Social and Emotional Competencies and Science Performance in the USA: Evidence from PISA 2015

Guillermo Montes*

Ralph C. Wilson Jr. School of Education, St. John Fisher College, USA

Submission: October 20, 2019; **Published:** November 05, 2019

***Corresponding author:** Guillermo Montes, Ed.D. Program in Executive Leadership, Ralph C. Wilson Jr. School of Education, St. John Fisher College, Rochester, USA, Children's Institute, Rochester, USA Alesi 106C, St. John Fisher College, 3690 East Ave., Rochester, NY 14618, USA

Abstract

This paper asks whether students with different socioemotional learning (SEL) profiles perform differently in science. Using latent class analysis, we found three distinct groups of students: a majority of students who are relatively unmotivated and isolated, a sizeable group of students who are strong co-operators, and a relatively small group of students who are highly motivated and enjoy science, but do not value cooperation. After controlling for student and family covariates, as well as classroom, teaching and school leadership and institutional variables, the highly motivated, individualist group substantially outperformed the isolated group, with the co-operator group having intermediate performance. These SEL related differences in science performance were large, larger than performance differences associated with socio-economic variables.

Keywords: PISA 2015; STEM; Emotional Intelligence; Social and Emotional Learning; SEL; CASEL; Science Education; Adolescents.

Introduction

Social and Emotional Learning (SEL) is the proposition that emotional intelligence can be improved by explicit instruction of key social and emotional skills at two levels: individual student level and school climate level [1]. There is good evidence that many SEL-related educational problems such as truancy, lack of attention, behaviour problems, and lack of ability to work in teams result in poor academic performance. A meta-analysis of 213 studies studying SEL universal interventions [2] demonstrated that SEL competencies can be systematically taught in the classroom, and that doing so results in substantial academic gains. This research corroborated earlier work demonstrating that SEL leads to better academic performance, Zins, Weissberg, Wang, Walberg (2004). In addition, the Collaborative for Academic, Social and Emotional Learning (CASEL) SEL program guides have established that there are now veritable catalogues of SEL interventions that once correctly implemented and adequately supported at the institutional level are likely to yield considerable cognitive and non-cognitive benefits for students [3,4]. Recent cost benefit analyses of specific SEL interventions found an average return on investment of 11:1 [5]. In addition, because SEL interventions often provide greater benefits to those students who come from disadvantaged backgrounds, systematic SEL training as a national policy is likely to bring about more equitable educational outcomes and help reduce inequality and poverty [6]. Importantly, early SEL competencies have been shown to have long term associations with educational outcomes many years later; as well as impacts on non-educational areas such as mental health, criminal behaviour and substance abuse [7].

These evidence-based conclusions derived from educational and psychological research have been corroborated by more recent economic research on the development and return on investment of non-cognitive skills. Much PISA-related research uses an economics of education framework, making this approach relevant to the current study. The concept of non-cognitive skills includes SEL skills but often also personality characteristics or other associated psychological constructs such as locus of control. Often, it is the economists' way to refer to those skills not measured by academic test scores. Starting with the work of Heckman & Rubinstein [8] that attributed the high school graduate–GED disparity in earnings not to cognitive scores but to the lower level of non-cognitive skills GED recipients typically have, there have been various studies on the role of non-cognitive skills in education and labor market success. These studies have corroborated SEL research in finding that students with higher SEL skill levels are more likely to

stay in school, Carneiro, Crawford & Goodman (2006); Broghans et al. (2008), and more likely to command higher incomes over and above what one would expect from the student's educational attainment and grades, Judge and Hurst (2007). Economists also have documented family income, food insecurity, parental education and socioeconomic status as determinants of SEL skill development in children [9,10], as well as how various parental investments such as music education [11], reading to young children [12], use of computers [13] or early schooling influence SEL skill acquisition [14,15]. As it is the case in educational and psychological research, economists have also concluded that early intervention is a wise investment [8], particularly through the malleability of SEL skills, Cunha, Heckman, Lochner & Masterov (2006)

Little is known in any of these fields, however, about what clusters of SEL competencies students display in the classroom and how those SEL competencies are associated with student achievement. This paper addresses that question by seeking latent classes of SEL competencies in the PISA 2015 USA data and then determining the academic performance in the PISA science test of these latent classes, controlling for the student, family, classroom and school factors.

