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Exploring the leadership and non-cognitive skills development using propensity score matching

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Summary

Based on the data of the Research on Improving Systems of Education in Vietnam (RISE VN) project collected from 2017-2020, this study investigated the influence of students participating in learning group leader tasks on develop their non-cognitive skills by: (i) Constructing a binary Treatmental variable (zero when the individual does not participate in group activities or participates but has never been a group leader. 1 when the individual is sometimes or always leads the study group); (ii) regression estimates using a simple OLS model show that student participation as a learning leader increases SD by 0.44 SD in non-cognitive IRT scores; (iii) the logit regression estimate initially found three models to predict the status of students participating in learning groups, which are: (1) students' family economic conditions, demographics, (2) province, city, and (3) past level of non-cognitive development and class size; (iv) estimate the propensity score thereby dividing the subject into two groups of Treatmental and Control; and (v) estimation of propensity score matching for each model shows that when students participate as group leaders, non-cognitive scores will increase by 0.427 SD (model 1), 0.382 SD (model 2) and 0.226 respectively. SD (model 3).

Key words: Study group; Non-cognitive; Propensity score matching; Impact assessment

Preamble

According to Gomez, Arai, and Lowe (1995) and Tsou (2005) research, student participation in classroom activities is essential for effective learning. Likewise, Marks (2000), in his research has shown that academically successful students are more likely to participate in class-related activities than students who do not. Wojtek Tomaszewski and colleagues (2022) discovered a strong correlation between active participation in the classroom and reading scores in 7th and 9th graders in their study on the influence of active teaching practice on student learning outcomes.

Several studies have found that students' group participation in leadership roles has a positive relationship with the development of academic and non-cognitive skills. Teaching in small groups/pairs will help form and develop learning skills as well as non-cognitive skills for students (Robert JMarzano, Debra J. Pickering, Jane E. Pollock, 2001); Vygotsky L. X, 1978). Organize Pairs Check - one person is the "coach", checking exercises and giving advice to the other; The other person clearly explained what he was doing. Organize a group activity on a topic to develop leadership qualities - the team leader will plan, develop ideas, and direct the problem-solving process, sharing, taking notes and commenting (Kagan S. 1992).

A number of factors affecting cognitive and non-cognitive skills have been demonstrated such as: (1) willingness to perform the responsibilities of team leader, secretary and team member, process and individual contribution to the team. overall performance (Atkinson, Anthony B. Piketty, Thomas 2007 ; Horwath & Morrison, 2011;

Darlington & Feeney, 2008); (2) effective leadership roles and methods are very important to promote collaborative skills (Atkinson et al., 2007); ability, leadership qualities of the team leader create strong connections, promote effective learning (Horwath & Morrison, 2011); (3) Opportunities to use communication skills, creativity, self-confidence, etc. for all team members (Darlington & Feeney, 2008) and (4) Monitoring and feedback recognizing mutual efforts members, reflect and learn from practice, assess progress, and develop learning strategies (Carpenter, Webb, Bostock, & C. Coomber, 2012; Lalayants, 2013). (5) Ability to work effectively and respect different groups; flexible and willing to help each other to accomplish common goals; evaluate individual contributions in the group (Claire Scoular, Dara Ramalingam, Daniel Duckworth and Jonathan Heard, 2020) In summary, studies show that taking on leadership roles and performing team leader responsibilities in learning activities affecting the development of non-cognitive skills of students.

Most of the studies mentioned above assume student involvement in learning activities/learning programs when estimating its effect on outcomes. These studies tend to be based on the assumption of functional relationships by regressing outcomes on variables that represent student participation.

This study differs significantly from the studies mentioned above in that it considers the causal relationship of student participation to the potential outcome framework (Angrist and Pischke, 2009; Glewwe and Todd, 2022) using the 'Propensity Score Matching' approach (Abadie and Imbens, 2016). In this way, focus is on describing the effect of student participation on outcomes according to causal inference (which is the average intervention effect).

I. Research design

1.1. Research purposes

Exploring the impact of leadership qualities on non-cognitive skills development for 9th graders using the propensity score matching approach

1.2. Research question

Why use the propensity score matching approach in impact assessment?

How does student leadership affect the development of non-cognitive skills in 9th graders?

