2003

Problem-Based Learning in a Fourth Grade Gifted and Honors Mathematics Class

Barbara J. Barr
Central Washington University

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PROBLEM-BASED LEARNING
IN A FOURTH GRADE GIFTED AND HONORS
MATHEMATICS CLASS

A Project
Presented to
The Graduate Faculty
Central Washington University

In Partial Fulfillment
Of the Requirements for the Degree
Master of Education
Master Teacher

by
Barbara Barr
July, 2003
Problem-Based Learning in a Fourth Grade Classroom

by

Barbara J. Barr

July, 2003

Problem-based learning was used to deliver math instruction on three different occasions. Thirty-two fourth-grade students were involved in the project. The purpose was to investigate students' attitudes towards word problems and the development of their confidence with problem-solving skills by providing differentiation through Problem-based learning. The results showed that the majority of the students perceived themselves as good problem solvers and that math in school was related to real life.
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CHAPTER 1

BACKGROUND OF THE PROJECT

Introduction

Problem-based learning was originally developed as a tool to promote learning in medical schools. Students were given experiences in handling real-life situations involving the diagnosis and treatment of case study patients (Evensen & Hmelo, 2000). In recent years problem-based learning (PBL) has become more prevalent in elementary and secondary schools as a means of increasing student performance and emphasizing higher level thinking skills (Delisle, 1997). According to Gallagher and Gallagher (1994), skills including analysis, synthesis, and evaluation can be developed through differentiation. When PBL is used for differentiation, it is done by introducing content specific problems or dilemmas that require students to move beyond their traditional methods of thinking. They become researchers and must bring resolution to the problem in a meaningful way (Lambros, 2002).

In 2000, The National Council of Teachers of Mathematics (NCTM) published Principles and Standards for School Mathematics. It emphasized problem solving, stating problem solving is integral to learning
mathematics and it should not be taught as an isolated skill. PBL offers students the opportunity to use their higher level thinking skills to solve involved problems that integrate problem solving and content skills in real world problems (Gallagher, 1997).

Purpose of the project

The purpose of the project was to investigate students' attitudes towards word problems and the development of their confidence with problem-solving skills by providing differentiation through PBL. Traditionally, students struggle when trying to solve word problems. Even the brightest students claim that they do not know where to start. In an ideal program there would be development of concepts and operations "embedded in networks of knowledge structured around key ideas and taught within an application context" (Good & Brophy, 2000, p.434-435). This project provided a foundation of skills for students to use when they were asked to solve more complicated problems. Skills learned during problem-based investigations helped students relate math to the real world and become more confident problem solvers. This is one of the primary functions of problem solving according to NCTM (2000).
Significance of the project

Teaching a fourth grade gifted and honors math class can be challenging. According to the California Math Content Standards, elementary teachers are required to teach numerous math content standards with the idea that all children will master them by the end of the year (2001). Clark (2002) states that parents of gifted children have high educational expectations for them. In essence, they want their children to experience learning that takes them above and beyond the traditional curriculum and turns them into thinkers, problem solvers, and life-long learners. Galbraith stated that gifted students want their learning to be challenging and interesting (as cited in Gallagher & Gallagher, 1994). Well-constructed PBL lessons that are embedded in the content, require students to stretch their minds beyond what is on the paper, and are formulated around situations that students will find engaging (Delisle, 1997; Lambros, 2002). This is different from the traditional problem solving lesson where the teacher provided problems for students to solve that are well-structured and require them to use algorithms and formulas they already know. This teaches problem solving
as an isolated skill. At issue, however, is the idea that teaching isolated problem solving skills is not enough (Good & Brophy, 2000). It is necessary to teach problem solving in a way that enables students to develop new strategies that can be utilized in new situations (Heibert et al., 1997; NCTM, 2000). This is possible when problem solving is integrated into the content.

Limitations of the Project

The subjects in this project were a homogeneous group of fourth-grade high achieving and gifted students. The sample size was relatively small. Q-sort statements twenty and thirty were not clearly written and therefore could have been confusing to the subjects when participating in the Q-sort.

Definition of terms

*Problem-based learning:* a method based on the principle of using ill-structured problems as the starting point for the acquisition of new content knowledge (Lambros, 2000).

*Q methodology:* a method for the scientific study of human self-perceptions that is based on statistical factoring in order to groups subjects according to descriptors that are determined by the researcher (McKeown & Thomas, 1988).
Differentiation: the modification of curriculum content, process, and products to meet the needs, abilities, and interests of the student (Clark, 2002).

