

**Enhancing Self-efficacy through Problem-Based Learning Intervention across Agricultural Disciplines**

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### Introduction

Statistics holds significant importance in agricultural disciplines. Nevertheless, mastering statistics can be challenging, especially for students who have limited exposure before. In this pilot study, we introduce a teaching model for statistics that utilizes Problem-based Learning (PBL) along with specific instructional design strategies. We investigate the processes and outcomes of employing PBL approach in a statistics course offered within a higher education agricultural department. Our research seeks to address two primary questions. Firstly, does the implementation of Problem-based Learning have a positive impact on students' self-efficacy? Secondly, we aim to examine the relationships between motivation, self-efficacy, the influence of PBL, cognitive engagement, teaching support, and academic performance.

### Theoretical framework

Bandura (1977) defined self-efficacy as an individual's belief in their ability to successfully accomplish certain tasks. Students' self-efficacy beliefs can impact their learning behavior and outcomes (Hall & Vance, 2010; Jungert & Rosander, 2010). Some studies have suggested a link between self-efficacy and the elements of the Community of Inquiry (CoI) framework which consists of teaching presence, cognitive presence and social presence (Garrison et al., 2001). The framework is grounded in a collaborative constructivist viewpoint of education (Garrison & Archer, 2000, p. 11).

### Methodology

The intervention spanned two semesters and involved a total of 23 graduate students, consisting of ten in Spring 2023 and thirteen in Fall 2023, with a wide range of statistical backgrounds. The project utilized instructional design strategies such as problem-based learning, simulation-enhanced project-based learning, and a flipped-classroom approach. To assess the impact of the intervention, surveys and tests were administered before and after the intervention. The pre-survey included motivation (Pintrich & De Groot, 1990) and self-efficacy (Pathirage, 2015). The post survey included self-efficacy and the effects of problem-based learning (PBL) (Lee, 2010), along with cognitive presence, social presence, and teaching presence (Arbaugh et al., 2008).

### Findings

As shown in Table 1, the mean score on the self-efficacy pretest was 31.85 (SD=11.00), while the mean score on the posttest was 45.33 (SD=10.42). To assess the normal distribution of the data, the Shapiro-Wilk test was employed, revealing that the data did not significantly deviate from normality ( $p>0.05$ ). A paired sample t-test demonstrated a statistically significant improvement in students' self-efficacy in statistics following the intervention ( $t = 6.46, p<0.001$ ).

Table 1. Self-efficacy descriptive statistics.

	Number	Mean	S.D.
Self-efficacy pretest	23	31.85	11.00
Self-efficacy posttest	23	45.33	10.42

The correlation matrix in Table 2 reveals several significant correlations. Specifically, we observe the following statistically significant correlations: Cognitive presence exhibits a strong correlation with teaching presence ( $r=0.84$ ), impact of PBL ( $r=0.64$ ), pre self-efficacy ( $r=0.59$ ), and post self-efficacy ( $r=0.71$ ). Teaching presence is notably correlated with the impact of PBL

( $r=0.76$ ), pre self-efficacy ( $r=0.55$ ), and post self-efficacy ( $r=0.80$ ). The impact of PBL demonstrates a significant correlation with post self-efficacy ( $r=0.80$ ). Pre self-efficacy and post self-efficacy are moderately correlated ( $r=0.56$ ). These strong correlations among the key components of the community of inquiry, self-efficacy, and the impact of problem-based learning suggest a collective influence on the overall quality of the learning experience for students. Additionally, our findings highlight that academic performance is correlated with pre self-efficacy ( $r=0.51$ ) and teaching presence ( $r=0.41$ ), underscoring the importance of enhancing students' self-efficacy and implementing effective instructional design and facilitation to improve academic outcomes.

Table 2. Correlation matrix.

Variables	1	2	3	4	5	6	7	8
1. Cognitive Presence								
2. Social Presence	0.19							
3. Teaching Presence	0.84***	0.34						
4. Impact of PBL	0.64***	0.32	0.76***					
5. Motivation	-0.04	0.21	0.07	-0.04				
6. Self-efficacy(Pre)	0.59**	-0.08	0.55**	0.41	-0.17			
7. Self-efficacy (Post)	0.71***	0.15	0.80***	0.80***	0.03	0.56**		
8. Academic performance	0.24	-0.12	0.41*	0.14	-0.01	0.51*	0.28	

Note: \*  $p < .05$ , \*\*  $p < .01$ , \*\*\*  $p < .001$

### Conclusions

This research has demonstrated the effectiveness of a problem-based learning intervention on students' self-efficacy. Moreover, the study has unveiled noteworthy connections, including correlations between the essential elements of the community of inquiry framework, self-efficacy, and the influence of problem-based learning. Additionally, academic achievement has been found to be moderately associated with both pre self-efficacy and teaching presence.

### Implications/Recommendations

This study has uncovered two significant findings. Firstly, it has demonstrated the positive impact of problem-based learning interventions on students' self-efficacy in statistics learning. Secondly, through the strong correlations observed between cognitive presence and the impact of PBL, as well as between teaching presence and the impact of PBL, we have gained statistical evidence that highlights the crucial elements for effective instructional strategies. These findings offer valuable insights and guidance for designing effective statistics education in higher education, especially in agricultural disciplines. Furthermore, we have identified a significant correlation between post self-efficacy and the impact of PBL, which aligns with the effectiveness of the PBL intervention. Additionally, significant correlations have been observed between post self-efficacy and cognitive presence, teaching presence, and the impact of PBL. These correlations open avenues for exploring the causal relationship between students' self-efficacy and the components of the community of inquiry in future research. Future studies may delve into how teaching presence and cognitive presence can enhance students' self-efficacy. It is recommended to use larger sample sizes to replicate and validate these findings for future research.

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