1.3. Impact assessment[1]

a) Cause-and-effect reasoning

Impact assessment is a study that measures the causal impact of a project/policy/programme on outputs (Glewwe, Paul & Todd, Petra, 2022).

Example: Does gender affect the academic performance of 9th graders? It can be observed that female students often have better results in Mathematics and Literature than male students. But female students often study harder than male students, so the higher achievement of girls may be due to them studying hard, not because of being female.

To establish a causal relationship between the project/policy/program and the outputs, impact assessment is used to exclude non-program factors.

Call factor Y an outcome (such as health status, academic achievement, level of non-cognitive skill development, etc.) that is causally affected. of the Program/Policy factor (such as practicing active teaching methods, practicing learning group leadership, etc.). For example, consider the influence of students' practice of group leader tasks. practice with conventional non-cognitive test scores: students participating in the practice of group leader tasks belong to the Treatmental group; Students who did not participate in the

[1] This section is an overview from: Glewwe, Paul & Todd, Petra, (2022); Austin, PC, & Mamdani, MM (2006); Little, RJ, & Rubin, DB (2000);…

practice of learning group leader tasks belonged to the control group.

For each student, Y has two potential values denoted as follows (Y is the potential outcome if the student participates or does not participate in the Treatmental process, not the observed outcome when he or she actually does the Treatment). leader):

$$Y = \begin{cases} Y_0 \; if \; the \; individual \; does \; not \; participate \; in \; the \; treatment \\ Y_1 \; if \; the \; individual \; participates \; in \; the \; treatment \end{cases}$$

The treatment effect is the difference between Y_1 and Y_0, and is denoted by $\Delta = Y_1 - Y_0$.

Let P be the Treatmental program variable, with the following values:

$$P = \begin{cases} 0 \; if \; the \; individual \; does \; not \; participate \; in \; the \; program \\ 1 \; if \; the \; individual \; participate \; in \; the \; program \end{cases}$$

Then a student has two observed values of Y: $Y = \begin{cases} Y_0 \; if \; P = 0 \\ Y_1 \; if \; P = 1 \end{cases}$

The relationship between P, Y_0, Y_1 is shown by the formula: $Y = PY_1 + (1-P)Y_0$

The causal effect of an Treatmental program on individual outcomes is the difference between outcomes when they participate and do not participate in the Treatment $(Y| P=1) - (Y| P= 0) = Y_1 - Y_0 = \Delta$.

However, it is *not possible to observe Y when P=1 and when P=0 for the individual at the same time* – this is a problem that impact assessment will have to deal with. In which, Y| P=0 represents the counterfactual factor, which is what would happen if the person didn't join the program. This factor was not directly observed for program participants, so it should be estimated from the control group (this group is similar in all respects to the Treatmental group, except for Treatmental participation).

b) ATE and ATT

The impact of a program can be different for different individuals. It is generally desirable to estimate a person's $Y_1 - Y_0$ or at least the average of a population group, denoted $E(Y_1 - Y_0)$.

There are two common parameters in impact assessment: ATE (Average Treatment Effect) and ATT (Average impact of Treatment on the Treated). In there:

$ATE = E[Y_1 - Y_0] = E[\Delta]$, called the population mean Treatmental effect

$ATT = E[Y_1 - Y_0 | P=1] = E[\Delta | P=1]$ is called the mean Treatmental effect of the Treatment group

It is possible to estimate ATE and ATT for a person with characteristic X (which is a vector of observable variables) as the formula below. Where, ATE(X) is the average increase if a person with trait X is randomly selected to participate in the program, and ATT(X) is the average increase of those who actually participate in the program (P= 1).

$ATE(X) = E[Y_1 - Y_0 | X] = E[\Delta | X]$

$ATT(X) = E[Y_1 - Y_0 | P=1,X] = E[\Delta | P=1,X]$

In an ideal Treatment, it is common to randomly select students into the Treatmental group (P=1) and the control group (P=0). Therefore, the potential output of HS i is usually independent of the Treatmental state, denoted $Y_{i0}, Y_{i1} \perp P_i$. With this condition, Cunningham (2019) showed that the selection biases and Treatmental efficiency deviations are zero. Therefore, the mean comparison between Treatmental participants and non-participants is an unbiased estimate of ATE.

