CHAPTER 10

PROBLEM-BASED LEARNING

Teachers Who Flourish and Flounder

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This essay explores problem-based learning (PBL) by analyzing case study data from two teachers at a public high school. The purpose of this study is to explore teachers’ facilitation of the classroom learning environment during PBL instruction. Data included observations, interviews, and a card sort activity. Achievements and obstacles with PBL implementation are described. Findings reveal that teachers must guide motivation, facilitation, collaboration, and reflection in order to flourish when implementing PBL.

INTRODUCTION: TWO CONTRASTING TEACHING EXPERIENCES

“Good afternoon students,” said Dana as she greeted her biology students at the door. Students energetically entered science class to start a new problem-based learning (PBL) unit on classification of kingdoms. She began this PBL lesson by explaining that, during the next 2 weeks, students would be assuming the role of an ecologist to determine how organisms should be classified. Students quickly identified several topics of interest they wanted to research and were subsequently provided with a
A research guide to assist with acquiring relevant information. When Dana noticed several students struggling with conceptual issues, such as understanding the ecological role of consumer, producer, and decomposer, she facilitated a short 10-minute lecture to help aid student comprehension. Dana then circled the room. After a few minutes of independent problem solving, she approached groups to entertain questions. She answered one question at a time and spent only a few minutes with any one group. If groups had follow-up questions, she would state, “discuss together and I will circle back around in a few minutes.” By the time she came back to the group, students often had answered their follow-up questions themselves. Dana ended PBL lessons with closing discussions that provided opportunities for students to reflect on problems.

Just down the hall from Dana, Emma sat at her desk getting organized as students congregated around the hallway outside her classroom. Like Dana, Emma also taught high school biology in the same school. Shortly after the bell rang, Emma explained to students they were going to work in groups. At first, students seemed excited about learning in groups. Emma distributed a problem for students to read. As students tried to make sense of the problem, Emma sat down with one of the groups and provided assistance for nearly five minutes before moving to a second group. After helping the second group, Emma held a whole-class discussion explaining the problem students were to investigate, identified what students needed to research, and distributed research guides. Next, she sat with one group for an extended time and explained conceptual issues. She neglected several other groups of students while helping the one.

Dana and Emma both flourished and struggled, but to varying degrees, when using PBL instruction. PBL has gained popularity in school curriculum as a means of increasing student gains in cognition and developing critical thinking skills, fostering independent learning, cooperation, and motivation (Chiappetta & Koballa, 2006; Smith, 1995; Sonmez & Lee, 2003). Canadian medical schools are given credit for the modern origin of PBL (Savery, 2006). About 35 years ago in Hamilton, Ontario, McMaster University Medical School pioneered the use of case study teaching, also known as PBL. The benefits of this pedagogical approach inspired other medical schools in the United States and abroad to modify curriculum to include cases that focus on real patient problems (Herreid, 2003). The success of PBL in the medical school environment led educational researchers to study and implement this teaching strategy in the K-12 school setting (Ertmer & Simons, 2006).

Despite encouraging studies on the effectiveness of PBL with K-12 students, widespread implementation of PBL by K-12 teachers has not occurred (Ertmer & Simons, 2006; Wang, Thompson, & Shuler, 2007).
The reason may be because teachers often experience challenges when attempting to facilitate PBL (Barron et al., 1998). Thomas (2000) and Hmelo-Silver (2004) both comment on the need for more PBL research in K-12 education. Hmelo-Silver recommends conducting empirical studies that inform educators about adapting PBL in the secondary curriculum, and recent research has begun to address PBL in the K-12 setting (Wirkala & Kuyn, 2011). To implement student-centered instruction like PBL, teachers must effectively facilitate the classroom learning environment, which entails overcoming pedagogical obstacles and identifying achievements in order to maximize learning. The purpose of this study is to explore teachers’ facilitation of their classroom learning environment during PBL instruction. The main research question is: Why might teachers experience pedagogical achievements and obstacles while facilitating PBL instruction?

