

Collaboratively Conscious: An Examination of Disposition as a Determinant for Classroom Collaborative Problem Solving

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Abstract

Collaborative problem solving (CPS) has emerged as a critical competency in 21st-century education, reflecting broader pedagogical shifts toward student-centered learning environments. As classrooms increasingly emphasize collaboration, understanding the factors that influence students' engagement and success in CPS has become essential for both educators and researchers. This quantitative research study employed secondary data analysis to examine the dispositions of high school students regarding collaborative problem solving in classroom contexts, and further explored relationships between learning variables and beliefs. Data are drawn from questionnaires of the U.S. sample of students who participated in the 2015 Programme for International Student Assessment (PISA). Specifically, this study focuses on the classroom experiences of U.S. students with dispositions toward activities within clinical classroom peer groups. Results indicated that while participants exhibited overall favorable views of collaborative problem solving, responses were interpreted as more variable and may reflect shifting ideologies regarding collaborative problem solving as a classroom learning construct. Furthermore, results suggested differences in disposition based on gender and grade-level of students. Interestingly, books per household had little effect on dispositions of students.

Keywords: collaborative problem solving, pedagogy, disposition, PISA

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1. Introduction

Pedagogical shifts in teaching have led to more collaborative group work, inquiry-driven curriculum, and project-based learning in U.S. schools (Nagel, 2008). Students are assessed more often through group work as they become investigators in their own learning experiences (Blumenfeld et al., 1996; Fiore et al., 2017). Preservice teachers are taught to use group work and collaboration as part of their teacher credentialing, yet assessing this type of student learning is difficult to measure (von Davier & Halpin, 2013). However, while teaching and learning experiences have changed to increase collaboration in the classroom, students' learning is assessed based on individualized state-mandated assessments.

Unfortunately, this disconnect between pedagogical shifts in curriculum and instruction, and the lack of appropriate collaborative learning assessments creates questions as to whether these techniques are working to increase student learning. Toward this end, universities' schools of teacher education are challenged with addressing the lack of collaboration testing data while advocating evidence-based teaching practices in clinical education (Bain, et al., 2009; Begeny & Martens, 2006; Boyd, et al., 2009; Detrich, et al., 2007; Scheeler, et al., 2016). This issue, compounded by teaching and technological reform movements, requires exploration into collaborative problem-solving (CPS) assessments in K-12 education.

Students from the United States do not typically score well on international assessments (von Davier & Halpin, 2013; Darling-Hammond, 2014). However, the United States sample of students did relatively well on the 2015 Programme for International Student Assessment (PISA) CPS assessment, scoring 13th in the world on the CPS portion of the examination (OECD, 2016). Currently, there is no explanation for the historical discrepancy in U.S. scores with their CPS scores. Therefore, the purpose of this research study is an investigation of student disposition of CPS through the 2015 PISA. Created by the Organization for Economic Co-operation and Development (OECD), PISA added an addendum CPS assessment to the international science, mathematics, and reading tests. To date, little research has examined the influence of student disposition as a determinant of CPS in classroom contexts. Specifically, the purpose of this research study is to examine student attitudes towards classroom collaboration that may have led to the increase of U.S. students' CPS achievement.

Specifically, this research study sought the following questions:

- 1) By creating a collaborative problem-solving composite scale, is there a difference between the mean level of students' attitudes toward collaboration in the classroom?
- 2) Is there at least one grade level whose mean scores on the Student Attitudes Toward CPS composite scale are different than the other grade levels 9-12?
- 3) Do independent variables (Student Grade Level; Books per Household) significantly predict scores on a set of dependent variables (Student Attitudes Toward CPS composite)? If so, what is the predicted score for a dependent variable based on the score on a set of independent variables?

2. Literature Review

2.1 Theoretical Framework

Drawing on the theoretical constructs of Lev Vygotsky and Albert Bandura, this research study seeks to conceptually understand if students' dispositions play a role in CPS achievement. The seminal work of Lev Vygotsky's socio-cultural development theory (1962, 1978) studied social interaction in teaching and learning environments. Vygotsky developed a framework in which meaning making occurs through collaboration. This social constructivist approach is garnered in teacher education programs as the importance of group work. Students may begin developing cognition at an individual level, but as they begin to interact with classmates and teachers, students begin to move beyond their individual cognition into their Zone of Proximal Development (Vygotsky, 1978). Cooperative learning became CPS using Vygotsky's work as the justification of a child's social learning development, and teacher education programs began to shift teaching practices (Fiore et al., 2017).