Socio Emotional Competencies and the CASEL Framework

There is a national framework for thinking about SEL competencies established by CASEL. The CASEL's integrated framework has five core competencies with subcompetencies within each area [16]. The model highlights shorter (e.g. improved attitude, pro-social behaviors) and longer-term outcomes (e.g. high school graduation, better mental health). It acknowledges the importance of classroom curriculum, school climate, family and community partnerships, as well as the role of state and federal policies and supports [1]. The five major competency areas are self-awareness, self-management, social awareness, relationship skills and responsible decision-making. Self-awareness is linked to the growth mind set, it includes knowledge of one's emotions and thoughts and their influence on one's behaviour. It includes constructs like self-confidence, accurate self-perception, and recognizing one's strengths.

Self-management is the core of self-regulation including being able to motivate oneself, having good impulse control, being able to set reasonable goals, and managing stress well. These two competencies focus on the person's internal life. The three remaining competencies involve the person's fit with his or her social environment. As in the internal world, awareness precedes self-regulation and management, thus social awareness includes the ability to think from someone else's perspective, empathy, and respecting others. Relationship skills are what traditionally was called social skills, including communication and teamwork, as well as one-on-one relationship development. The final core competency is responsible decision-making which focuses on problem solving, understanding social norms, and understanding when one should comply or defy such norms. The CASEL framework was based on previous work on emotional intelligence by Goleman [17] and has been widely used throughout the US to create SEL learning standards at the state level. We used this framework to identify which of the scales available in the PISA 2015 data collection fit within the five major SEL competency areas.

Methods

The Program for International Student Assessment (PISA) is an OECD sponsored systematic triennial effort for international student assessment intended to measure the quality, equity and efficiency of school systems across the planet. Approximately, 540000 students participated in PISA 2015, representing 29 million 15-year olds in 72 countries [18]. There are extensive detailed reports on the PISA assessment and data collection procedures available from OECD. In this study, we use the USA portion of the PISA 2015 data collection.

Outcome Variable: PISA Science Test

The main outcome of the 2015 cycle was science as measured by the 2015 science assessment framework which defined a scientifically literate students as one that could "explain phenomena scientifically", "evaluate and design scientific enquiry" and "interpret data and evidence scientifically" ([19] p.43). The assessment itself focused on competencies, knowledge and contexts. PISA has a complex process for selecting the final items that will be given on the test which includes national submission of items, review of items, inclusion of field items, and the creation of computer-based items. In the USA, the test was given via computer. No student takes the complete test; rather students take portions of the tests. The final test score for each student is basically imputed 10 different times (plausible values methodology). Thus, any regression analyses on outcome PISA science test data must take account of all ten plausible values per student.

Variables related to the CASEL framework

All PISA derived indices based on student response were analysed during the crosswalk to determine their alignment to the CASEL framework, as described below. Here we summarize the item information of the selected student-level response indices that were used for latent class analyses. The remaining indices were used as control variables in the production function.

Sense of belonging to school was measured with 6 items (e.g. "I feel like an outsider at school", "I make friends easily at school") on four-point strongly agree-strongly disagree Likert scale. It had an alpha reliability of 0.86 for the USA. Enjoying cooperation (alpha 0.73) was measured with 4 items (e.g. "I am a good listener", "I enjoy seeing my classmates successful") on a similar agreement metric. Valuing cooperation (alpha 0.84) was measured with 4 items (e.g. "I prefer working as part of a team to working alone"). Enjoying Science (alpha 0.95) was measured with five items (e.g. "I generally have fun when I am learning [broad science] topics"). Instrumental motivation (alpha 0.92) was measured with 4 items

(e.g. "Many things I learned in my [school science] subjects will help me get a job"). Test anxiety (alpha 0.84) was measured with 5 items (e.g. "I get very tense when I study for a test"). Achievement motivation (alpha 0.86) was measured with 5 items (e.g. "I want to be the best, whatever I do"). Science self-efficacy (alpha 0.90) was measured with eight items that described scientific tasks (e.g. " Interpret the scientific information provided in the labelling of foods") on a four point scale ranging from "I couldn't do this" to "I could do this easily". All indices were subjected to IRT scaling methods, with a mean of zero and standard deviation of 1 across all OECD countries. For technical details, please see the PISA 2015 technical manual.