PBL: KEY COMPONENTS

Hmelo-Silver and Barrows (2006) define PBL as “an active learning method based on the use of ill-structured problems as a stimulus for learning” (p. 24). During PBL instruction, small permanent groups of students work with a teacher (Herreid, 2003). The teacher facilitates instruction and diagnoses student understanding, conceptual thinking, content knowledge, and interactions during activities. The teacher’s primary role as a facilitator of PBL instruction is to assist students in collaborative knowledge construction by scaffolding problems and questions to support metacognition and reflection. Facilitative teaching is achieved by modeling problem-solving processes, encouraging self-regulated learning, and coaching through effective questioning strategies (Hmelo-Silver & Barrows, 2006).

Hmelo-Silver (2004) identifies four main components of PBL instruction: motivating students through the problem/case, guiding students through pursuit of information, fostering collaborative learning, and supporting student reflection. Generating and presenting the problem is critical to successful implementation of PBL. When presenting the case, students should engage in real world problem solving. For example, over the course of the 20th and 21st centuries, biologists have reconsidered how to classify organisms based on information that became available through new technology. Early scientists proposed a three or four kingdom classification system prior to the more current six kingdom structure; however, some scientists support a radical restructuring of classifying organisms. Another significant consideration when presenting the prob-
lem is to highlight the relevance of the problem to the learner, not simply
to provide key information.

The most critical component is the facilitator’s role of emphasizing
learning through problem solving. Outstanding facilitators are expert
learners who model good learning and thinking strategies. They move
their students through problem-solving stages while monitoring progress
for involvement in critical thinking. These teachers probe for students’
knowledge by asking metacognitive questions such as “Why?” “What do
you mean?” “How do you know that’s so?” rather than scaffolding the stu-
dents to the “right” answer through logical questioning. The best facilita-
tors make quick decisions in support of PBL goals, model problem-
solving processes and self-regulation skills, challenge students to think,
and help students learn to effectively collaborate (Hmelo-Silver, 2004;
Savery & Duffy, 1995).

Collaborative learning occurs when group members distribute the cog-
nitive work and participate in discussions, thereby promoting shared
knowledge construction and enhancing higher order thinking and prob-
lem-solving skills. Johnson and Johnson (1999) define cooperative learn-
ing as a group of students working together to accomplish shared goals.

The final component of PBL instruction, reflection, is key to support-
ing the construction of extensive and flexible knowledge by helping stu-
dents “(a) relate their new knowledge to their prior understanding, (b)
abstract knowledge mindfully, and (c) understand how their learning and
problem-solving strategies might be reapplied” (Hmelo-Silver, 2004,
p. 247). Reflection should be an ongoing activity through PBL instruction
and ideally increases students’ ability to transfer knowledge.

RESEARCH APPROACH

PBL Workshop Experience

Both Dana and Emma took part in a PBL workshop offered as an
extension program at a major university in the southeastern United
States. The purpose of the workshop was to train teachers in the PBL
method so they could facilitate PBL. During the workshop, instruction
focused mostly on teachers implementing and writing PBL cases aligned
to state science standards. Workshop facilitators provided recommendations
for classroom management techniques when facilitating PBL. In
order to produce student-generated questions that match state standards,
facilitators also explained that a sound design is dependent upon the
quality of the problem presented to students.
During the workshop, teachers also learned about PBL by participating in several PBL activities. After experiencing PBL as a learner, participants observed a veteran PBL facilitator perform a PBL lesson with high school students. Participants then formed small groups and designed a PBL lesson. The following day, participants taught their PBL lesson to a group of high school students. Each activity was followed with a whole class discussion.

Description and Context of Teacher Participants

The participants in this study were selected based on purposeful and convenience sampling related to their expertise and competence (Merriam, 1998). To establish teacher expertise and competence in teaching PBL instruction, the selection criteria for this research project included secondary science teachers with at least 3 years of teaching experience, degrees in science education, and state licensure. In addition, the teachers completed the PBL workshop training. This case study research consisted of two secondary science teachers and was part of a larger comprehensive study on PBL instruction. Dana had more than 4 years of experience facilitating PBL, and Emma had 2 years of experience facilitating PBL.

