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A Longitudinal Study Investigating the Effects of the PBL Approach in Secondary Mathematics Education

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Abstract

This longitudinal study investigated the effect of Project-Based Learning (PBL) on Secondary mathematics' students in order to determine both academic skill development and motivational factors that affect learning. Specifically, for two years, this study followed two comparable groups of 8th and 9th graders from a PBL school and a conventional public high school; these students represented a wide range of mathematical abilities (deep vs. superficial conceptual knowledge) and demographic diversity (race/ethnicity/SES). Each semester, on-line surveys, classroom observations, and student and teacher interviews were administered and analyzed.

Results showed that at-risk and minority students benefited from PBL in learning mathematics; the academic performance gap was present, but the width of the gap diminished significantly. However, there were grounds for concern in using PBL. Compared to conventional high school students, PBL students were stronger in employing or regulating effective study strategies, self-efficacy and self-regulation, while showing significantly lower test anxiety.

RESEARCH QUESTIONS

- What was the effect of PBL on secondary students' mathematics-academic skill, and what were the factors that contributed towards the acquisition of such;
- How did PBL affect the motivational and social factors of secondary students' mathematics learning;
- How did PBL fair with at-risk and racial/ethnic minority secondary mathematics students? Specifically, we investigated whether the PBL classroom provided an alternative setting for minority (Latino American and other minority students) and At-risk students as defined as Low SES students who were known to be underachieving in mathematics.

METHOD

quantitative data
 participants' standardized test scores

qualitative data
 on-line survey, classroom observations, student and teacher interviews

Training for all researchers on coding of data and interviewing was held throughout the years to maintain 80% inter-rater reliability and the integrity of the research methodology.

Participants. Note: In terms of mathematics achievement, number of low proficient students (% of student <60%) in PBL school is 10% more than that of the comparison school.

Attrition
 14%, not significantly different between PBL and the comparison school ($p = .431$)