Control variables

Student demographics included as control variables were gender, immigration status (native, 1st or 2nd generation immigrant), age, whether the 15-year-old student is above or below the modal grade (the grade level that typically 15th students attend). Family covariates included a variety of indices developed by PISA including the sociocultural and economic index based on parental occupation, household possessions and parental education; material wealth index (e.g. television, room of your own, internet, car, etc.), home educational resources index (e.g. "does child have a desk to study at home?"); cultural possession index (e.g. books of poetry, works of art).

Classroom resources including teaching modality were collected from the student point of view and include disciplinary climate index (e.g. "students don't listen to what teacher says"), inquiry based teaching index (e.g. "there is class debate about investigations"), teacher support (e.g. "the teacher gives extra help when students need it"), direct instruction index (e.g. "the teacher discusses our questions") perceived feedback index (e.g. "the teacher tells me how I can improve my performance") and adaptation of instruction index (e.g. "the teacher adapts the lesson to my class's needs and knowledge").

School resources were measured from the principal's point of view and include leadership in a variety of arenas including curricular development, instruction, professional development, and teacher participation. Institutional characteristics include school size, class size, attending private school (vs. public), shortage of educational material, and shortage of educational staff; and two school climate variables: one focuses on student behaviour that hinders learning (e.g. "student use of alcohol or illegal drugs") and the other on teacher behaviour that hinders learning (e.g. "teacher absenteeism"). Although used as covariates in models 4 and 5, please note that there are several indices that are measuring classroom climate and school climate which are SEL related constructs at those levels.

Data Limitations

This study used only the USA portion of PISA 2015. Results both in class membership and the SEL class relation to science performance may be different for different countries. In this regard, it is known that different cultures set different social norms for display of emotion, behaviour and interaction between the sexes. Thus, what may be considered as good behaviour in one culture may not be viewed the same in another [20]. We were also limited by the variables and framework used by the PISA team which did not systematically incorporate SEL as a framework, as discussed in the following sections.

Empirical Strategy and Findings

Our estimation approach considers four issues related to the PISA 2015 data: missing data, plausible values, multi-level structure of the data, and sampling design. The basic empirical strategy was first to crosswalk PISA derived indices to the CASEL SEL framework at the item level to identify the PISA indices most aligned with the CASEL SEL framework. Then, after missing value imputation we ran several models to determine latent classes of students regarding their SEL functioning. Once latent classes were obtained, we characterized the class by the average scores of the SEL aligned indices and provided basic demographic information about what kind of student is more likely to belong to each class. Finally, we included the latent SEL classes in a standard model to determine the association of SEL profile to PISA science test performance controlling for the remaining elements of the production function.

Following Hanushek & Woessmann [21] treatment on education production functions for international assessment data, we started with the following modified production function:

$$T = a_0 + a_1 SEL + a_2 F + a_3 R + a_4 I + a_5 A + \varepsilon \quad (1)$$

T is the PISA 2015 science test result. SEL are the latent classes previously obtained based on eight SEL-related indices aligned with the CASEL framework. The vector F incorporates both student and family background variables, R is a vector of school resources, I is a vector institutional features of schools, and A is individual ability.

We used Stata 15 to conduct the analysis. Because latent class analysis is not a supported command with multiple imputation of missing data, we generated a single imputation using chained regression models, and then estimated the LCA model on the resulting dataset. Sensitivity analysis revealed that the single imputation worked well and that results were not likely to change with different imputations based on different random seeds. The LCA model was appropriately weighted for sampling design. We used the individual weights because our analysis focused on a single country. Number of latent classes was determined based on interpretability and size of class membership. LCA models with two classes were found to be uninteresting as they divided students into a below average isolated majority group and high performing SEL-rich group. LCA models with four classes identified a class that had a relatively small group membership which made statistical analyses likely to be underpowered. Fortunately, the three