Gifted: a high level of intelligence that indicates advanced and accelerated brain functions (Clark, 2002), including rapid cognitive development and an extensive knowledge base (Gallagher & Gallagher, 1994).
CHAPTER 2

REVIEW OF THE RELATED LITERATURE

Introduction

The review of the literature is organized into six different areas including: 1. the definition of problem-based learning (PBL), 2. the history of the development of PBL, 3. the benefits of PBL, 4. PBL in Gifted education, 5. the potential drawbacks of PBL, 6. conclusion of the related literature

Definition of PBL

In order to clearly define PBL, it is important to emphasize its central governing principle. Lambros (2000) states that “PBL is a method based on the principle of using problems as the starting point for the acquisition of new knowledge” (p. 1). Similar statements are found throughout the literature, confirming the use of the problem as the delivery system for the content (Evensen & Hmelo 2000; Delisle, 1997; Stepien, 1997).

PBL problems must be structured in a way that engages students in the learning of the content. The term “ill-structured” is commonly used to characterize these problems (Gallagher, 1997). An ill-structured problem can be solved in more than one way and frequently has more than one correct answer. The problem needs to be
connected to the student's real world and usually has some intrinsic value that generates motivation. The problem itself does not contain all of the information necessary to solve it. Students must create a plan, implement it, and come up with a solution to the problem (Glasgow, 1997; Lambros, 2002).

History of the Development of PBL

PBL was developed in 1968 for the new medical school at McMaster University in Canada, according to Barrows and Tamblyn (as cited in Boud and Feletti, 1997). According to the literature, there was a desire to create a more interactive program for students entering medical school. Instead of a curriculum based primarily on the dissemination of facts by a teacher, a program was designed that allowed for active participation in problem-solving experiences. The McMaster's program motivated students to become active participants in their learning by presenting them with bio-medical situations to solve in small groups. The teacher no longer stood in front of class lecturing, but became like a tutor or learning guide, helping facilitate learning. This type of learning mimicked the daily life students were likely to have when they became real doctors (Evensen & Hmelo, 2000). Because of its success, PBL was eventually offered
as a course of study in medical schools around the world. In the 1980s, other disciplines became involved with PBL. Educators began using PBL at the various levels, from elementary school to college (Delisle, 1997).

**The Benefits of PBL**

According to Gagne (1988), good instruction requires that students' internal learning processes are supported effectively by external events. Planning successful lessons means developing the following nine elements: “1. gaining attention, 2. informing the learner of the objective, 3. stimulating recall of prior learning, 4. presenting the stimulus, 5. providing learning guidance, 6. eliciting performance, 7. providing feedback, 8. assessing performance, and 9. enhancing retention and transfer” (Gagne, 1988, p. 118). These elements, couched in different forms, are part of what makes PBL educationally effective.

PBL uses problems that are closely related to real-life (Delisle, 1997). This, according to Delisle, provides for student involvement on an elevated level and provides them with answers when they question why a topic needs to be studied. Learning that is related to real-life is more relevant to students. This relevancy gets students' attention, keeps them interested, and leads to
better understanding of the content (Lambros, 2002; Dods, 1997).

In PBL students need to collaborate in order to solve problems. This requires a certain level of respect and the development of advanced communication skills with their peers (Lambros, 2002).

The ultimate goal of PBL is not for the student to find the right answer. “Instead, the actual learning takes place through the process of solving the problem-thinking through the steps, researching the issues, and developing the project” (Delisle, 1997, p. 13).

PBL in Gifted Education

The National Association for Gifted Children published a document that recommends standards for district programs for gifted and talented students (NAGC, 1998). These recommendations include the development of critical, problem solving and research skills in a manner that promotes inquiry, self-directed learning, discussion, debate, and metacognition.

Research shows that gifted students need differentiated curriculum that includes acceleration, complexity, depth, novelty, and intensity (Clark, 2002). PBL provides for this. It allows for students to move through the learning process at their own pace. Well-
written problems are quite complex and lead to an in-depth investigation of the subject. Creating problems that relate to real life makes the learning novel and provides an intensity that traditional wrote learning does not (Gallagher & Gallagher, 1994).