Albert Bandura's seminal work on social cognitive theory demonstrated the personal factors of an individual as cognitive functions and affective dispositions. This in turn affects what activities within the classroom the individual will choose. These choices impact further development of cognitive and affective processes by a reciprocal-bidirectional mutual influence (Bandura, 1986). This social approach is garnered in teacher education programs as the importance of modeling and observational learning as students develop dispositions toward schooling. Researchers can study students' disposition to find potential causes for testing results (Scalise et al., 2016). While children develop this collaborative blended learning approach in classrooms, CPS is the direct beneficiary.

For this research study, OECD's definitions will be used. The following is the key term in the research study:

Collaborative problem solving (CPS): "The capacity of an individual to effectively engage in a process whereby two or more agents attempt to solve a problem by sharing the understanding and effort required to come to a solution and pooling their knowledge, skills and efforts to reach that solution" (OECD, 2017).

2.2 Collaborative Problem Solving as Construct

The construct of collaborative learning is based on the interaction between participants. Interaction can move beyond the direct instruction of classroom teachers (Nagel, 2008), and into "collaborative communities" of learning (Blumenfeld et al., 1996). As collaborative communities assist all students in the group, researchers began to see the connection to student-centered learning, project-based learning, collaborative group work, and dyads/triads (Hiebert et al., 1996). Research began to show integral scientific relationships within collaborative group classwork. CPS had been found to draw upon different social and cognitive skills, and can be both teachable and measurable (Gauvain, 2018; Graesser et al., 2018; Hesse et al., 2017).

Hesse and colleagues (2017) argue that cooperative learning is necessary for collaborative learning to occur, and part of a social and cognitive skill set that lays the foundation for collaboration. From this framework, researchers believe that CPS means approaching a problem responsively by working together and exchanging ideas. Collaboration relies on factors such as "a readiness to participate, mutual understanding, and the ability to manage interpersonal conflicts" (p. 38). Griffin (2017) has considered CPS as the collaborators' understanding of their interdependency. This work informed the Assessment and Teaching for 21st Century Skills (ATC21S) to develop a framework for a formative assessment of CPS. While the research suggests a debate for the social and cognitive benefits of CPS, there is potential tension between a process approach to problem solving and a cognitive ability approach (Gauvain, 2018; Hesse et al., 2017). This is evident in the long history concerning the teachability of higher-order thinking processes, and whether the two approaches should be in competition with

one another. Toward this end, both approaches were blended to assist in the creation of an online 2015 PISA CPS assessment (OECD, 2017).

There is a significant societal need in which different fields can inform theory and empirical research regarding CPS. While there is a debate amongst scholars regarding processes, there is agreement that while K-12 students are learning collaboratively, they are gaining both knowledge and experience (Gauvain, 2018; Graesser et al., 2018; Hesse et al., 2017). Little of the extant empirical literature on CPS is focused on age-related and developmental factors. In particular, Wang, et al. (2009) examined a student self-report teamwork assessment. There were 57 items developed to assess 'cooperation', 'negotiation', and 'guiding others' (Wang, et al., 2009). The study found significant positive correlations regarding the developmental trajectory of teamwork disposition in late adolescence and teamwork achievement scores. Using similar disposition variables in the 2015 PISA questionnaire regarding teamwork, groupwork decision-making, cooperative learning, and perspective-taking can benefit researchers regarding age-related but differing grade levels.

Mary Gauvain (2018) found that older children have demonstrated more gains from CPS than younger children, and that more research is needed for middle school and elementary school-aged children. This can only be done if scholars accept that CPS has developmental aspects as well as social and cognitive skill sets. The rigor that is necessary to make cause-and-effect inferences must be done in controlled settings in the classroom, and this work can further advance with participants of different ages and developmental levels (Gauvain, 2018).

3. Methods

This study was conducted using a quantitative approach with data derived from the 2015 Programme for International Student Assessment (referred to as the 2015 PISA). The OECD began by looking at CPS from its definition and identification of cognitive subskills. The particular clusters of subskills are of interest for the future of assessment (Care et al., 2016).

3.1 Sample

The data represent the United States student questionnaire conducted by the Organization for Economic Cooperation and Development (OECD) that surveyed 15-year-old students who are typically in their 10th grade year. The data sample used for this study represents a U.S. sample of 5,712 students in both public and private schools. The PISA uses stratified sampling, and each country submits a sampling frame to the international consortium responsible for test implementation. The OECD sets a high threshold of minimum response rate at 85% (Hopfenbeck, et al., 2018). Additionally, the U.S. sample had to meet statistical standards for response rates from the U.S. National Center for Education Statistics (OECD, 2016).