Dana had secondary teacher certification in biology and a BS in biology education. Dana’s science experiences were limited to her undergraduate laboratory classes, as she did not have any practical experience working as a scientist. She graduated with honors and immediately accepted a science teaching position in the same school as her student teaching assignment. At the end of the eight years of teaching, Dana took 5 years off to raise a family. She had been teaching for the last 8 years at her current high school. In total, Dana had 16 years of experience teaching pre-biology, biology and honors anatomy.

Emma had a BS in biology and education, lateral entry provisional secondary teacher certification in biology and chemistry, and a PhD in biomedical science. Upon completion of a doctorate, Emma worked in a research laboratory for 17 years. Thus, she possessed considerable practical experience working as a scientist. She completed her teaching certification out of state and let her teaching license expire while working as a research scientist. At the time of this study, she was completing her third year of teaching. During those years, she taught prebiology, biology, honors biology, chemistry, and honors chemistry. When the 2008-2009 school year ended, Emma was eligible for a standard provisional license to teach biology and chemistry.
Data Collection

A qualitative interpretive case study approach exploring the lived experience (Merriam, 1998) informed the design of this study. Yin (2003) defines case study as the most effective way to identify, document, and explore the pedagogical practices of teachers by providing an approach to study, observe, and analyze the classroom’s complex learning environment. Data collection consisted of semi-structured interviews, a card sort activity in which participants categorized instructional outcomes, and observations during PBL implementation. The goal of this study was to identify the achievements (events of desired learning), and obstacles (events that interfered with or restricted learning). Desired teaching and learning achievements and obstacles were determined by data gathered from interviews, approximately forty 50-minute classroom observations, and the card sort activity. Prior to teaching, the two participants answered interview questions that focused on the anticipated achievements and obstacles with facilitating the PBL unit. Researchers recorded in field notes observations of achievements and obstacles. At the end of each teaching event, participants recorded these achievements and obstacles on three-by-five index cards. After teaching the PBL unit, participants met individually with the researchers and grouped their index cards into major or minor events and then categorized the cards. In 45 minute post-interviews, participants answered questions that focused on the achievements and obstacles. After data analysis (using the constant comparative method of inductive analysis with respect to the teacher’s role in the four main components of PBL instruction), participants were provided with a draft analysis to review and provide comments.

FINDINGS

Hmelo-Silver’s (2004) four main components of PBL instruction—motivating problem/case, teacher as facilitator, collaborative learning, and reflection—provide the framework for interpreting the data.

Dana

Dana encountered challenges and also found success in implementing PBL. While teaching the PBL instructional unit, Dana compiled a list of instructional outcomes combined during the card sort activity as achievements and obstacles. She attributed major achievements mostly to reflection and major obstacles to administration. In general, Dana modeled
problem-solving processes by scaffolding the PBL process in prior lessons. She also facilitated class discussion by providing analogies, such as the organization of a grocery store, to help students understand classification of kingdoms. Furthermore, Dana encouraged self-regulated learning by purposefully moving from group to group and asking “Why?” and “What do you think?” Dana encouraged students to explore possible answers, thus becoming a “supportive coach” (Hmelo-Silver & Barrows, 2006).

As students directed more of their learning, student engagement was observed to increase. According to Dana, high engagement was related to student motivation to actively participate in solving the problem by organizing organisms on their own in different ways (interview, May 15, 2009). Dana used a few techniques to help students stay focused on learning. She gave time limits with reminders, was specific about expectations, and continuously moved around the classroom. At different times during the PBL unit, Dana used the role of students as taxonomists to engage students through personal relevance. Later in the lesson, students were asked to compare their organism classifications to the two actual taxonomists in the PBL. Dana commented that a couple of apathetic students lacked motivation regardless. She also noted that some students lacked continuous focus, which was normal for these learners (interview, May 15, 2009).