One of the most important ways to differentiate the curriculum for gifted students is to make it more sophisticated or complex (Gallagher & Gallagher, 1994; Coleman, 2003). When applying Bloom’s Cognitive levels of development to gifted students, they should not be spending as much time in the less complex levels of knowledge and comprehension as they should in the more complex levels of application, analysis, synthesis and evaluation levels. PBL offers this higher-level stimulation through its investigation of real life problems that are ill-structured (Gallagher & Gallagher, 1994).

In a study done by Gallagher, Stepien, and Rosenthal (1992), gifted high school students in a PBL science class and a comparison group’s problem solving skills were tested to determine changes in their use of problem solving skills as they solved ill-structured problems. The students that participated in the PBL class showed significant improvement in problem solving skills as
compared to the experimental group. The researchers were clear to point out that the study was narrow, but the results were promising and "warrant further experimentation with the process" (Gallagher, Stepien, & Rosenthal, 1992, p.200).

Teaching students to be problem solvers is a goal of gifted education (Gallagher & Gallagher, 1994). In the past the focus was on teaching the steps of good problem solving, like using a recipe to make a cake. PBL takes the emphasis of the problem solving method and puts it on learning the content through the solving of real world problems (Coleman, 1995). Instead of using well-structured problems that tend to have one correct answer, the students are forced to analyze the problem, decide what to study, and arrive at an answer that was not predetermined (Gallagher & Gallagher, 1994).

Potential Drawbacks of Problem-Based Learning

Some issues that affect the implementation of PBL include changing teacher roles, changing student roles, time, and assessment. Both teachers and students will need to change how they view learning (Lambros, 2002). Teachers will need to re-evaluate their role in the classroom. They will move from the disseminator of knowledge to the facilitator of learning. Instead of
telling students what they need to do to solve problems, teachers will have to allow students to decide what is important and necessary (Delisle, 1997). Students on the other hand will have to take more responsibility for their own learning. They will be required to plan and organize what they need to do in order to answer the problem in a thorough way, keeping track of their learning as it progresses (Delisle, 1997).

PBL can also require more time to plan and teach compared to more traditional programs. Extensive preparation is necessary in order to ensure learning targets are clear and that the problems will teach those targets. It is an ill-structured problem that has to be structured well enough to meet the necessary learning goals (Gallagher, 1997). Class time generally needs to be increased in order to facilitate learning during discussions. Since students are learning in a nontraditional format, assessment must also change. Due to the fact that PBL problems have numerous learning goals, a variety of assessments will need to be used to adequately assess learning (Delisle, 1997; Lambros, 2002; Stepien & Pyke, 1997).
Conclusion of Related Literature

Problem-based learning was created to meet the increasing demands of medical school to produce students that have real world problem solving skills. Units of study revolve around an ill-structured problem that leads students to research the most probable solutions. In the 1980s, PBL made the leap to other disciplines and various levels of education. PBL has been used in gifted education to differentiate instruction to meet the needs of the students. Studies have shown PBL’s success in developing problem solving skills. In order to implement PBL in the classroom students and teachers need to understand that this non-traditional system of instruction means their roles in the classroom will change.
CHAPTER 3

METHODOLOGY

The purpose of the project was to investigate students' attitudes towards word problems and the development of their confidence with problem-solving skills by providing differentiation through PBL.