3.2 Instruments

The questionnaires and examination developed into a formal computer-based assessment at the 2015 administration of the examination. PISA surveys are administered by trainers and examination administrators with procedures to foster strong validity and high reliability. While the PISA questionnaires incorporate students, teachers, schools, technology, and parents, it is the data derived from students that drive the outcomes of the test. Unfortunately, student testing data specifically on the CPS is not available in the public-access data. Instead, this study will incorporate the surveys of students that directly impact CPS in the teaching and learning spaces of classrooms.

3.3 Procedure

First, line items in student questionnaires were assessed for research questions using SPSS 25. The study looked at descriptive statistics to describe the central tendency of the frequency distribution for the sample of U.S. students. A composite scale was created using five variables for students' attitudes toward collaboration in the classroom. The variables 'like working as a team', 'teams make better decisions', 'enjoy different perspectives', 'teamwork raises proficiency', and 'enjoy cooperating with others', were used as each of the variables provided respondents with a four-point Likert scale.

In this study, several analytic approaches were employed to answer research questions. First, descriptive statistics describe the means and standard deviations for student attitudes toward collaboration in the classroom,

and the types of collaboration as would be taught in the classroom. An ANCOVA was used to determine grade level differences with the CPS composite scale (attitudes toward CPS in the classroom) with the covariate of books per household to control for parent literacy levels. A Pearson product moment correlation was used to examine the relationships between the independent variables and dependent variables in the study. Next, the study incorporated a multiple-regression analysis to see the effects of predictor variables on the CPS composite. A chi-square analysis for books per household and students' attitudes toward CPS in the classroom was analyzed. Furthermore, the differences with students who attend public or private schools regarding student attitudes to CPS was studied.

4. Results

The purpose of this study was to explore student attitudes towards classroom collaboration that may lead to the increase of U.S. students' CPS skills. A composite variable was created by summing the variables for student attitudes toward CPS using SPSS 25 (see Table 1). Data from Grade 7 ($n = 1$) was not an accurate measure for that specific grade level because of sample size. A post-hoc test cannot be administered with less than two cases, therefore Grade 7 was eliminated from the study. Descriptive statistics for the CPS composite by grade level can be found in Table 2. As can be seen there, Grade 12 students exhibited the highest mean ($M = 15.29$) for attitudes toward collaborative problem solving. Next, the internal consistency was tested for reliability of the CPS composite scale. The variables 'like working as a team', 'teams make better decisions', 'enjoy different perspectives', 'teamwork raises proficiency', and 'enjoy cooperating with others', were used. For the five variables, Cronbach's Alpha was .814 for the CPS composite. There is sufficient evidence for reliability with the CPS scale (Field, 2018). Validity of the composite was determined with a Pearson's Product Moment with all variables at $r < 0.05$, therefore the instrument was valid. Next, a difference was sought between the mean level of students' attitudes toward collaborative problem solving (CPS composite) with male and female students. Descriptive statistics for the gender of U.S. students who participated in the 2015 PISA CPS can be found in Table 3.

An independent groups t -test was conducted to determine if the mean level of students' attitude toward collaborative problem solving (CPS composite) differed between male students ($n = 2,732$) and female students ($n = 2,744$). Levene's test for homogeneity of variances was conducted, and it was determined that the assumption of equal variances was met. It was further determined that male students ($M = 15.18$, $SD = 2.785$) had statistically more positive dispositions of CPS than female students ($M = 14.69$, $SD = 2.781$), $t(5474) = -6.435$, $p < .001$, $d = .18$, a small effect size. A post-hoc power analysis was run to determine the sample power. The observed power of a two-tailed hypothesis was 0.99. Next, the study sought to find correlations between the following relationships: students' books per household and repeating a grade level. Regarding the students' books per household variable (parent literacy level) and student repeating a grade variable, there was a negative low significant correlation between books in the home and students repeating a grade level, $r = -0.123$, $p < .001$, $n = 5,452$. This means that for student participants in the study, when they have less books in the home, they tended to have slightly higher rates of repeating a grade level.

