PROBLEM-BASED LEARNING IN THE MATHEMATICS CLASSROOM

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Instructional practices over the years in mathematics classrooms have not varied significantly. In addition, they have not adequately aided students in developing a deep understanding of mathematical ideas. Mathematics education stakeholders continue to seek a methodology that will best educate learners of the 21st century since many students in the mathematics classroom are lacking in their ability to understand, communicate, and apply key concepts in mathematics (O'Brien, 1999; 2004). In an attempt to meet the needs of today's diverse learners, some national organizations are urging classroom teachers to use innovative methods of instruction that aid students in demonstrating comprehensive learning and apply it to real world settings (e.g., National Council of Teachers of Mathematics, 2000; National Science Foundation, 2006).

Education stakeholders are now placing an emphasis on students' ability to understand and use information, not just merely possess it (Richardson, 2003). According to many researchers and practitioners, problem-based learning (PBL) is an innovative inquiry-based, viable instructional approach for teaching mathematics that can aide students in reaching these significant learning goals (e.g., Erickson, 1999; Lubienski, 1999; Ronis, 2008). Consequently, the purpose of this study was to examine the perceptions of mathematics teachers of their PBL professional development and implementation of PBL into their classroom.

1 THEORETICAL FRAMEWORK

Problem-based learning has its roots in constructivism, but many of these views date back to John Dewey (1938). While PBL has a foundational framework in medical education, it is consistent with the principles of constructivism (Torp & Sage, 2002). In classrooms using

problem-based learning, teachers address these principles of constructivism, and Savery and Duffy (1995) have argued that PBL learning environments may be one of the best examples of a constructivist learning environment.

Research in PBL usually focuses on whether students who are taught with PBL learn as much as students who are taught with a traditional instructional approach (Gallagher & Gallagher, 2013). Research supports that students in PBL classrooms can learn as much as or more than students taught using a traditional method if the problems are closely aligned with content objectives (Gallagher & Stepien, 1996; Goodnough & Cashion, 2003). Students must also be provided with appropriate support (Hmelo-Silver, Duncan, & Chin, 2007; Vardis & Ciccarelli, 2008) for PBL to be effective. However, research specifically related to secondary school mathematics students or secondary mathematics teachers is scarce.

2 METHODOLOGY

Participants

The target population in this study was secondary mathematics teachers who had completed a PBL professional development workshop. This sample consisted of teachers who were members of the Problem-based Learning Network (PBLN) at the Illinois Mathematics and Science Academy (IMSA). PBLN provides professional development to PBL facilitators, who range in experience from novice to expert, on inquiry-based teaching strategies and skills. Teaching and facilitation experience are indicated in Figure 1. There were 75 secondary mathematics teachers who had gone through the PBLN training. All PBLN participants who responded to the survey were included in this study.

3 PROCEDURE

The sample consisted of 75 secondary school mathematics PBL facilitators, which revealed a 55%(n=41) response rate. All participants completed the standard demographic information (i.e. gender, age, in what state do you live, highest level of education, number of years teaching mathematic). The dat

a were analyzed using SPSS, version 21. As illustrated in Table 1, a demographic profile emerged from the survey sample indicating a heterogeneous sample in a number of categories (e.g., age, gender, education, teaching experience, and facilitator training).

Figure 1 – Teaching and Facilitation Experience of PBL Teachers.