Q methodology

Q methodology provided a way for the researcher to study what students had to say about their own personal experience. It was a systematic way to collect data and allowed for the analysis of the students' opinions and perceptions in a way that maintained their "'internal' frame of reference" (McKeown & Thomas, 1988 p.12). The first step was for the researcher to develop Q-sort statements. The researcher made the decision about which type of statements would be most useful for the study. Naturalistic samples were created by the researcher, as compared to standardized statements. Since the statements were created by the researcher, information was collected from the students through interviews, and converted to Q-sort statements (see Figure 1).
<table>
<thead>
<tr>
<th>I am more confident of my answers when I work with others.</th>
<th>Other students in the class are better at math than me.</th>
<th>I get the right answers, but I have a hard time explaining my thinking to others.</th>
<th>I have to work hard to figure out the right answer.</th>
</tr>
</thead>
<tbody>
<tr>
<td>I can easily explain how I get my answers.</td>
<td>I am good at solving word problems.</td>
<td>I like to work alone on class assignments.</td>
<td>I enjoy working with other students on assignments.</td>
</tr>
<tr>
<td>I would not take math if I did not have to.</td>
<td>I use math when I am not at school.</td>
<td>Math in school is not related to real life.</td>
<td>Math is easy for me.</td>
</tr>
<tr>
<td>I look forward to coming to math class.</td>
<td>There is only one way to get the right answer to a problem.</td>
<td>Word problems are an important part of math.</td>
<td>Word problems are the easiest part of my homework.</td>
</tr>
<tr>
<td>I wish word problems did not exist.</td>
<td>Math is my favorite subject in school.</td>
<td>I wish math class was longer every day.</td>
<td>I solve problems in many different ways.</td>
</tr>
<tr>
<td>I do not like word problems.</td>
<td>I need my parents' help with my homework.</td>
<td>I do my homework by myself.</td>
<td>Word problems are hard for me to understand.</td>
</tr>
<tr>
<td>I understand concepts better when I talk about them with my classmates.</td>
<td>I need it quiet in the room so I can concentrate on my work.</td>
<td>My teacher needs to spend more time explaining concepts.</td>
<td>I see a word problem as an obstacle.</td>
</tr>
<tr>
<td>My teacher gives us problems and lets us work on them.</td>
<td>My teacher spends too much time explaining concepts.</td>
<td>Learning new concepts is something I look forward to.</td>
<td>I see a word problem as a challenge.</td>
</tr>
<tr>
<td>I prefer to do math I already know how to do.</td>
<td>I take risks in math class.</td>
<td>I want to take math classes as long as I can.</td>
<td>I like to let others answer questions in class.</td>
</tr>
</tbody>
</table>

**Figure 1.**
The Q-sort statements that were given to the students to sort and attach to the Q-sort board.
Next, the student was asked to sort the statements along a continuum on a Q-sort board. The continuum read from negative, to neutral, to positive (see Figure 2). The student read all of the statements and placed them in three piles. The pile on the right included the statements the student agreed with, the pile on the left included the statements that the student disagreed with and the pile in the middle was the statements the student was neutral about.

![Q-sort board example](image)

**Figure 2.** An example of the Q-sort board that was developed for the study. Negative: least like my situation. Positive: most like my situation.

The piles of statements were sorted again. The student had sorted the statements into the "most like my situation" pile, the student choose the two that were the
most like their situation and put them on the chart. This was then done for the "least like my situation" pile. The procedure was repeated until all of the statements were placed on the board according to the student’s perceptions and or beliefs.

From the Q-sort data the researcher extrapolated information about how the participant evaluated him or herself according to the statements. Using a Q-sort computer program called PQMethod, by John Atkinson at Kansas State University, the data was sorted. The students were grouped around the Q-sort statements. The factor groups that were derived shared common ideas or perceptions of themselves.

Limitations of Q methodology

Two of the statements used for the Q-sort posed a problem during analysis. The researcher became aware that the statements chosen for the study could have been unclear, confusing, or had more than one meaning to the subject. As far as the researcher could tell, those two statements did not have any influence on labeling the factors.

Another issue was the fact that students were limited to a certain number of statements in each column on the Q-sort board. Some students had difficulty because
they had three statements they thought were "most like me," but there were only two spaces to be filled. The students eventually eliminated one of the choices and continued with the Q-sort process.

**Study Methodology**

Participants in the project were in a fourth-grade gifted and talented mathematics class at Roosevelt Elementary School in Santa Barbara, California. They were chosen to be in the class because they officially qualified for gifted instruction by passing the California Achievement Test, or they were high achieving according to Stanford 9 test scores and previous teachers' recommendations. The thirty-four students were selected from a larger group of ninety-six students in the fourth-grade. There were 21 girls and 13 boys in the class. They ranged in age from nine to ten years old. There were 20 students designated as gifted and talented and 14 honors/high achieving students.

The project was implemented in a fourth-grade classroom that is part of an elementary school with a population of 523 students: kindergarten through sixth grade. Roosevelt was a neighborhood school in an urban setting. The school had approximately 45% English Language Learners. Their primary language was
predominantly Spanish. However, all students received instruction in English in all subjects beginning in kindergarten. There were two English Language Learners in the fourth-grade class used for the study. Student k’s primary language was Spanish and student u’s primary language was Chinese. Both students had been tested and were considered Fluent English Proficient according to the Language Acquisition Survey given by the school district.