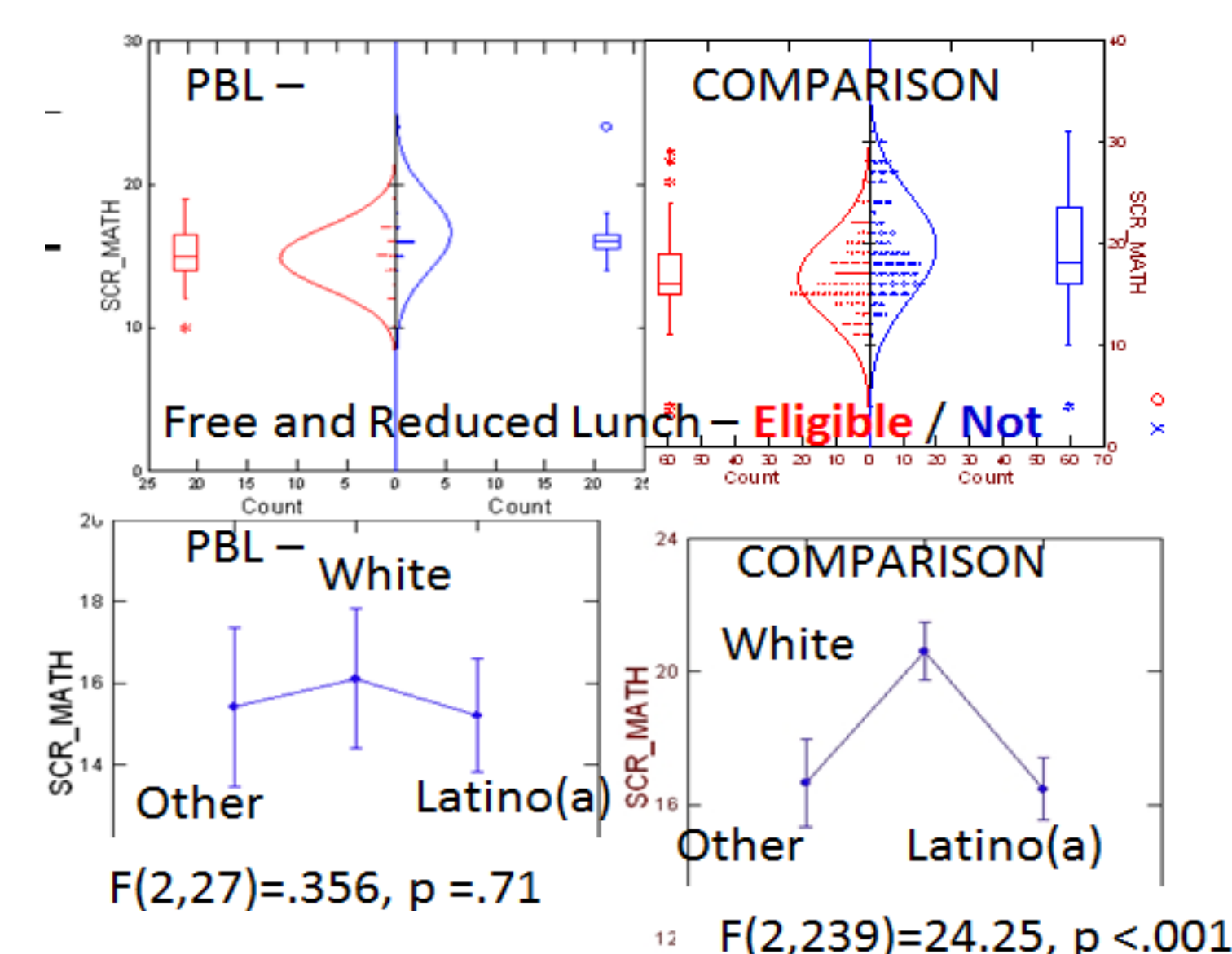
	Experimental PBL School		Comparison Non-PBL	
	1st Year (n=88)	2nd Year (n=78)	1st Year (n=444)	2nd Year (n=381)
Grade				
8 th	47 (53%)		186 (42%)	
9 th	41 (47%)	44 (56%)	258 (58%)	205 (54%)
10 th		34 (44%)		176 (46%)
Gender				
Male	51 (58%)	47 (60%)	198 (45%)	189 (50%)
Female	37 (42%)	31 (40%)	244 (55%)	192 (50%)
Ethnicity / Race				
Afr. Amer.	11 (13%)	8 (11%)	22 (5%)	13 (8%)
Euro Amer.	37 (42%)	33 (43%)	173 (39%)	151 (40%)
Latin Amer.	26 (29%)	28 (36%)	178 (40%)	168 (44%)

