lavy and Schlosser, 2011; Hoogendoorn, Oosterbeek, and Van Praag, 2013; Oosterbeek and Van Ewijk, 2014). For example, class disruption, such as bullying, may be lower in coeducational schools compared to single-sex schools, and adolescents may wish to show a positive image to attract popularity from the opposite sex, all of which can lead to students spending more time on self-regulated study via peer effects.

Peer effects on self-regulated study are more pronounced among students in urban schools (Columns 3 and 4 in Table 5). The schooling environment is generally different between urban and rural schools. For example, a highly competitive atmosphere among students is prevalent in urban regions, which can make students be affected by peers who spend significant time studying.

Peer effects on self-regulated study may also vary depending on whether a school is public or private (Zimmer and Toma, 2000; Park, 2016). Our analysis shows that peers' self-regulated study is statistically significant in public schools (Columns 5 and 6 in Table 5). This may be partially due to the different environments between public and private schools, in which the latter pays more attention to academic programs that can substitute for self-regulated study.

The peer effects of self-regulated study were more evident for high school students compared to middle school students (Columns 7 and 8 in Table 5). In view of the differences in incentive structure and school environment, the result that peer effects on self-regulated study are greater for high school students is reasonable. For example, high school students need to consider college entrance; accordingly, studying becomes more important. High schools also often create an autonomous learning atmosphere by operating self-studying classes after school.

[Table 5] Heterogeneity by school type

Subsamples	(1) Coeducational	(2) Single-sex	(3) Urban	(4) Rural	(5) Public	(6) Private	(7) Middle	(8) High
Peers' self-regulated study	0.957***	0.040	1.327**	0.970**	1.257**	0.956	1.214*	1.024*
	(0.230)	(0.369)	(0.511)	(0.347)	(0.421)	(0.917)	(0.515)	(0.449)
R^2	0.105	0.135	0.073	0.161	0.083	0.148	0.047	0.111
N	5,931	568	5,656	843	6,140	359	3,545	2,954
F statistic	141.482	117.553	76.194	30.499	87.484	102.434	63.303	45.304
School fixed effect	Y	Y	Y	Y	Y	Y	Y	Y
Student and family controls	Y	Y	Y	Y	Y	Y	Y	Y
Homeroom teacher controls	Y	Y	Y	Y	Y	Y	Y	Y

Note: Standard errors are clustered at the school level in parentheses, *** $p < 0.001$, ** $p < 0.01$, * $p < 0.05$.

First-stage F-statistic is based on the Cragg–Donald Wald F-statistic.

We identified no significant results (Columns 1 and 2 in Table 6) relating to students' gender. This can be interpreted that peer effects do not occur exclusively between pupils of the same sex.

When we considered household income, we found that the peer effects of self-regulated study are observed when students are from a household with averagely lower family income (Columns 3 and 4 in Table 6). We inferred that they are more affected by their peers' self-study time as it is difficult for them to rely on shadow education, making them focus on self-study for their academic achievement.

Finally, we found few statistically significant results when we divided the subsamples by academic performance (Columns 5 and 6 in Table 6).

[Table 6] Heterogeneity by individual type

Subsamples	(1) Male	(2) Female	(3) Income > mean	(4) Income < mean	(5) Score > mean	(6) Score < mean
Peers' self-regulated study	0.208	2.473	0.487	1.395**	2.181	0.692
	(2.917)	(2.549)	(0.905)	(0.531)	(1.530)	(0.588)
R^2	0.139	0.016	0.126	0.102	0.022	0.074
N	3,277	3,222	2,604	3,895	3,200	3,299
F statistic	7.997	19.242	32.275	91.581	31.191	99.854
School fixed effect	Y	Y	Y	Y	Y	Y
Student and family controls	Y	Y	Y	Y	Y	Y
Homeroom teacher controls	Y	Y	Y	Y	Y	Y

Note: Standard errors are clustered at the school level in parentheses, *** $p < 0.001$, ** $p < 0.01$, * $p < 0.05$.

First-stage F-statistic is based on the Cragg–Donald Wald F-statistic. Column (3) is the result of the subsample of which household income is greater than the average value, and otherwise in Column (4). Column (5) is the result of the subsample of which academic performance is greater than the average value, and otherwise in Column (6).

V. Conclusion

This article analyzed whether peers' self-study time affects the engagement of individual students in their self-regulated study. To infer the causal relationship, we applied the school fixed effect coupled with the IV approach to the GEPS data by exploiting the randomly assigned classrooms of the schooling environment in South Korea. Our findings indicated that the self-regulated study time of classmates leads to an increase in individuals' self-regulated study.

This study contributes to the flourishing literature on peer effects from the perspective of time allocation. Our work provides new evidence that peer effects are significant and positive for students' self-regulated study in middle and high schools.

Particularly, it provides compelling evidence that peer effects via classmates who spend the longest time in school and have many interactions significantly affect individuals' time utilization. Our findings have arguably better generalizability considering that we used nationally representative samples from middle and high schools in the largest province of South Korea.

Overall, the existence and structure of peer effects on self-regulated study may have substantial implications for Korean education policies regarding school schedule operation, classroom organization, and ability tracking classrooms. For example, in a highly competitive environment where peers influence students' study time, there may be a strong demand for studying among students who fear falling behind the competition. In these circumstances, forcing self-study after school can find its own meaning in terms of reducing shadow education and building self-study habits.

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무작위 학급 배정 시스템을 활용한 자기주도학습의 동료효과 분석

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초 록   자기주도학습은 학생들의 인적자본 축적과 인지 및 비인지능력 발달에 큰 영향을 미친다. 학급친구가 학생 개개인의 자기주도학습에 어떠한 영향을 미치는지 실증적으로 분석한 선행연구는 많지 않다. 이 연구는 한국 중고등학교에서 학생들의 학급이 무작위로 배정된다는 점을 활용하여 학급친구가 학생들의 자기주도학습에 미치는 영향을 분석하였다. 인과효과 식별을 위해 학교 고정효과와 도구변수를 결합한 회귀분석 모형을 활용하였다. 분석결과 학급친구가 개별 학생들의 자기주도학습에 긍정적인 영향을 미친다는 점을 확인할 수 있었다. 또한 분석결과는 이질적이어서 남녀공학 학교, 도시 소재 학교, 국공립 학교, 고등학교 및 학업성취도가 낮은 학생들인 경우에 통계적으로 유의미한 결과가 도출되었다. 이 연구는 자기주도학습에 있어서 동료효과가 존재한다는 점을 증명하고 있으며, 교육환경 개선을 위해 학급의 인적구성을 변화하는 작은 정책이 교육현장에 큰 변화를 가져올 수 있다는 점을 시사한다.