Next, an analysis of covariance (ANCOVA) was employed to determine if there were significant differences between grade levels 8-12 as measured through a CPS composite variable (see Table 4). The research question of "Is there at least one grade level whose mean scores on the Student Attitudes Toward CPS composite scale are different than the other grade levels when controlling for books per household?" was studied. As shown in Table 4, this analysis revealed a significant main effect of student attitude toward CPS, $F(5, 5447) = 2.88$, $p = .013$, $\eta_p^2 = .003$. The partial Eta Squared value indicates the effect size is small (Huck, 2012). The covariate of Books per Household was significant, $F(1, 5447) = 22.90$, $p < .001$. This means that higher grade levels demonstrate an increased positive attitude toward collaborative problem solving. Furthermore, the covariate of Books per Household demonstrated a statistically significant relationship with student attitude toward collaborative problem solving.

Next, as shown in Table 5, we looked at the number of public and private schools that took part in the collaborative problem-solving portion of the PISA. A stepwise multiple linear regression was used to build a model of predictor variables capable of predicting the criterion variable: Student Attitudes Toward CPS. The first variable to be included in the model was 'Student Gender.' The beta weight for this variable was .088. This model explained .8% of the variance in the criterion variable. Utilizing analysis of variance (ANOVA), this simple regression was found to be statistically significant, $F(1, 5452) = 42.290$, $p < .001$. The next variable to enter the model was 'Books per Household'. The beta weight for 'Student Gender' became .085 and -.059 for

'Books per Household'. This model had an R^2 of 1.1%. The ANOVA results for this model were statistically significant $F(2, 5453) = 30.78, p < .001$. See Table 6 for ANOVA.

t -tests to determine the significance of the predictor variables were also performed. For 'Student Gender, $t(5451) = 6.29, p < .001$, indicating a significant coefficient. For 'Books per Household', $t(5451) = -4.37, p < .001$, indicated a significant coefficient. The predictive model then becomes: $y = .085(x_1) + -.059(x_2)$. This was the final model found through the stepwise method because the addition of no other variable met the inclusion criterion. Lastly, a chi-square test was performed to examine the relationship between Books per Household and Public/Private Schools. The relationship between these variables was significant, $\chi^2(5, n = 5541) = 100.546, p < .001, \phi_c = .14$. There is a statistically significant relationship between books per household and whether a student attends a public or private school. The cross-tabulations are presented in Table 7. As books per household increased, private school students were more likely to have a higher parent literacy than public school students. The effect size is considered small (Huck, 2012).

5. Discussion

The research study provides evidence to support the effects of collaborative problem solving in the classroom as a pedagogical practice, and the effects on students' attitudes toward collaborative problem solving. The research questions that guided this study were 1) Is there a difference between the mean level of students' attitudes toward collaboration in the classroom? 2) Is there at least one grade level whose mean scores on the Student Attitudes Toward CPS composite scale are different than the other grade levels 9-12? 3) Do independent variables (Student Grade Level; Books per Household) significantly predict scores on a set of dependent variables (Student Attitudes Toward CPS composite)? If so, what is the predicted score for a dependent variable based on the score on a set of independent variables?

Mixed-ability grouping directly connects with Vygotsky's (1962, 1978) work on mixed-ability grouping in order for students to interact with other students of different Zones of Proximal Development. This is where Vygotsky argued that learning occurs, and that students will learn most when grouped with students of differing ability. Bandura's (1986) work on observational learning has impacted the cognitive dimensions of student achievement while increasing self-efficacy and dispositions toward collaboration in classroom contexts.

First, male students had a slightly more positive attitude toward collaborative problem solving than female students. While males demonstrated statistically significant positive disposition toward collaborative problem solving, the effect size was small. The mean scores for both genders indicate a positive attitude towards group work in classrooms and may indicate why the U.S. sample achieved at a high level on the 2015 PISA for collaborative problem solving.

Next, the research study determined that as students are in higher grade levels, they tend to demonstrate an increased positive attitude toward CPS. While the students were of the same age, there were students who were advanced in grade level and viewed collaboration as positive. Furthermore, the covariate of books per household demonstrated a statistically significant relationship with student attitude toward CPS. Again, this indicates that parent literacy levels impact student achievement and attitudes toward group work at grade level. Additionally, a research model was created to predict student gender and books per household for attitudes toward CPS. Both variables indicated a significant coefficient and provides impetus for further research on predictors on future international CPS examinations.