RESULTS

Academic factors

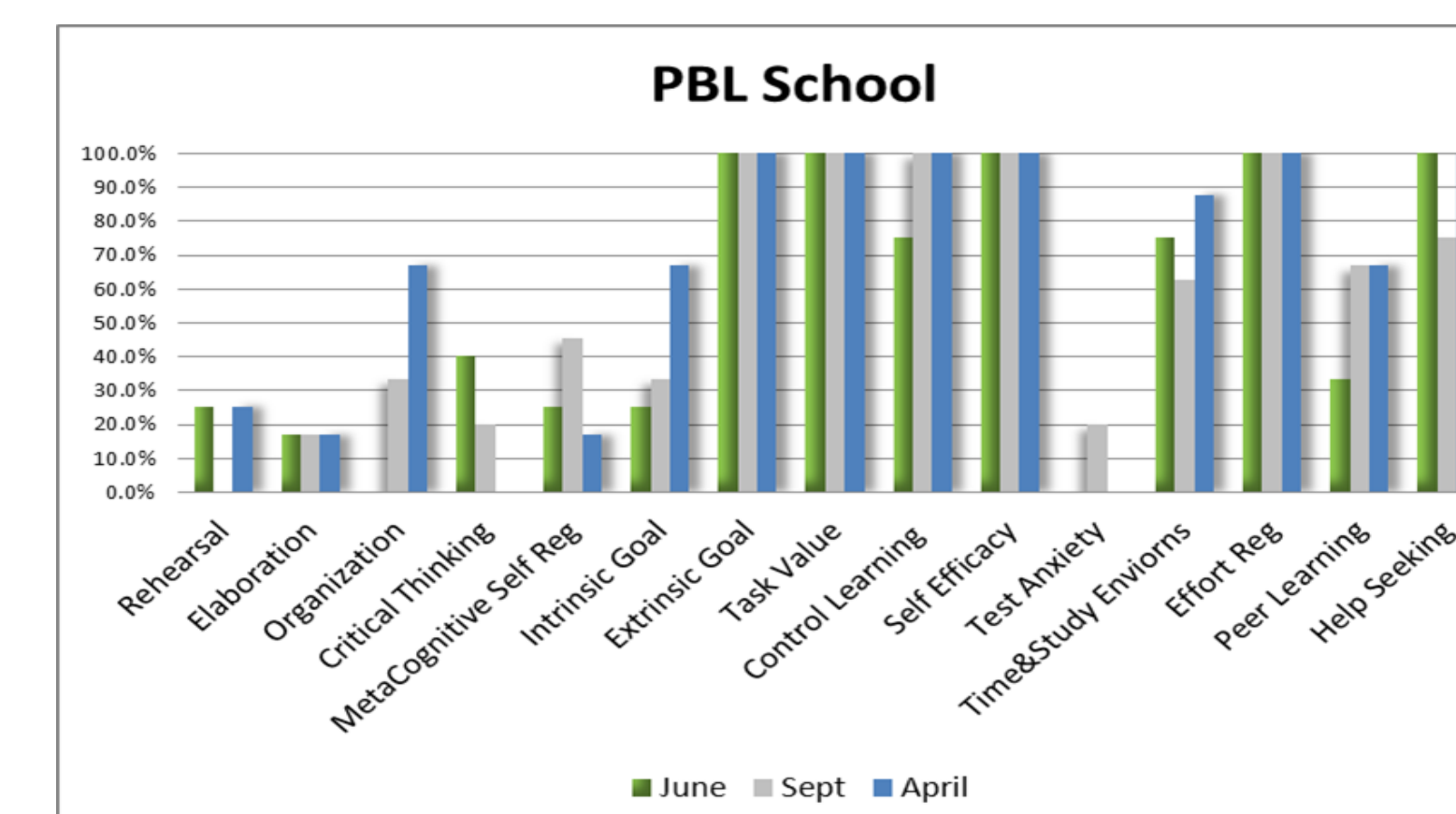
Race was not a determining factor in PBL school performance, but SES factors were.

PBL & Comparison schools' Fall 2012 Disaggregated standardized math scores		PBL overall 15.53(2.46)	Comparison overall 17.887(5.01)
		Mean (StdDev)	
Free and Reduced Lunch	Eligible	14.90 (2.16)	16.62 (4.09)
	Not eligible	16.64 (2.66)	19.64 (5.15)
Race / Ethnicity	1 Other	15.43 (1.81)	16.67 (4.68)
	3 White	16.11 (2.09)	20.61 (4.90)
	4 Latino(a)	15.21 (3.00)	16.48 (3.91)