Student ownership of learning was evident in Dana’s facilitation of the PBL unit. For about 10 to 15 minutes at the beginning of each problem, Dana gave a little assistance as she walked around the room. She smiled, gave encouragement and stated that she would be back to answer just one question. Dana spent each day of the PBL instruction walking between groups, thus varying her proximity and availability for student questions. Dana carried with her a clipboard and paper for taking attendance, recording notes, and formatively assessing student understanding. When circling the room and helping individual groups, Dana spent short amounts of time with each group and did not allow any one group to dominate her time. When asked how she facilitated a good flow between groups, Dana remarked:

> You have to honor and answer that first question; if they have another one, you go, “ok, you guys think through that one.” You have to get around to other groups. If you stand there forever you’re going to answer every question they have, and then they’re not doing anything. So they realize that I’m not going to answer every question they have; that they’ve got to think. (interview, May 15, 2009)

By giving students merely enough help to “push through so that they don’t get too frustrated and give up” (interview, May 15, 2009), Dana shared the direction of learning with students while encouraging student ownership of learning (Ertmer & Simons, 2005).
Dana served a coaching role by tolerating some off-task behavior and working patiently to help students refocus on learning by using strategies such as increasing her proximity to off-task students, questioning off-task students about their work, and providing new information to keep groups challenged. Formative assessment of student understanding led her to conclude that students were progressing steadily in small groups and that whole class discussion was not necessary. Dana kept observational data to help facilitate student learning. Assessment helped her to know when to provide a short mini-lecture. When asked how she knew when to provide groups with assistance, she commented:

Look at their faces. Look at how they’re interacting with each other and you know they quit [stopped working on the task]. That’s the group you need to go to next. You can’t be at all groups at one time, so you have to read their body language, and it’s not something you can explain because it’s something a teacher knows. (interview, Mary 15, 2009)

Dana established a good rapport and trust with her students, thus allowing them to share control of the learning environment (Ertmer & Simons, 2005). Students self-selected cooperative groups and worked collaboratively on the PBL. She believed students skillfully worked through the problem by using provided resources. Dana remarked, “students participated who usually did not” and “they liked using the pictures” (interview, May 15, 2009). When an absent student returned to class, fellow group members explained the missed material.

Student reflection for this PBL occurred mostly during small group and a few times with the whole class. Dana remarked, “I didn’t think this PBL centered on let’s all stop and talk about where we are. Sometimes it’s good to stop and talk about where you are, but this time it’s not. I didn’t feel like it.” Dana commented that higher order thinking occurred during the lesson because “students knew the difficulty of designing dichotomous keys.” A dichotomous key is used to classify organisms by presenting two characteristics until species are identified. Student reflection also occurred when discussing the problem and applying learned information for the final assessment product (interview, May 15, 2009).

On the whole, Dana flourished, but she also struggled in certain areas. Mandated curriculum presented obstacles for her. Dana saw administrative support as critical for successful implementation of PBL commenting, “administrators need to be OK with noise.” She believed that administrators could have done more to reconcile students’ social issues outside of class, which negatively impacted a few students’ ability to work in collaborative groups. Dana labeled as a minor obstacle the county mandated pacing guide, which did not allow enough time to adequately implement PBL lessons. Dana found it challenging to narrow down the PBL to be
“doable for students in the short period of time allotted in the pacing guide” (interview, May 15, 2009).

Emma

On the whole, Emma experienced more challenges than achievements in implementing PBL. Emma’s PBL unit stands in sharp contrast to Dana’s even though she taught just down the hall. Emma attributed her major achievements to motivation and the majority of her minor obstacles to administration. Interestingly, Emma did not list any obstacle as a major impediment to PBL instruction. Emma did not model problem-solving processes, had mixed results with self-regulated learning by ignoring certain groups, and frequently neglected effective questioning strategies (Hmelo-Silver, 2004).

While overall student engagement was observed to be low, individual student engagement varied during the PBL. Two students exhibited high engagement during the entire PBL. Emma noted that most students were more motivated working in groups in this PBL than doing bookwork; however, at any one time, the number of students actively engaged in learning was less than half the class. Several students exhibited moderate engagement when Emma visited their small group, but they did not sustain that level at other times. Emma tried to use personal relevance by reinforcing their roles, telling students, “Well you’ve got this deadline, remember. You want to impress your new boss.” Rather than ask questions, she tended to give subtle threats. Other students, with whom Emma had a strained student-teacher relationship, exhibited even lower levels of attentiveness. One student was not engaged during the entire PBL lesson; he sat in a chair and rested his head on the desk the entire week. Emma attributed some students’ lack of motivation to students’ lack of desire to learn and “giving up and deciding not to try because they do not have support to get an education” (interview, May 15, 2009).