class LCA revealed interesting latent classes with enough class membership for meaningful analyses. The estimation of the production function was done in stages starting with a simple model (Model 1) that only contains the SEL classes as predictors of PISA 2015 science performance, then we add vector F (Model 2), then the portion of vector R which is classroom specific and collected from the student perspective (Model 3). These three models were estimated using regression analysis and the pv command that accounts for the 10 plausible values of the PISA science test. Models 4 and 5 were multilevel in nature because they included the portion of vector R that was school specific and collected from principals, as well as vector I which were the institutional characteristics of the school. These models were also estimated using the pv command to account for plausible values using multilevel regression models. As mentioned before, sensitivity analyses were conducted to determine the sensitivity of the paper's conclusions to a different imputation of missing values.

Identifying SEL-related Student-Level PISA scales

A systematic crosswalk between the PISA derived indices and the detailed CASEL SEL framework resulted in the identification of eight indices that could be aligned with the CASEL SEL framework. This crosswalk was done using the PISA 2015 technical manual and looking up each individual item used in the indices to decide of whether the index measured any of the constructs within the SEL framework. There were indices (e.g. interest in science topics, teacher instruction modalities) that implicitly require the student display one or more of the SEL competencies (e.g. self-awareness, social awareness), but are not a measure of the student's SEL competency. Other indices did contain some measure of a SEL competency but often included elements of several SEL competencies as well. For example, sense of belonging included items that measure social awareness (e.g. "other students seem to like me") and items that measure self-awareness (e.g. "I feel lonely at school"). This is to be expected since the SEL framework was not used in the design of the items or the indices. The crosswalk yielded eight student response indices that contained substantial SEL content and measured partially all five core competencies of the SEL framework: sense of belonging to school, achievement motivation, instrumental motivation, test anxiety, joy in science, science self-efficacy, values cooperation, and enjoys cooperation. These indices were analysed using latent class analyses.

Results

SEL - Latent Class Model

Figure 1 shows the average scores of the SEL related variables for each of the 3 latent classes. When interpreting these results, one must keep in mind that the PISA indices are IRT scaled with mean equal to zero for the OECD average, not the US average. We use these results to create appropriate labels for each class. Members of the first class had below OECD-average scores in sense of belonging, enjoying and valuing cooperation, enjoying science and science self-efficacy. They also had the lowest average scores in instrumental and achievement motivation and showed the highest scores in test anxiety. In characterizing this group with a short, descriptive label, we chose to call them the isolated latent class (I LC) because of their low average score in cooperation and belonging. Yet, this label is not intended to obscure the relatively low levels of motivation, science self-efficacy and high levels of test anxiety.
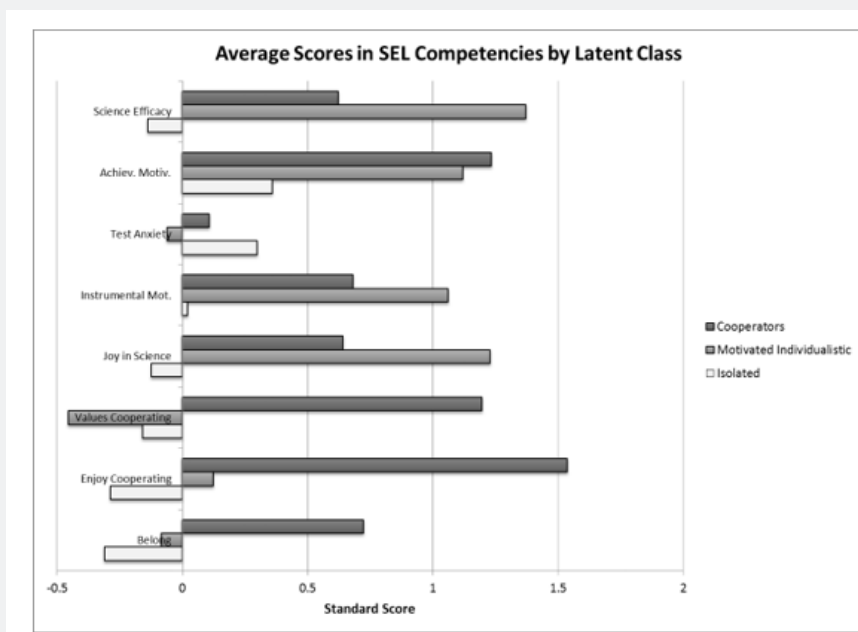

Figure 1: Average Scores in SEL Competencies by Latent Class.