To obtain an unbiased estimator of ATE and ATT without any random data, two assumptions need to be based. First, the potential outcome is independent of the Treatmental state on a set of observed characteristics, i.e. $Y_i0, Y_i1 \perp P \mid \boldsymbol{X}$(assumes conditional independence). Second, the probability of selecting students to participate in the conditional Treatment is $0 < \Pr(P = 1 \mid \boldsymbol{X}) < 1$, where the expression $p(\boldsymbol{X}) = \Pr(T = 1 \mid \boldsymbol{X})$represents the Propensity score (also known as the probability of students participating in the Treatment), and $Y_i0, Y_i1 \perp P_i \mid p(\boldsymbol{X})$. From there it is only necessary to estimate the propensity score instead of all observed features X. In other words, just balance the propensity score instead over all dimensions of X (Angrist and Pischke, 2009). The propensity score matching (PSM) can then be used to estimate the ATE.

1.4. Data

Data sources collected from 2017-2020 by the RISE VN project, including cognitive skills Math, Literature and non-cognitive skills, consulted students, parents, teachers and the community, as well as the teaching practice of teachers.

The Self-Perception Profile for Children for students in grades 3-8 (8-15 years old respectively) is also used for Vietnamese students. With 48 questions, distributed alternately into the following 6 areas:

1. School capacity refers to a child's cognitive ability to learn at school, such as how quickly to complete a school assignment, etc.

2. Social competence refers to how to make friends, skills to make others like yourself, accept you, etc.

3. Athletic competence mainly refers to ability in sports, including outdoor games,

4. Appearance explores how children feel a beautiful person, happy with a look, body, face, hair... of themselves.

5. Attitude behavior exploits the extent to which a child likes a person's behavior, doing the right thing, acting according to standards, how to avoid trouble, etc.

6. Self-worth exploits a common perception of self-worth, and promotes social competence

In which, the questions are in the form of 'structured alternative' (according to Harter 1982): provide diverse responses of society and participants choose responses in accordance with their feelings. The following illustration is a structured alternative question:

	Really true to me	partly true for me				partly true for me	Really true to me
Sample sentences							
a	☐	☐	In their free time, there are friends who prefer to play outdoors	BUT	There are others who like to watch TV	☐	☐

Each question is a statement that helps determine a level on the non-cognitive scale - it will be marked with a (+) or a (-) sign representing a personal situation that matches the beginning or the end of the statement. there. Each question is scored in such a way that the first half is scored 1, 2, 3, 4 and the other half is scored 4, 3, 2, 1. Where 4 represents the most complete self-reflection and 1 represents the lowest self-review. This ensures illustrates the field 'School Capacity'. that kids are following the question, not just providing random feedback. Table 1

Table 1. Matrix of questions in the field of School Competence

Sentence#	Key	School capacity
1	+	There are people who find themselves doing very well at school Are there any of you who are worried that they can do their homework in school?
7	+	There are students who do not understand something, they will ask the teacher immediately Others like to try to find the answer on their own
13	-	There are people who always do the right thing There are other friends who often don't do the right thing.
19	-	There are friends who are good at new sports even though they have never played before There are others who fear that they may not be good at sports that they have never tried
25	+	Some of you forget what you've learned There are others who can remember what they have learned easily
31	-	There are people who are not really sure if they did well on the test until they get their graded work back The other students knew pretty well if they did well or not before they even received the graded work

A database was built to encode each student's response on all questions and estimate non-cognitive competency through a 2-parameter (2-PL) logistic model in Item Response Theory (IRT). The non-cognitive test results for 2017 and 2020 are balanced against each other to help compare non-cognitive skill development over time.

This study focuses on the impact of students' 'participation as learning leaders' on the development of the aforementioned non-cognitive skills. Figure 1 shows: 50% of students have never, 40% sometimes and 10% always perform the role and responsibilities of learning group leader at school (see left image); There is a strong correlation between participating in group leadership and non-cognitive skills (see right figure), students who are always group leaders have 2.4 times higher non-cognitive capacity than occasional students and nearly 10 times higher than non-cognitive students. Never been a team leader.