The research study sought to find relationships between students who attend public and private schools with books per household. There was a statistically significant relationship between books per household and whether a student attends a public or private school. As books per household increased, private school students were more likely to have a higher parent literacy than public school students. This finding indicates that students in private schools scored relatively well on the CPS portion of the 2015 PISA. Lastly, books per household is frequently studied as an indicator for parent literacy levels which impact their children's learning potential. It was determined that when students have less books in the home, they tended to have slightly higher rates of repeating a grade level. This is not a significant finding, although it falls in line with research regarding students' achievement in school and parent literacy levels.

There are some limitations regarding post hoc attempts to study secondary data sets. Data may potentially lack depth, but most importantly, student testing data was not available in the public-access dataset. Reliability and validity concerns are null because of OECD produced documentation for reliability and validity of the examination. Additionally, there are limits to studying grade-level and age for generalizability (Chudgar &

Luschei, 2014).

Further research is imperative to find why the U.S. sample achieved beyond the norm for international tests on collaborative problem solving. There was no way for classroom teachers to prepare students for the examination, and it may validate pedagogical practices in the classroom and students' dispositions toward collaborative group work. While research acknowledges the difficulty in measuring collaborative problem solving as a pedagogical shift in U.S. classrooms, the teaching and learning that develops through Vygotsky's and Bandura's work on social development of student learning further shows the importance to the educational community on the continued instructional shifts and their validation for student collaborative learning achievement. Future research should further explore longitudinal and experimental designs to better understand causal relationships between student dispositions and collaborative problem-solving outcomes. Additionally, expanding studies to include diverse age groups and international comparisons may provide deeper insight into developmental and cultural influences on CPS. Finally, incorporating direct assessment data alongside self-reported measures could strengthen the validity of findings and inform more effective classroom practices.

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Table 1
Descriptive statistics for CPS composite

	N	Minimum	Maximum	Mean	SD
Student grade level	5712	7	12	10.07	.519
Working as a team	5577	1	4	2.79	.816
Teams better decisions	5573	1	4	2.94	.771
Enjoy different perspectives	5550	1	4	3.16	.598
Teamwork raises efficiency	5550	1	4	2.92	.792
Enjoy cooperating w/peers	5544	1	4	3.12	.689

Table 2
Descriptive statistics for grade level CPS composite

	N	Mean	SD	Std. Error	95% Confidence Interval for Mean			
					Lower Bound	Upper Bound	Min	Max
Grade 8	11	13.7273	3.00303	.90545	11.7098	15.7447	8.00	17.00
Grade 9	482	14.8672	2.57668	.11736	14.6366	15.0978	6.00	20.00
Grade 10	4049	14.9948	2.80011	.04400	14.9085	15.0811	5.00	20.00
Grade 11	926	14.7149	2.85747	.09390	14.5306	14.8992	5.00	20.00
Grade 12	7	15.2857	2.42997	.91844	13.0384	17.5331	11.00	18.00
Total	5476	14.9332	2.79313	.03774	14.8592	15.0072	5.00	20.00

Table 3
Descriptive group statistics for students' gender

	Student Gender	N	Mean	SD	Std. Error Mean
Student Att. CPS	Female	2744	14.6917	2.78106	.05309
	Male	2732	15.1757	2.78470	.05328

Table 4
Tests of Between-Subjects Effects

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Correct Model	281.414a	6	46.902	6.045	.000	.007
Intercept	5804.982	1	5804.982	748.178	.000	.121
Books per House	177.676	1	177.676	22.900	.000	.004
Grade Level	111.775	5	22.355	2.881	.013	.003
Error	42262.293	5447	2.881			
Total	1258798.000	5454	7.759			

Notes: R² = .007 (Adjusted R² = .006)

Table 5
Descriptive statistics for public and private schools

	Frequency	Percent	Valid Percent	Cumulative Percent
Public School	5303	92.8	94.5	94.5
Private School	310	5.4	5.5	100.0
Total	5613	98.3	100.0	
Missing System	99	1.7		
Total	5712	100.0		

Table 6
ANOVA Results for Multiple Linear Regression

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	475.056	2	237.528	30.777	.000 _b
	Residual	42068.651	5451	7.718		
	Total	42543.707	5453			

Notes: _a Dependent Variable: Student_Attitudes_CPS

_b Predictors: (Constant), How many books in your home?, Student (Stand.) Gender

Table 7
Cross-tabulation Results of Chi-Square Analysis

Count	Public School	Private School	Total
Books per Household			
0-10 books	1295	29	1324
11-25 books	1061	37	1098
26-100 books	1459	88	1547
101-200 books	762	65	827
201-500 books	468	54	522
More than 500 books	192	31	223
Total	5237	304	5541