Members of class 2 were the group who valued cooperation the least, had average levels of enjoying cooperation, test anxiety and sense of belonging. They were one standard deviation above the mean in both instrumental and achievement motivation and had the highest levels of science self-efficacy and enjoyment of science. Thus, members of this latent class are motivated individuals who like science and think they are good at it, but do not value cooperation. We called this group the motivated individualistic latent class (MI LC).

Members of class 3 had the highest average scores of both enjoying and valuing cooperation, and achievement motivation; and had intermediate scores in enjoying science and self-efficacy. Members of this class are motivated, co-operators (CO LC).

As shown in Table 1, the weighted distribution of latent classes was as follows: 67% of students are members of the isolated class, 18% belong to the motivated individual class and 21% have membership in the co-operator class. Table 1 also shows the demographic characteristics of each latent class. There were no gender differences by latent class. The MI LC members had the highest socio-economic status, and parental education. The I LC members were more likely to contain first- and second-generation immigrants, and have fewer cultural possessions and educational resources, as well as lower parental education, wealth and socio-economic status. The CO LC is an intermediate group like the MI LC in cultural possessions, wealth and home educational resources, but lower than this group in parental education and overall socio-economic status (Table 2).

Table 1: Demographics of Latent Classes.

	Isolated (1 LC)	Motivated Individualistic (MI LC)	Co-Operator (CO LC)	ALL*	Statistically Significant Differences**
N	2538	734	871	4143	
Prevalence	61.23%	17.66%	21.11%	100.00%	
Student Demographics					
Student is female	52.18%	48.90%	48.73%	50.87%	
Student is 2nd generation Immigrant	15.61%	12.95%	15.91%	15.20%	MI<1=CO
Student is 1st generation Immigrant	7.23%	4.77%	5.57%	6.45%	MI <I=CO
Student is below modal grade	9.09%	5.53%	5.90%	7.79%	MI = CO<I
Student is above modal grade	15.61%	21.91%	18.61%	17.36%	MI = CO>I
Age	15.81	15.82	15.81	15.81	IvII>1
Cultural Possessions Index	-0.2	0.22	0.14	-0.06	MI, CO>I
Home Educational Resources Index	-0.23	0.22	0.26	-0.05	MI, CO<I
Wealth Index	0.44	0.74	0.7	0.55	MI, CO>I
Sociocultural and Economic Index	0.06	0.48	0.31	0.18	MI >CO>I
Higher Education Index	4.78	5.15	4.98	4.89	MI>CO>1

Note: *Indices nonmed at mean =0 for DECO, not USA sample.
**Statistically significant differences at p<05 reported.

Table 2: Regression Models Results.

Variable	Model 1	Model 2	Model 3	Model 4	Model 5
SEL Latent Classes					
MI LC	66.58***	49.98***	47.00***	46.63***	46.75***
CO LC	16.58***	6.23	9.01*	13.78**	13.02*
Student and Family Covariates					
Student is female		13.00***	_20.57***	-19.21***	-19.57***
Student is 2nd generation Immigrant		-3.48	-4.97	1.74	0.91
Student is 1st generation Immigrant		-20.93**	-17.31**	-13.76	-13.23
Age		-15.98*	-17.46**	-15.61	-14.49
Student is below modal grade		-67.37***	-54.45***	-41.46***	-39.97***
Student is above modal grade		19.34***	19.84***	25.67**	25.76**
Cultural Possessions Index		4.16**	6.06***	4.71	4.83
Home Educational Resources Index		-3.01*	-2.75*	-5.27*	-5.40*