The researcher developed two PBL lessons to teach the California Math Content Standard 3.0 Number Sense: Students solve problems involving addition, subtraction, multiplication, and division of whole numbers and understand the relationships among the operations (California Math Content Standards). The researcher chose number sense for the first two PBL lessons in order to introduce the format of a PBL.

The first PBL problem was adapted by the researcher from Arithmetic Teacher (Raphel, 1993). Students were presented with the PBL problem, “The Candle Factory,” which read:

You are the owner of a candle factory and you are looking to break into a new market selling candles. You want to sell them for Hanukkah. How would you go about coming up with a plan? What is your plan?
This problem introduced adding numbers in a series by having students figure out how many candles were needed for a menorah during Hanukkah. The students were manufactures of candles and had to determine the correct number of candles needed in a box. The students were told to work with their seat partner to determine what information they already knew and what information they needed to research.

The researcher provided pictures of menorahs and informational books about Hanukkah for the students to use. For the rest of the period the students worked on a solution. The pairs of students could compare their answers with other groups if desired. At the end of the class each student turned in a solution. The next day the students presented their solutions along with their justification for their answers.

The second PBL lesson was also adapted by the author from Arithmetic Teacher (Raphel, 1993). It involved more complicated numbers in a series. Students were presented with the PBL problem, “Gifts Unlimited, Inc.,” which read:

Gifts Unlimited, Inc. has just hired you as a temporary employee for the holiday season. Your first day on the job a man came in and said that he wanted to send the love of his life gifts for the twelve days of Christmas, just like the song. It is
your job to put together the order so your boss can approve your purchases.

Students were told to work with their seat partner. They were to develop a list that included what they already knew about the problem and what they needed to find out in order to solve the problem. All the groups agreed that they needed to know the words to the song "The Twelve Days of Christmas."

Each student was given a copy of the song. After reviewing the song "The Twelve Days of Christmas," the students were asked to determine the number of gifts necessary to fulfill the order. The students were responsible for ordering the correct amount of each gift, having it delivered on the correct day, and researching the total cost of one of the gifts.

A third, and more elaborate PBL unit was written to teach California Math Content Standard 1.0 Measurement and Geometry: Students understand perimeter and area (California Math Content Standards). The researcher chose area and perimeter for the third PBL unit because children can frequently confuse the two concepts. The third lesson, "The Butterfly Garden," was created by the researcher after meeting with Roosevelt School's Parent and Teachers' Association garden committee. Students were
presented with the PBL problem, "The Butterfly Garden," which read:

The Santa Barbara School District needs some landscaping done on the hill next to the green picnic tables at Roosevelt School. Before they can do the work, they need to have a plan. They are asking landscape architects to submit their ideas. Your firm, Barr and Associates, is submitting designs from a number of different design teams. Your team needs to create a plan to submit for review. The deadline is a week from Friday.

What do you know? What more do you need to know? How will you proceed?

The students were allowed to choose three other students to work with on their design team. They were required to have two girls and two boys on each team, until there were no more boys left.

In their design teams, the students brainstormed what they knew about the problem and what they needed to know in order to solve the problem.

Over the course of the next three weeks, the students measured and re-measured the space provided for the garden, listened to guest speakers present necessary information, researched possible plants to include in the garden, and then created a map for their version of the garden. A professional gardener and a landscape architect were brought in as experts in order to teach the students information about butterfly gardens.
Design teams used graph paper to create a final plan for the butterfly garden. The students were responsible for using all of the information collected through their research to draw up their plans. These plans were taken by the landscape architect and synthesized into one master plan for the butterfly garden.

The culmination of this lesson was the planting of a butterfly garden. On a Sunday afternoon everyone met at the school and planted the garden. Parents, students, and teachers were involved.

Traditional instruction can rely heavily on memorization of procedures. Sometimes students confuse the formulas for area and perimeter because of a lack of conceptual understanding. The constructivist approach of PBL developed the students understanding of area and perimeter through problems related to their daily life. The area and perimeter PBL unit was designed to create a conceptual understanding of the two ideas.

At the end of the third PBL lesson, students were asked to complete a Q-sort developed to determine their perception of themselves related to mathematics. The statements were developed from listening to students' comments in class and interviewing some of the students individually, and in small groups. Each student received
a Q-sort board and thirty-six statements that the researcher had developed specifically for this class. Students were asked to read the statements and sort them. Students then worked individually, and placed the thirty-six statements on their boards according to their perceptions of themselves and the math class. The researcher answered any questions the students had during this time. When the students were finished placing their statements on the board, they glued the statements onto their boards in the appropriate columns. The boards were collected when the students were finished.