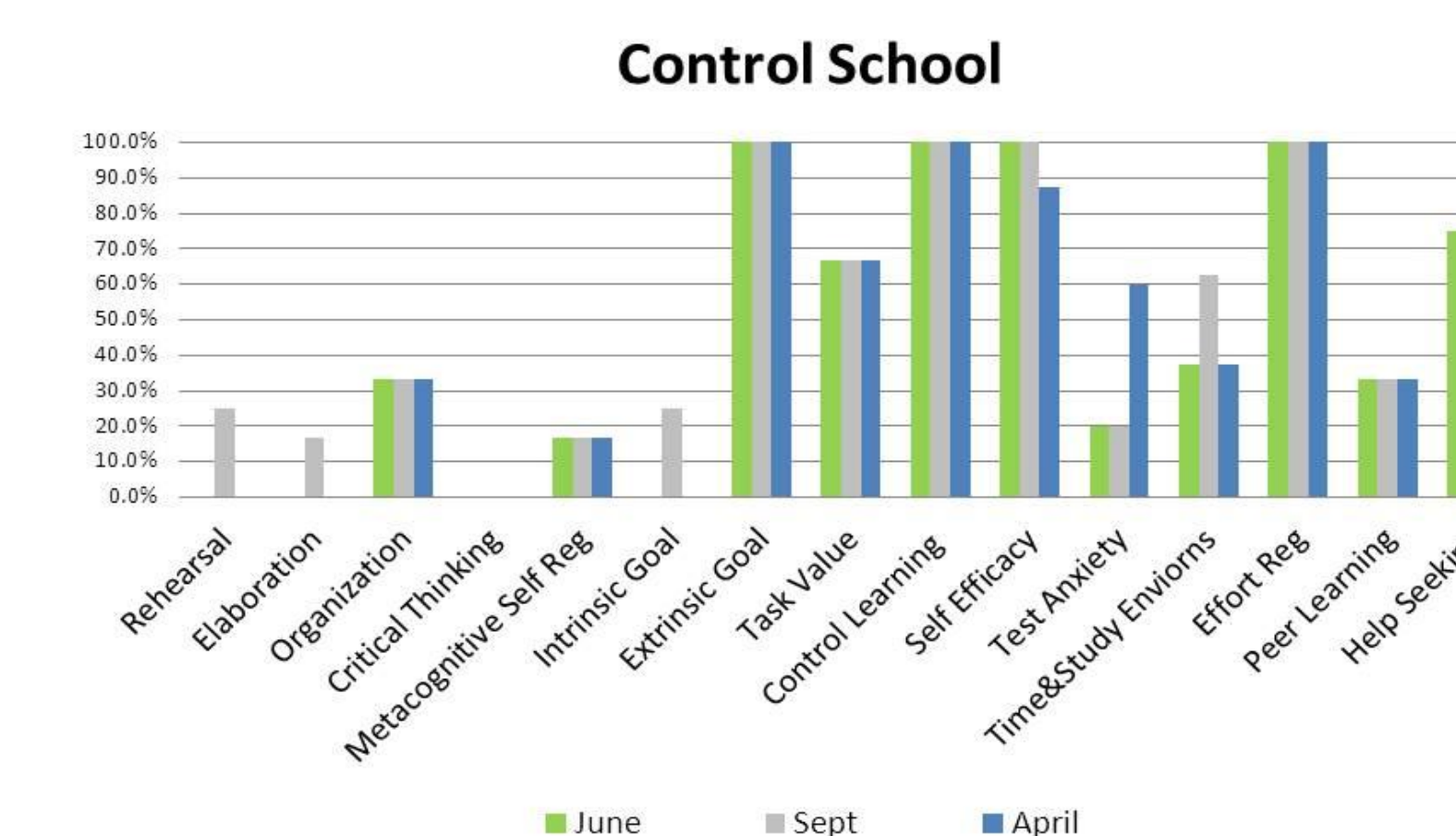


- Confirms the existing assumption that PBL increase the conceptual knowledge in mathematics.
- Contradicts the misconception. PBL benefits students from differing demographics (e.g., at-risk and race/ethnic minority students)
 - For white student population, further analysis needed.