Wealth Index		-8.44***	-6.43***	-4.43*	-4.77*
Sociocultural and Economic Index		42.90***	36.'09***	27.30***	28.38***
Higher Education Index		-8.67***	-7.66***	-4.56	-5.02
Classroom Resources					
Disciplinary Climate Index			14.84***	12.75***	12.60***
Inquiry Based Teaching Index			-10.74***	-9.34**	-9.41**
Teacher Support Index			2.21	-0.02	0.18
Direct Instruction Index			9.09***	6.86**	6.85**
Perceived Feedback Index			_22.50***	_19.60***	_19.79***
Adaptive Instruction Index			10.47***	9.42***	9.42***
School Resources					
Curricular Development Leadership				-3.67	-4.78
Instructional Leadership				9.95	9.74
Professional Development Leadership				-7.91	-3.59
Teacher Participation Leadership				-7.6	-6.35
School Institutional Characteristics					
School Size					2.00E-03
Class Size					0.02
Student attends private school					-41.55***
Shortage of Educational Material					-5.23
Shortage of Educational Staff					-5.56
Negative Student Related School Climate					-15.71***
Negative Teacher Related School Climate					2.5

Note: I (Isolated) LC Class is default case. *p<.05, **p<.01, ***p<.001. Models 1-3 015,. Models 4-5 Multi-level. Individual weights and plausible values accounted for.

SEL- Latent classes predicting science performance

All models used the I LC as the default case because it was the majority group. Compared to the I LC, Model 1 shows that on average CO LC scored 17 points higher and members of the MI LC scored 67 points higher. Model 2 controls for family socio-economic background and student demographics reduces these margins substantially to 50 points for the MI LC and 6 points for the CO LC. Adding student perception of classroom environment including teaching variables such as the type of teaching and type of feedback received does not substantially modify these margins (47 MI LC, 9 CO LC). The addition information provided by the principal about leadership practices also does not change the results much for the MI LC (46) and raised the CO LC margin to 14 points (Model 4). The final model yielded estimates of 46 points for the MI LC and 13 points for the CO LC above the default baseline case of most students in the I LC. Thus, a main conclusion of the study is that the MI LC contains the highest performing individuals, followed by the CO LC.

Regarding the sign and effects of other variables in the production function the results are standard. Boys outperformed girls by 19 points. Immigration status was associated with poorer science

test performance only for first generation immigrants and only on models that did not include school-level variables. Students who were 15 years old but were at a lower grade level performed substantially worse in all models. Socio-economic status, as measured by the OECD ecsc variable, was associated with higher performances starting at 30 points for Model 2 and reducing to 21 points in the final model that included classroom and school variables. The disciplinary climate of the classroom was associated with better performance of around 12 points for classrooms that were better managed or had better behaved peers. This is a classroom level SEL classroom climate indicator. Inquiry based learning had a negative association of about 9 points, which is somewhat surprising given the high expectations OECD had for this mode of teaching; but the result is consistent across most PISA 2015 studies. Conversely, direct instruction had an overall positive association of 7 points. One of the strongest predictors was perceived feedback, with a negative effect of -20 points. Teachers who tailored their instruction to their class had students who performed better (9 points). The leadership variables did not seem to predict student science test performance (Model 4 and 5) at all. From Model 5, students attending public school had higher PISA science test performance once SEL class membership and socioeconomic status

is accounted for, and students attending schools where in general students displayed behaviors counterproductive to learning were substantially lower than other students (-15 points). This variable can be thought of as a school-wide SEL climate variable. It is noteworthy that in terms of effect size, the individual level SEL latent class membership effects are among the largest in the education production function estimation.

Discussion

This paper has three substantive findings: First, SEL matters for science performance. The effect sizes are large and remain large after controlling for a whole constellation of student, family, teacher, classroom and school variables. We found that SEL mattered at all three levels: individual SEL profile which was the focus of the study, classroom disciplinary climate and school SEL-related climate variables.

Second, there are distinct SEL profiles among US students. The majority of US 15-year olds are relatively isolated, unmotivated, and have science test anxiety. This is the lowest performing group based on SEL profiles. Second, there is a substantial group of students who value and enjoy cooperation, feel integrated into their schools, have science self-efficacy, relatively low-test anxiety and above average motivation to perform on science and who outperform the majority of the classroom. Yet, these co-operators latent class is outperformed by a smaller group who does not value cooperation, but who enjoys science and is highly motivated both externally (instrumentally, i.e. in order to get a job) and internally to perform well in science. These members of the motivated individualistic latent class are the highest performers for whom collaboration is likely always with students who perform worse than they do in science, which may explain the low value they attribute to cooperation. These effects are large, so SEL is a construct that deserves to be monitored, measured and used in future estimations of education production functions. This set of findings is consistent and develops further the argument that "learning is social and emotional" and that "social and emotional development is multi-faceted and integral to academics – to how school happens and how learning takes place" both key conclusions from the consensus statement of the National Commission on Social, Emotional, and Academic Development [22].