Emma provided students with an opportunity to take partial ownership of their learning, and about half of her students accepted this responsibility (Ertmer & Simons, 2005). She provided students with instructions and let them work in their groups for about 10 minutes while she tended to other duties. One or two students would take the lead and do most of the work on the assignment. Emma thought students directed the learning “because they have a lot of freedom.” While students were working on the PBL lesson, Emma attempted to guide students by asking questions. Emma’s confrontation with students contributed to further obstacles. Emma unevenly distributed her time between groups by providing some groups with more attention than others. As a facilitator of student learning, Emma
mentioned not being as prepared to teach the lesson as she should have been (interview, May 15, 2009).

Emma thought that since the PBL provided students with choices, students were in control of the learning environment. However, Emma tried to control other aspects of the learning environment. She assigned student groups, organized where students should sit on different days, and directed most aspects of the learning environment. A few days into the PBL, some students remarked that they “liked working in groups instead of copying notes.” Emma thought that in general students performed at a satisfactory level when negotiating in groups because there were not any quarrels. Emma admitted having “not fostered a culture that encourages students to work well together” (interview, May 15, 2009).

Not having much opportunity to develop cooperative learning skills, reflection was challenging for some students. Emma ranked thoughtful discussions and higher order thinking as major achievements. She commented that students engaged in thoughtful conversation and grasped the complexity of classifying living organisms. Observations revealed a few students reflecting when Emma directed their discussion. Student reflection when Emma was not involved, however, was extremely limited.

Emma believed she and her students faced challenges because they did not have the support of school administration. She cited her lack of backing in dealing with “a difficult mix of students in one period” (interview, May 15, 2009). When asked about the student who refused to participate, Emma blamed the administration stating that he had issues, and in her opinion, had given up on school. She went on to explain that both social and cognitive complexities compelled administrators to switch the student between three different biology teachers during the school year. Additionally, Emma noted that there was not enough time to fit PBL into the county pacing guide. Despite student comments to the contrary, she believed students simply preferred bookwork with right and wrong answers. Emma also thought that PBL required students to have writing skills beyond their ability level (interview, May 15, 2009). Emma tended to flounder more than she flourished. In general, she faced more obstacles when implementing PBL than achievements.

Cross-Case Analysis

Throughout the PBL unit, Dana and Emma reinforced the notion of students taking on the role of taxonomists. Thereby, attempting to motivate students through personal relevance. While Dana did so in an encouraging manner, Emma did so in a more intimidating way. Dana maintained a positive rapport with students; they were motivated to perform for her. In
contrast, Emma’s negative relationships with her students interfered with their PBL engagement, as students who were initially excited to be learning through PBL lacked motivation after being confronted by Emma about non-academic issues. Dana’s students were more consistently on-task and working on the problem; Emma’s students were less engaged. Differences in facilitation of the PBL may have contributed to the varied engagement levels of students. Often differences, such as classroom dynamics, are also contributing factors to student engagement. However, a comparison of problem-solving, self-regulated leaning, and questioning strategies led to noticeable differences in these two PBL facilitations (Hmelo-Silver, 2004).

Dana promoted student-ownership and inquiry by allowing students to direct more aspects of their learning. She had a strategy for giving students little assistance during the beginning of the lesson and limiting the time she spent with each group throughout the lesson. By circulating continuously between groups, Dana maintained student focus. Emma, on the other hand, had no discernable strategy for facilitating the PBL lessons. She allowed a few groups to dominate the majority of her time and consequently ignored the other groups in the process. Having anticipated student responses, Dana was prepared to assist small groups; however, Emma admitted to not being prepared to facilitate the PBL unit.