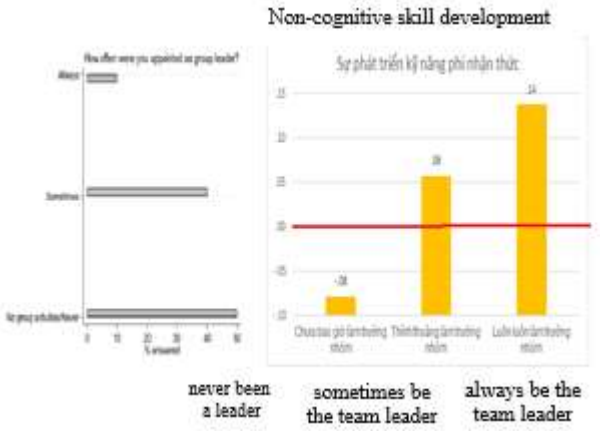

Figure 1. Frequency of choice and average non-cognitive skill development

Given the significant benefit in developing non-cognitive skills from participating in the aforementioned learning group leadership, we set out to assess the effect of this practice on non-cognitive skills. First, we construct a binary Treatmental variable: zero for those who do not participate in group activities or participate but have never been a group leader (50% of students); and 1 for those who are sometimes or always learning group leaders (50% of students). Then use PSM technique to estimate ATE.

2. Research results by propensity score matching

Estimating the linear regression model (*the independent variable is Treatmental, the dependent variable is the non-cognitive score*) using the Ordinary Least Square (OLS) method shows that: students participating in the learning group increase 0. 44 SD (Standard Deviation) in non-cognitive IRT scores (see Table 2). If the potential outcome is not independent of student participation as a learning group leader, then this is a biased estimate of the mean Treatmental effect due to selection bias and heterogeneous Treatmental impact bias.

Table 2. Simple OLS: the independent variable is Treatmental; The dependent variable is the non-cognitive score

	(1)
VARIABLES	Non-cognitive skills
Treatment	0.440***
	(0.0640)
Constant	0
	(0.0452)
Observations	1.047
R-squared	0.043

Table 3 presents Logit regression estimation results for three different models in three columns (*Treatmental variable is the dependent variable*). Model (1) controls for independent variables on students' family economic conditions and demographics. In the second model (2), the provincial variable is added to investigate the unobserved heterogeneity between provinces. In model (3), continue to add classroom conditions and non-cognitive outcomes from the past (when the children were in 7th grade).

It can be seen that the family's economic conditions, female students and father's (non-mother's) understanding of Vietnamese affect a student's participation in performing the tasks of the group leader. The provincial variable indicates that the status of students participating as study group leaders varies significantly between provinces. The final model showed that level of noncognitive development in 7th grade was also a major predictor of a student's participation as a learning leader.

Table 3. Three Logit regression models: Treatmental variable is the dependent variable

VARIABLES	(1) treatment	(2) treatment	(3) treatment
Student's family conditions (standardized)	0.354**	0.351**	0.315**
	(0.139)	(0.144)	(0.145)
Family conditions HS squared	0.0522**	0.0445*	0.0421*
	(0.0222)	(0.0229)	(0.0231)
Age	0.0610	0.0662	0.0645
	(0.0626)	(0.0661)	(0.0672)
Students are ethnic minorities (0/1)	-0.178	-0.591***	-0.542**
	(0.161)	(0.208)	(0.213)
Female students (0/1)	0.780***	0.848***	0.899***
	(0.131)	(0.136)	(0.139)
Mother can read and write TV RECODE of student_q108a	0.194	0.292	0.309
	(0.303)	(0.327)	(0.334)
Father can read and write TV RECODE of student_q108b	0.789**	0.645*	0.627*
	(0.329)	(0.337)	(0.342)
Lai Chau		0.782	0.578
		(0.604)	(0.613)

Yen Bai	0.730	0.354
	(0.460)	(0.490)
Thai Binh	-1.139**	-1.358**
	(0.550)	(0.572)
Thanh Hoa	-0.738**	-1.011***
	(0.325)	(0.355)
Nghe An	-0.152	-0.492
	(0.339)	(0.372)
Quang Tri	-0.838*	-1.278***
	(0.439)	(0.478)
Quang Nam	-0.524	-0.888**
	(0.364)	(0.391)
Binh Dinh	-0.716	-1.017**
	(0.480)	(0.498)
Binh Thuan	-1.149***	-1.288***
	(0.394)	(0.481)
Dak Lak	-0.0784	-0.242
	(0.341)	(0.357)
Lam Dong	0.611	0.446
	(0.438)	(0.448)
Tra Vinh	-0.646*	-0.922**
	(0.377)	(0.394)
Kien Giang	-0.777*	-0.993**
	(0.400)	(0.419)
Students have been absent from school for more than 10 days in the past school year		-0.313
		(0.365)
Grade 7 Noncognitive Skill Score		0.347***
		(0.0744)