It also supports the approach Heckman has taken to "always advocate for the package of cognitive and social skills" (Heckman Equation Website, n.d.), not just one or the other. Third, clearly the isolated, relatively low performing, majority latent class could probably benefit from SEL interventions. This group has below average levels of feeling that they belong at school, do not enjoy cooperating, and have high test anxiety. In addition, it is also possible that SEL intervention on both remaining latent classes (CO and MI LCs) may raise the performance of both groups and at least raise the performance of CO LC members without harming the performance of the MI LC. Doing so would extend somewhat the current approaches advocated by CASEL and others. Yet, our

data showed that the highest performers in science did not value cooperation much and this finding must be better understood and respected, as it may be the case that high performance in science requires some level of isolated work to develop. Based on the coefficients for classroom and school climate alone, one could advocate for universal SEL intervention for which there is substantial evidence. This would probably address most students in the isolated group and may also help members of other classes. In the past, more targeted SEL interventions often have focused on "problem students"; but our research suggests that there may be a missed opportunity to target SEL intervention to high performing groups to address their specific SEL-related issues. Obviously, SEL interventions on these groups needs to be carefully monitored and assessed to ensure that it is not iatrogenic to the highest science performers in the country. Both groups of students need to be nurtured if the US is going to reach the national US STEM education goals of increasing the number of students who pursue science degrees, while increasing women and minority representation [23].

These findings have alternative explanations due to the cross-sectional design and the nature of the questions asked. First, it could be the case that causality is driven by a third factor (i.e. student ability) which determines both performance and SEL class membership. We tried to adjust for this possibility by including ability in the empirical model and measuring it with variables such as the modal grade; yet as acknowledged in the limitations section available measures of student ability were quite weak. Second, causality could run from science performance to SEL class membership. For example, high science performers may be unable to find similarly interested and knowledgeable peers and choose a SEL strategy that does not value cooperation. These alternative explanations ought to be studied in future studies, probably using qualitative designs that probe the lived experienced of high and low performing science students regarding SEL constructs.

Future quantitative studies probably need to go in two separate directions: domestically, we need to understand if there are interactions and fit between educational environments and teacher practices and students with different SEL profiles and explore other fields besides science [24,25]; internationally, we need to discern if SEL profiles found for the USA hold for other countries and to determine if their effects on their respective production functions are similar to those reported in this paper, or whether for example individualistic motivated students outperform others in the US but not in other countries with a more collectivistic culture [19]. In other words, are the results of this paper culturally dependent?

Limitation

This study has several potential limitations. We were limited by how the survey was conducted. If the OECD focused on SEL in a future iteration of the PISA study a well-constructed framework for SEL measurement based on CASEL or other suitable frame-

work would obtain much more reliable results than what we present here. Our crosswalk is an attempt to obtain SEL measures out of variables that are rich in SEL content but were not designed to measure SEL directly. Potentially, a different crosswalk determination may yield slightly different results. Second, we were limited by the variables available. In particular we lack strong measures of student ability (other than modal grade variables); which may confound some of our results, as explained. Finally, the survey design cannot allow any inference of cause and effect. Even with these limitations, this paper shows that the relationships between SEL and science performance deserves careful and detailed study.

Conclusion

In sum, the contribution of this study is that we provide evidence of a direct link of a subset of non-cognitive skills, SEL skills, within a widely used and recognized framework (the CASEL SEL framework) to US performance in science international assessments, surely an important indicator of national competitiveness for the future. In this regard, attention, promotion and assessment of SEL skills is likely to help the US meet its national STEM goals.

Acknowledgement

Conflict of Interest

The author does not have any conflicts of interest to disclose.