Throughout the year students were asked to write about themselves, the math class, and specifically the PBL lessons. Sometimes the teacher gave the students a topic to write about, and sometimes the students were allowed to choose for themselves. Their writing was used to help document their attitudes and understanding in mathematics during the course of the lessons.

The researcher kept a journal to record information that could be reviewed at a later date. This provided the researcher with a timeline of events and documentation of events necessary to the project.
CHAPTER 4
RESULTS OF THE PROJECT

Introduction

The researcher used the program PQMethod adapted from the program Qmethod, by John Atkinson at Kansas State University in order to perform the factor analysis. This program was specifically designed to meet the requirements of Q-sort studies.

The program factored the numerical values assigned to the statements by the subjects. The factors were sorted to find groups of subjects that loaded on the same factors. The subjects were grouped by the values they assigned to the statements.

Presentation and Analysis of Data

After analyzing the eigenvalues for statistical significance, it was determined that ten of the thirty-two factors were statistically significant. The eigenvalues became less statistically significantly after Factor 10, when they dropped below 1.0 (see Table 1).

Table 1
Statistically significant list of eigenvalues

<table>
<thead>
<tr>
<th>Factors</th>
<th>eigenvalues</th>
</tr>
</thead>
<tbody>
<tr>
<td>Factor 1</td>
<td>8.1661</td>
</tr>
<tr>
<td>Factor 2</td>
<td>3.8568</td>
</tr>
<tr>
<td>Factor 3</td>
<td>3.1658</td>
</tr>
<tr>
<td>Factor 4</td>
<td>2.1606</td>
</tr>
</tbody>
</table>
Factor 5  1.8771
Factor 6  1.5377
Factor 7  1.4598
Factor 8  1.2813
Factor 9  1.1719
Factor 10 1.0243

---------------------
Factor 11  0.8100

However, for the purpose of this study, the theoretical or practical value of using factors beyond Factor 4 could not be supported. By reviewing the eigenvalues it was determined that a four-factor analysis would be the best fit. The eigenvalues tapered off after the fourth factor (see Table 2).

Table 2
Practically significant list of eigenvalues

<table>
<thead>
<tr>
<th>Factors</th>
<th>Eigenvalues</th>
</tr>
</thead>
<tbody>
<tr>
<td>Factor 1</td>
<td>8.1661</td>
</tr>
<tr>
<td>Factor 2</td>
<td>3.8568</td>
</tr>
<tr>
<td>Factor 3</td>
<td>3.1658</td>
</tr>
<tr>
<td>Factor 4</td>
<td>2.1606</td>
</tr>
<tr>
<td>Factor 5</td>
<td>1.8771</td>
</tr>
<tr>
<td>Factor 6</td>
<td>1.5377</td>
</tr>
</tbody>
</table>

Since there were no outliers in the data, a varimax factor rotation was used in order to determine the load on each factor for each student. It was determined that a load of .45 or higher would be considered statistically significant.

There were fifteen students that had a positive load on Factor 1 (see Table 3).
Table 3
The load scores for Factor 1

<table>
<thead>
<tr>
<th>Student</th>
<th>Score</th>
</tr>
</thead>
<tbody>
<tr>
<td>a</td>
<td>+0.67169</td>
</tr>
<tr>
<td>e</td>
<td>+0.56126</td>
</tr>
<tr>
<td>g</td>
<td>+0.63545</td>
</tr>
<tr>
<td>h</td>
<td>+0.57733</td>
</tr>
<tr>
<td>j</td>
<td>+0.58916</td>
</tr>
<tr>
<td>m</td>
<td>+0.79401</td>
</tr>
<tr>
<td>n</td>
<td>+0.65534</td>
</tr>
<tr>
<td>p</td>
<td>+0.61825</td>
</tr>
<tr>
<td>r</td>
<td>+0.61489</td>
</tr>
<tr>
<td>v</td>
<td>+0.77020</td>
</tr>
<tr>
<td>w</td>
<td>+0.60590</td>
</tr>
<tr>
<td>x</td>
<td>+0.77298</td>
</tr>
<tr>
<td>bb</td>
<td>+0.61384</td>
</tr>
<tr>
<td>dd</td>
<td>+0.49694</td>
</tr>
<tr>
<td>ee</td>
<td>+0.65786</td>
</tr>
</tbody>
</table>