Class size			0.0166
			(0.0121)
Constant	-1.438***	-0.910*	-1,241*
	(0.427)	(0.527)	(0.637)
Observations	1.007	1.007	1.007

With the above estimates, we calculate the predicted empirical probability, i.e. the predicted propensity score. Then, select each student to participate as a study group leader against students who have never been group leaders with similar propensity scores. This matching process aims to create two Treatmental and control groups that are equivalent in terms of predicted propensity scores.

Figure 2 shows the distribution of propensity scores according to learning group participation status for the models in Table 2. In each model, the raw distribution (left) represents the entire original sample, while the lateral distribution shows must show the distribution of the matched sample, i.e. each student who has participated as a group leader, selects a student who has never been a group leader with a similar propensity score. The results show that the two distributions are almost identical.

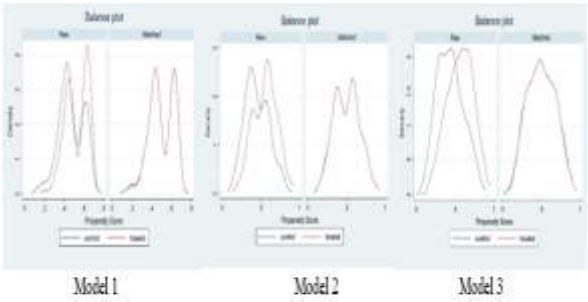

Figure 2. Estimated Propensity Score Balance

From there, estimate the propensity score matching from model 1 to model 3 in Table 4. When modeling propensity score as a function of economic and demographic conditions, the estimated mean Treatmental effect is 0.427, slightly lower than the results of the OLS regression shown in Table 1. This is because the Treatmental and control groups are relatively balanced in these characteristics besides ethnic minorities.

However, when modeling differences in empirical status across provinces in model 2, the ATE estimate is 0.382. The difference from the simple OLS regression estimate was lower than expected, as there were half of the provinces where the fixed efficiency coefficient was significant in Table 3. Finally, when past nonperceived performance and class size into the propensity point model, estimated ATE is 0.226. This is because these factors influence students' participation as class leaders. This result shows that students who sometimes lead the group or more have an average non-cognitive score of 0.226SD compared to students who do not participate. Under the assumption of conditional independence, this means that when a student joins the group as a group leader from time to time, it will increase the non-cognitive score by 0.226SD.

Table 4: Estimated propensity score matching for Logit models

VARIABLES	Model 1	Model 2	Model 3
ATE	0.427***	0.382***	0.226***
	(0.0698)	(0.0739)	(0.0707)
Observations	1.006	1.006	1.006

3. Conclusion

- Using propensity score matching in impact assessment has some basic advantages over linear regression. First, set up an Treatment in which only the effects of the Treatment and the factors affecting the Treatment are estimated. In linear regression, both groups of factors are in the same equation, so the coefficients of the independent variables are not easy to interpret. Second, it does not impose a functional form on the outcome variable Y. Third, it only needs to be concerned with the propensity score rather than for all X variables.

- Using propensity score matching shows that the latent leadership qualities/capabilities of 9th graders can be promoted through active participation in tasks in the role of learning team leader. There is evidence that, when students participate as group leaders, it increases 0.44 SD of non-cognitive scores in the OLS model; increase by 0.427 SD (in model 1), 0.382 SD (in model 2) and 0.226 SD (in model 3).

- There is significant benefit in promoting student participation in the role and responsibilities of group leadership in the classroom. Therefore, it is necessary to create opportunities for all students to practice this leadership position.

- The propensity score matching approach allows an unbiased estimate of the mean Treatmental effect (ATE) under the assumption of conditional independence. Causal inference shows that: Participation as a learning group leader increases the non-cognitive score 0.44 SD.

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