Financial Disclosure

The author does not have any financial relationships relevant to this article to disclose.

Funding Source

References

1. Durlak JA, Domitrovich CE, Weissberg RP, Gullotta TP (Ed.) (2015) Handbook of social and emotional learning: Research and practice. Guilford Publications, United States.

2. Durlak JA, Weissberg RP, Dymnicki AB, Taylor RD, Schellinger KB (2011) The impact of enhancing students' social and emotional learning: A meta-analysis of school-based universal interventions. Child Dev 82(1): 405-432.

3. CASEL (2012) 2013 CASEL guide: Effective social and emotional learning programs – Preschool and Elementary School edition. CASEL, Chicago, United States.

4. CASEL (2015) 2015 CASEL guide: Effective social and emotional learning programs – Middle and High School edition. CASEL, Chicago, United States.

5. Belfield C, Bowden AB, Klapp A, Levin H, Shand R, et al. (2015) The economic value of social and emotional learning. Journal of Benefit-Cost Analysis 6(3): 508-544.

6. Abner L, Butler S, Danziger S, Doar R, Ellwood D, et al. (2015) Opportunity, responsibility, and security: A consensus plan for reducing poverty and restoring the American dream. American Enterprise Institute for Public Policy and The Brookings Institution.

7. Jones DE, Greenberg M, Crowley M (2015) Early social-emotional functioning and public health: The relationship between kindergarten social competence and future wellness. American Journal of Public Health 105(11).

8. Heckman J (2000) Policies to foster human capital. Research in Economics 54(1): 3-56.

9. Fletcher JM, Wolfe B (2016) The importance of family income in the formation and evolution of non-cognitive skills in childhood. Econ Educ Rev 54: 143-154.

10. Howard LL (2011) Does food insecurity at home affect non-cognitive performance at school? A longitudinal analysis of elementary school classroom behaviour. Economics of Education Review 30: 157-176.

11. Hille A, Schupp J (2015) How learning a music instrument affects the development of skills. Economics of Education Review 44: 56-82.

12. Kalb G, van Ours JC (2014) Reading to young children: A Head-Start in life? Economics of Education Review 40: 1-24.

13. Fiorini M (2010) The effect of home computer use on children's cognitive and non-cognitive skills. Economics of Education Review 29: 55-72.

14. Suzidelyte A, Zhu A (2015) Does early schooling narrow outcomes gaps for advantaged and disadvantaged children? Economics of Education Review 45: 76-88.

15. Muehlenweg A, Blomeyer D, Stichnoth H, Laucht M (2012) Effects of age at school-entry (ASE) on the development of non-cognitive skills: Evidence from psychometric data. Economics of Education Review, 31: 68-76.

16. CASEL (2017) Social and Emotional Learning (SEL) Competencies.

17. Goleman D (2006) Emotional intelligence. Bantam.

18. OECD (2015) PISA 2015: Results in Focus. OECD Publishing, Paris France.

19. OECD (2017) PISA 2015 Assessment and Analytical Framework: Science, Reading, Mathematic, Financial Literacy and Collaborative Problem Solving, OECD Publishing, Paris, France.

20. Hecht ML, Shin Y (2015) Culture and social and emotional competencies. In: Durlak JA, Domitrovich CE, Weissberg RP, Gullotta TP (Eds.) (2015) Handbook of social and emotional learning: Research and practice. Guilford Publications, United States.

21. Hanushek EA, Woessmann L (2011) The economics of international differences in educational achievement. In: Handbook of the Economics of Education. Elsevier, 3: 89-200.

22. Jones SM, Kahn J (2017) The evidence base for how we learn: Supporting students' social, emotional, and academic development. Aspen Institute, United States.

23. National Research Council (2011) Successful K-12 STEM education: Identifying effective approaches in science, technology, engineering, and mathematics. National Academies Press, United States.

24. Jones SM, Bouffard SM (2012) Social and emotional learning in schools: From programs to strategies. Social Policy Report 26(4): 3-22.

25. Lubotsky D, Kaestner R (2016) Do 'skills beget skills'? Evidence on the effect of kindergarten entrance age on the evolution of cognitive and non-cognitive skill gaps in childhood. Economics of Education Review 53: 194-206.