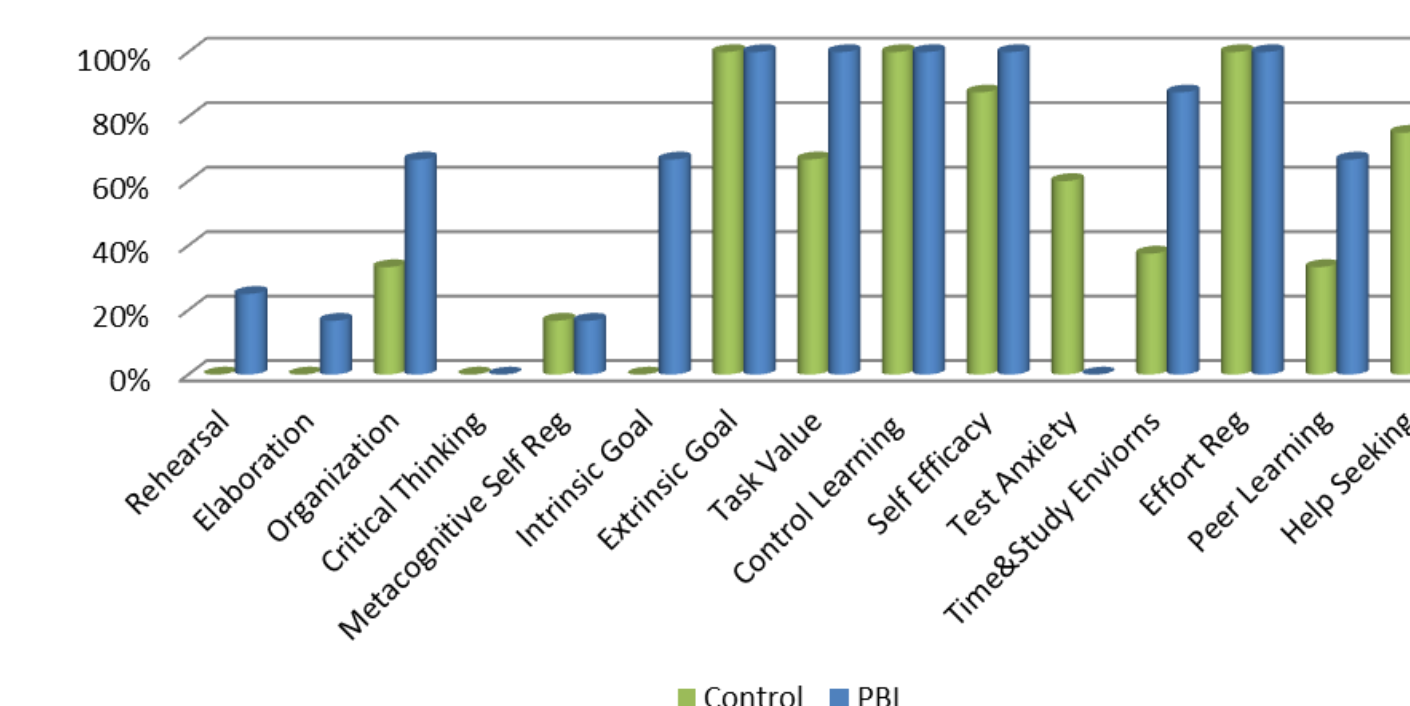
RESULTS



The comparison students showed two statistically significant changes during Phase I: Self-efficacy (from 99% to 87%); and Test anxiety (from 19% to 58%).



PBL vs. Control April 2012



Motivational factors cognitive, social and motivational

PBL students became more Intrinsically motivated (25% to 65%); showed that they believed they were in Control of their own Learning (75% to 97%); sought help from their peers; showed an appreciation for Peer Learning (35% to 65%); and became able to regulate their study Time and Study environment (75% to 85%).

- Responses of the PBL students are higher in Rehearsal (20% more), Elaboration (15% more), and Organization (30% more). Comparing learning motivations, the PBL students are strikingly more Intrinsically Goal Oriented (about 60%); and appreciate and value mathematics more (i.e., 33% more on Task Value).
- PBL students' expectation of success and judgment of their own ability (Self Efficacy in math) are 12% higher than the students in the comparison group.
- PBL students regulate their Time and Study Envs 50% more, appreciate working with peers 33% more, and exhibit Help Seeking 25% more. PBL students also show significantly lower Test Anxiety (55%).
- Both groups showed very low Critical Thinking and Metacognitive Self Regulation.

CONCLUSION

Our study confirmed the current research finding of the benefit of PBL in motivational factors in general. However, as there have not been many studies that explored the motivational aspects of mathematical pedagogy, we felt that we are in uncharted waters. This is a pioneering effort in assessing a mathematical pedagogy holistically. In an effort to understand what will motivate these students to enjoy and appreciate mathematics, and thereby pursue STEM career in the future, this study provides some directions. As the results showed, PBL motivated students to study more effectively, seek help from and work with peers, and appreciate the value of mathematics.

The findings of this PBL empirical research study will impact mathematics education and reform as a whole. First, the findings will generate knowledge that is necessary to transform the mathematics teaching practice, both in the targeted school studied and in the field at large. Specifically, the study gathers data to help educators and researchers determine whether PBL is a viable approach to innovate curricula programming for secondary mathematics teaching and learning. Secondly, through adopting the PBL pedagogy the achievement gap of minority and at-risk populations should decrease while the mathematics conceptual learning, problem solving and cooperative learning skills of these populations should increase. The findings can be also utilized in secondary mathematics education courses to train our future workforce.