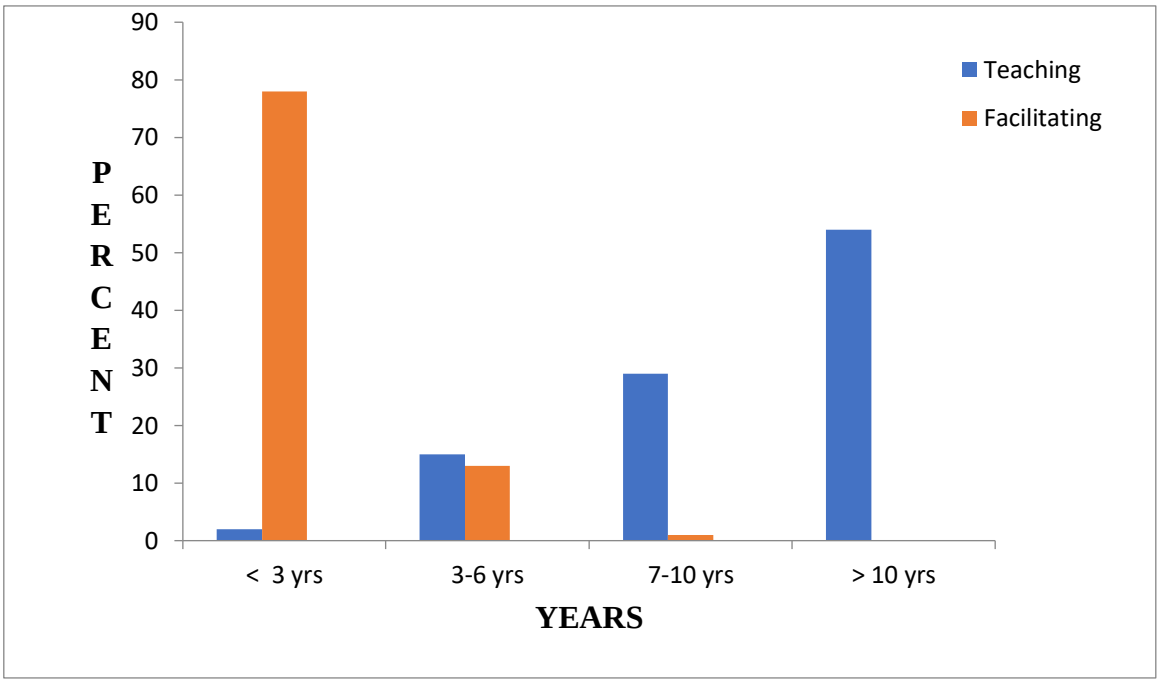

Table 1 – Survey Participants Demographics

Survey Item	Response	n	Percent
Teaching Experience	>10 years	22	54
	7-10 years	12	29
	3-6 years	6	15
	< 3 years	1	2
Facilitator Experience	>10 years	0	0
	7-10 years	1	3
	3-6 years	5	12
	<3 years	32	78
	Missing	3	7
Number of Problem Facilitated	< 2	19	48
	2-5	16	40
	>5	5	12
	Missing	1	3
Highest Level of Education	Bachelor's Degree	6	15
	Master's Degree	34	83
	Education Specialist Degree	1	2
Age	<40	13	32
	41-50	22	54
	>50	6	14
Gender	Female	27	66
	Male	14	34

4 RESULTS AND DISCUSSION

Research Question 1

Three questions on the survey focused on participants' perceptions of their PBL training. One question asked participants to rate their knowledge or understanding of the PBL philosophy, prior to PBL training. The responses to this question indicated that before PBL training, 7.5% (n=3) of the respondents rated their knowledge or understanding of the PBL philosophy as good or excellent. On the other hand, when asked to rate their knowledge or understanding of the PBL philosophy after PBL training, 80.7% (n = 32) of the respondents rated it as good or excellent. Forty-four percent (n = 17) agreed or strongly agreed with the statement: "I feel/felt confident before facilitating my first session," but an equal percentage (44%) of participants (n = 17) were not sure or disagreed with this statement. Also, two participants chose not to respond to this statement.

The next survey questions were used to gather responses on participants' perceptions on

Also, less than half (47.5%) of the participants (n = 19) agreed that their first experience facilitating was a success, and an equal percentage (47.5%) of participants (n = 19) felt confident after their first facilitation experience. Once the participants facilitated one theme, 65% (n = 26) agreed or strongly agreed that the PBL training made more sense in terms of understanding the role of the facilitator in small group learning sessions, and only 5% disagreed (n = 2).