These students were mathematically intuitive. The mathematically intuitive students perceived math to be easy for them and they were good at solving word problems. These students also looked forward to coming to math class, as it was their favorite subject in school. The students looked forward to learning new concepts and ideas and wanted to take math class as long as possible. They also thought that math in school was related to real life. This particular group had eleven-gifted students included in it. That was the highest amount clustered together, compared to the other three factors. The following statements represent the typical mathematically intuitive subjects:
I am good at solving word problems
Math is easy for me
I look forward to coming to math class
Math is my favorite subject in school
My teacher gives us problems and lets us work on them
Learning new concepts is something I look forward to
I want to take math classes as long as I can
Math in school is not related to real life
Word problems are hard for me to understand
I would not take math if I did not have to
My teacher spends too much time explaining concepts
I prefer to do math I already know how to do

There were seven students that had a positive load on Factor 2 (see Table 4).

Table 4
The load scores for Factor 2

<table>
<thead>
<tr>
<th>Student</th>
<th>Score</th>
</tr>
</thead>
<tbody>
<tr>
<td>b</td>
<td>+0.83048</td>
</tr>
<tr>
<td>d</td>
<td>+0.50005</td>
</tr>
<tr>
<td>k</td>
<td>+0.52647</td>
</tr>
<tr>
<td>l</td>
<td>+0.49174</td>
</tr>
<tr>
<td>t</td>
<td>+0.52200</td>
</tr>
<tr>
<td>u</td>
<td>+0.48097</td>
</tr>
<tr>
<td>z</td>
<td>+0.71685</td>
</tr>
</tbody>
</table>

These students were non-application oriented. These students saw the need for math in the future, and how math related to the real world. However, they were not confident with their problem solving skills when it came to word problems. These students liked math, but did not feel confident with their application skills, unlike the mathematically intuitive. They were more inclined to want
to work with other students on assignments. They were also more comfortable allowing other students to answer questions in class. The non-application oriented students were characterized by the following statements:

+ I enjoy working with other students on assignments
+ I understand math concepts better when I talk with my classmates
+ I like to let others answer questions in class
- I am good at solving word problems
- I can easily explain how I get my answers
- I would not take math if I did not have to
  - Math in school is not related to real life
  - My teacher spends too much time explaining concepts

Factor 3 was comprised of highly motivated students. There were seven students total that had a positive load on Factor 3 (see Table 5).

**Table 5**

*Load scores for Factor 3*

<table>
<thead>
<tr>
<th>Student</th>
<th>Score</th>
</tr>
</thead>
<tbody>
<tr>
<td>e</td>
<td>+0.65232</td>
</tr>
<tr>
<td>i</td>
<td>+0.68280</td>
</tr>
<tr>
<td>n</td>
<td>+0.46809</td>
</tr>
<tr>
<td>o</td>
<td>+0.60322</td>
</tr>
<tr>
<td>q</td>
<td>+0.55308</td>
</tr>
<tr>
<td>cc</td>
<td>+0.57116</td>
</tr>
<tr>
<td>ff</td>
<td>+0.61718</td>
</tr>
</tbody>
</table>

This factor contained students that liked math. In fact, math was their favorite subject in school and they planned on taking math classes as long as possible in school. These highly motivated students enjoyed learning new math skills, but were not confident in their ability
to explain themselves. There were no significant comments about word problems, positively or negatively, in this group, unlike the other three groups. After close examination, it was determined that five of the students were intrinsically motivated, while two of the students were extrinsically motivated. The following statements were typical of the highly motivated group:

+ I look forward to coming to math class
+ Math is my favorite subject in school
+ I wish math were longer every day
+ Learning new concepts is something I look forward to
+ I want to take math classes as long as I can
- I can easily explain how I get my answers
- I would not take math if I did not have to
- I prefer to do math I already know how to do

Factor 4 included algorithm/global oriented students. Factor 4 had four students with positive loads and one student with a negative load (see Table 6).