Both Dana and Emma placed students into cooperative learning groups to work through the PBL unit. Each also had the CHAMPS (conversation, help, activity, movement, participation, and success) system in place. CHAMPS encouraged a classroom culture for cooperative learning through positive interdependence, individual accountability, face-to-face promotive interaction, social skills, and group processing. Dana used the CHAMPS system with students during lessons preceding the teaching of the PBL unit. With a few exceptions, student groups were supportive, responsible, and invested in learning throughout the PBL unit. Despite also having a CHAMPS poster on the wall, Emma had not reinforced student expectations for learning and had no established routine for learning in cooperative groups. Positive interdependence and individual accountability were less evident as one or two students in a group tended to do the majority of the work. Face-to-face promotive interaction was only apparent among students doing the work, as these students appeared disinterested in their classmates’ success. Emma had not assisted students with building social skills and group processing abilities.

Opportunities for students to reflect existed throughout the PBL unit as each problem required students to apply and transfer knowledge. A few times during instruction, Dana facilitated a whole class discussion by helping students to relate new knowledge (i.e., scientific classification) to prior understanding (i.e., organization of items in a grocery store). Emma’s class discussion consisted of providing information to students.
Dana’s students contributed to ongoing reflection throughout PBL instruction whereas Emma’s students were less collaborative. Additionally, Dana’s groups presented their final performance assessment to the entire class while Emma’s students submitted artifacts to her at the end of the unit.

**DISCUSSION**

According to Hmelo-Silver (2004, p. 244), facilitating PBL instruction involves four main components—motivation, facilitation, collaboration, and reflection. Effective teachers ensure that students are motivated by the learning, coached through effective questioning strategies, invested in their own and other group members’ success, and required to be reflective throughout PBL instruction. Dana and Emma are two teachers who provide insight into effective facilitation of PBL. Several factors could have contributed to the different outcomes in Dana’s and Emma’s classrooms. Prior teaching experiences with PBL instruction, an authoritative classroom management, previously established inquiry classroom culture, and beliefs about the nature of teaching and learning may attribute to flourishing or floundering with a PBL lesson. However, the difference in part, can be attributed to the critical components of PBL instruction. Dana guided student motivation, facilitation, collaboration, and reflection more effectively than did Emma.

Motivation in PBL is a complex issue. Selecting a problem that engenders student ownership is one key to student motivation (Ertmer & Simons, 2005). This study suggests that highlighting a scientific role for students to assume motivates student learning. Likewise, positive student-teacher relationships play an important function in motivating students through PBL (Pecore, 2009).

Facilitation of the PBL environment involves fundamental changes to directing student learning in the classroom. Student activities must be structured and carefully monitored through PBL stages to facilitate success and meaningful learning (Mergendoller, Maxwell, & Bellisimo, 2006). Techniques that support effective PBL facilitation include circulating between groups, limiting the amount of time with any one group to a few minutes, and knowing when to stop the lesson and facilitate a short lecture or class discussion. By anticipating student needs, teachers can become skilled at asking and answering thoughtful questions (Mergendoller, Maxwell & Bellisimo, 2006; Wang, Thompson, & Shuler, 2007).

Creating a collaborative classroom culture is an important part of PBL learning environments (Hmelo-Silver, 2004) and students need opportunities to develop and practice collaboration skills (Ertmer & Simons, 2005).
Productive collaboration among students requires the support of teachers. Students need teachers to provide a structure for fostering positive interdependence, individual accountability, face-to-face promotive interaction, social skills, and group processing within the PBL environment.

PBL requires teachers provide opportunity for reflection of both content and process (Savery & Duffy, 1995). Students also should reflect on new knowledge (Savery, 2006). Since most learners are not automatically reflective, teachers must provide guidance and support through the use of generic prompts (Ertmer & Simons, 2006). Promoting reflection can occur through journals, small group conversations, and class discussions.

Teachers using a PBL approach experience a variety of achievements and obstacles. Some obstacles attributed to school administration include constraints with time, county mandated pacing guides, and end-of-course tests. With a supportive administration, these obstacles can be managed. Achievements will result, and obstacles will be overcome by expertly implementing the PBL method. A suitable problem, positive student-teacher relationships, and focused checkpoints can provide the necessary motivation for student learning. Carefully monitoring and skillfully guiding student progress seem to be essential for facilitating PBL lessons. Productive collaboration of student groups requires structure and accountability. Since reflection is not automatic, teachers need to provide assignments and have discussions with students which foster thinking about knowledge gains.

REFERENCES


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