Research Question 2

Research question two addressed whether there were any differences in the perceptions of roles and responsibilities among secondary mathematics PBL facilitators with different levels of facilitation experience (i.e., novice, intermediate, advanced, and expert). To determine if there were mean differences between the novice and advanced, secondary mathematics PBL facilitators on their *roles* scores, the ANOVA test was conducted. The mean *roles* score in the novice group (M = 3.33, SD = .44) was slightly lower than the mean *roles* score in the advanced group (M = 3.39, SD = .08). The results of the ANOVA test revealed $F(1, 38) = .22$, $p = .64$. Although the mean score for the advanced group was larger than the mean score for teachers in the novice group, the results indicated that there were no differences in the perceptions of roles and responsibilities among secondary mathematics PBL facilitators with different levels of facilitation experience (i.e., novice and advanced). At an alpha of .05, this finding supports that

there is no statistically significant difference between mean *roles* perception scores of novice and advanced secondary mathematics PBL facilitators. The effect size statistic, eta-squared, revealed .0056, which indicates a very small effect based on Cohen's (1988) guidelines. However, this value indicates that .56% (less than 1%) of the variance in the *roles* score can be explained by facilitation experience (number of problem scenarios facilitated).

Research Question 3

Research question three addressed whether there were any differences in the perceptions of the skills needed for effective implementation of PBL among secondary mathematics PBL facilitators with different levels of facilitation experience (i.e., novice and advanced). Like the previous research question, analysis of variance (ANOVA) was used to answer this research question. At an alpha of .05, this finding supports that there is no statistically significant difference between the mean *skills* perception scores of novice and advanced secondary mathematics PBL facilitators. The effect size statistic, eta-squared, revealed .0411, which indicates a small effect based on Cohen's (1988) guidelines. Given the small effect detected, it is possible that the sample size in this study might have influenced the results.

Research Question 4

Research question four addressed the challenges secondary school mathematics, PBL facilitators perceive they encounter while they are planning for and implementing PBL into the classroom. Twenty-five participants responded to the invitation to comment on this open-ended question: Describe any challenges and/or frustrations you have experienced in the PBL facilitation process. The most frequent comments were related to challenges concerning the roles of a facilitator. Thirteen participants commented on the difficulty and challenge of their roles. For instance, this is how one participant described the issue: "The students have had little experience of working together in a group. The process of trying to teach them how to work together while doing the problem was very difficult." At the same time, another participant explained that with time they improved in the role of facilitating the small group learning process. Specifically, the participant stated, "I am always working on the group dynamics. I am getting better at teaching students how to work in groups." These and other comments indicated that a diverse group of facilitators viewed the same roles as a challenge.

In general, facilitators indicated that they face a number of challenges, many of which describe the discomfort with their role. The level of discomfort seemed to vary from facilitator to facilitator. Time, curricular, and resource constraints were also perceived as challenges, though of a lesser magnitude than facilitators' discomfort with their roles. The open response question on the perception of facilitators' PBL implementation challenges suggests that challenges vary among participants with the roles of the facilitator mentioned most often as a significant challenge. The responses from this open-ended question seemed to support the results from the closed response questions.

5 IMPLICATIONS

With minor revisions, the *Facilitator Perception Survey-Revised* may be useful in other secondary education content areas using the PBL approach. It is applicable for new facilitators, practicing facilitators, individuals considering PBL facilitation, and researchers. The survey and the findings of this research also have practical implications for teacher educators involved with teacher development in secondary education. Barrows (1994) argued that the training of the PBL facilitator impacts the success or failure of PBL. Individuals designing learning experiences for facilitator training workshops may find this instrument useful as a vehicle to examine facilitators' perceptions. It may serve as a tool to engage workshop participants in activities to stimulate discussion on PBL issues. It can also be used as a self-evaluation tool. This may also increase self-awareness of a commitment to the PBL model that may benefit professional development programs and individuals.

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