Table 6
Load Scores for Factor 4

<table>
<thead>
<tr>
<th>Student</th>
<th>Score</th>
</tr>
</thead>
<tbody>
<tr>
<td>f</td>
<td>+0.58268</td>
</tr>
<tr>
<td>s</td>
<td>+0.51965</td>
</tr>
<tr>
<td>t</td>
<td>+0.46037</td>
</tr>
<tr>
<td>aa</td>
<td>+0.78087</td>
</tr>
<tr>
<td>dd</td>
<td>-0.45998</td>
</tr>
</tbody>
</table>

This factor involved students that did not like word problems. Word problems were difficult for them to solve and they wished math did not include them. They preferred
the repetition of concepts they already knew. The student that had a negative load on this factor was just the opposite of these students. This student enjoyed word problems and saw them as a positive part of mathematics and they were easy for him. Also, this student did not like to let others answer questions in class. The following statements were typical of the algorithm/global oriented group of students:

+ I use math when I am not at school
+ I enjoy working with other students on assignments
+ I do not like word problems
+ I wish word problems did not exist
+ I see word problems as an obstacle
- I prefer to do math I already know how to do
- I like to let others answer questions in class
- Word problems are the easiest part of my homework
- Math in school is not related to real life
- I see word problems as a challenge
CHAPTER 5
SUMMARY, CONCLUSIONS, RECOMMENDATIONS

Summary

The purpose of the project was to investigate students' attitudes towards word problems and the development of their confidence with problem-solving skills by providing differentiation through PBL.

Q methodology was used to gather and analyze the data.

The Mathematically Intuitive group was particularly large compared to the others. The researcher observed that these students pushed the rest of the class to learn new material, because they would always ask challenging questions. These students tended to be the driving force in the classroom.

The Non-Application Oriented group of students liked math but did not seem as able to apply what they knew to new learning situations. Using PBL helped this group because they were able to see how other students used their skills, and learn from them. In class they would wait until listening to other students before committing to an answer.

The Highly Motivated group was interesting to analyze. Five out of the seven were definitely intrinsically motivated. The students did the math
because they wanted to in their heart of hearts. The other two in this factor were just the opposite. Those students did the math because they knew it was what the adults and other students around them wanted them to do. These students were extrinsically motivated.

The Algorithm/Global Oriented group had the only negatively loaded student. Three of the students were good at the arithmetic, but had trouble applying what they knew to word problems. These students rarely raised their hand in class. Instead, they waited until other students answered before offering any information. The fourth student in this factor was just the opposite. He loved challenges of any kind that made him think beyond the algorithm. He saw math as a whole and was able to wrap his mind around it. He also loved to give answers, to the point where it was disruptive to the class. An interesting note is that other teachers commented that this behavior appeared in his other classes.

Providing gifted students with engaging instruction that develops problem-solving skills is a challenge. PBL is one way to do this. Throughout the units the students were highly motivated to develop their own solutions to the problems, even though a portion of them did not perceive themselves as good problem solvers. It could be
argued that PBL kept these students interested in a task that they deemed too difficult. Those that perceived themselves as good problem solvers maintained a high level of interest as well. The students did not become bored with the tasks.

In analyzing some of the statements, additional information was obtained. Twenty-two out of the thirty-two students thought that math in school was related to real life. It could be speculated that the PBL problems influenced their perceptions because the problems were directly related to real life situations.

Both of the second language learners ended up in the Non-Application factor. While their writing was coherent, they both struggled with correct grammatical use of words. In this class, the two-second language learners had difficulty with word problems and preferred to let others answer questions in class. This supports the idea that second language learners struggle with comprehension.

It should also be noted that PBL instruction requires the teacher to be extremely knowledgeable about the content. The teacher must be able to accurately assess the mathematics the students are doing and redirect any students that are not doing mathematically correct work.
Conclusion

PBL was an effective tool for teaching word problems to the math class. It met the needs of what experts agree gifted students need. It also motivated the students to become actively involved in their learning, building conceptual knowledge. When a student said, "Perimeter is what we measured around the garden, right?" I knew he would never forget that concept. Others made similar comments that reinforced this idea. Students saw the value of working on PBL lessons. The majority of the class said that the PBL homework was their favorite.

It needs to be noted that the q-sort statements included many of the elements of PBL but did not specifically mention PBL in them. Specifically, there was not a statement about learning content through an ill-structured question.

Recommendations

Further study needs to be done in the area of PBL. The subjects represented only a very narrow part of the entire student population. More could be done with younger students in order to see if PBL units have value in developing concepts before or during the learning of algorithms. It would also be interesting to pursue Second Language Learner issues. It is possible that with...
involvement in more PBL units, their confidence in problem solving could increase.
References


