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A Pilot Study on the Phenomenography of Problem Solving

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A Thesis

In

The Department

Of

Mathematics and Statistics

Presented in Partial Fulfillment of The Requirements

For the Degree of Master in the Teaching of Mathematics at

Concordia University

Montreal, Quebec, Canada

August 2002

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0-612-72881-1

Canada

Abstract

A Pilot Study in the Phenomenography of Problem Solving

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Concordia University, 2002

Great emphasis is placed on Problem Solving in the secondary school mathematics curriculum. Consequently a vast body of research has also been conducted. In the classroom, teachers persevere at demonstrating a variety of methods to model this skill we call problem solving. However, students remain to have great difficulty. Phenomenography, research with the goal of analyzing, and describing experience, is used in this study to determine what students believe Problems, and Problem Solving to be. Forty-six students from a secondary three and secondary four class were asked to answer two questions:

1. 1. Please define (in your own words) a problem. Think of it in the mathematical sense.

2. Please define (in your own words) problem solving. Think of it in the mathematical sense.

Student responses were tabulated. Five variables, (perseverance, classification of problems, personal attachment to problems and problem solving, interpretation of problem solving, and the mention of methods used to solve problems) are related to student achievement (measured by percentile rank). Observations are made about student perceptions, and their achievement. Further research is needed to determine if these perceptions can be modified.

Acknowledgements

I would like to share my deepest gratitude for my thesis supervisor, Dr. Anna Sierpinska, who has motivated, inspired, and believed in me throughout my years at Concordia University.

I would like to thank my friend, Dr. Pierre Q. Gauthier, who was the first person to see my inner light. In 1996, he told me that he believed in me, and to succeed in mathematics, I needed to believe in myself.

I would like to thank my mother, father, and brother, who have provided me with strength when I needed it, yet were able to give me space when I needed that. I am very grateful to God for giving me a supportive family.

I would like to thank my colleagues and students, at Beaconsfield High School, for their enthusiasm and encouragement. In particular, I would like to thank my Math 314 and Math 416 students (2001/2002 academic school year) who shared their lives, instead of simply coming to class.

This work is dedicated to all of my teachers and students, past, present, and future, for helping me achieve what I love most in life, teaching, and learning!

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Introduction

My aim in this thesis is to conduct a pilot study to determine if there exists a relation between what students *believe* a Problem and Problem Solving is, and their actual achievement in mathematics. The beliefs that students have are based on their perceptions of Problems and Problem Solving from their own personal reality -that is their own experience with problems and solving problems.

In Chapter I, I will present an overview of views on Problems and Problem Solving. Curriculum reform, after curriculum reform has stressed the importance of teaching students how to be good problem solvers or to "think critically." This is a key guideline stressed by the Ministry of Education in the new reform. But what does this mean to students, educators, and mathematicians alike?

In Chapter II, I will introduce a field of research called Phenomenography. Phenomenography is the study of one's perception of reality based on experiences. I became interested in knowing what my students believed problems and problem solving was. My goal is to determine if there exists a relationship between their achievement, and their perceptions on problems and problem solving.

In Chapter III, I will present the study, the data, and the analysis. Students were asked to answer two questions:

1. Please define (in your own words) a problem. Think of it in the mathematical sense.

2. Please define (in your own words) problem solving. Think of it in the mathematical sense.

The responses to these questions were tabulated, graphed and analyzed.

Finally in Chapter IV, I will provide some conclusions from this study, and further research interests. The results from this study will highlight areas that are linked to achievement. It would be very interesting to follow a group of students through at least one full year tracking their experiences, knowing this information. If certain perceptions are linked to achievement, then presumably, it would seem possible that changing these perceptions, would also change achievement. It is my goal to investigate the changing of perceptions in further research.

Chapter I

Views on Problem Solving

Introduction

As a teacher of secondary school mathematics, I have noticed that the words most

frightening, and ill received by students are "problem solving." The majority of students

seem to squirm in their seats at the mere mention of those two words when grouped

together. I see the panic in their eyes, and most of them have resolved that they are going

to "fail the problem solving questions." I often hear comments such as, "Miss, what does

English have to do with Math? Why can't you just give us numbers, and we can

calculate the answers. With so much resistance towards problem solving in the

classroom, it is often very difficult to know how to inspire these young students.

This fear of problem solving led me to wonder, what do my students believe problem

solving is? Moreover, what does it mean to teachers, parents, school boards, the

Ministère de l'Education du Québec, mathematicians, and actually our society as a

whole. What does problem solving mean to me? I did not know the answer, so I decided

to find out.

Meanings of "Problem"

To understand problem solving, we must first define what a problem is. Although there

are many definitions of a problem, there seems to be some consensus on a few

characteristics.

It is not possible to read through literature on problem solving with out the mention of

George Pólya. He is considered a pioneering founder in problem solving research. Since

he began writing and researching about problem solving well before it became

popularized in the eighties, we will start with a definition from his book, "Mathematical

Discovery" (1965). Pólya writes, "to have a problem means: to search consciously for

some action appropriate to attain a clearly conceived, but not immediately attainable

goal." He also refers to problems as having a "degree of difficulty." Kantowski (1980)

states, "A problem is a situation for which the individual who confronts it has no

algorithm that will guarantee a solution. That person's relevant knowledge must be put

together in a new way to solve the problem." Orton (1987) believes that "problems are

not routine, [and] are to a greater or less degree a novelty to the learner." Problems may

also need time to solve, and may need to be "pondered and thought about to allow the

subconscious mind to find a solution that the conscious mind can not." Some researchers

have classifications of problems. Leblanc, Proudfit, and Putt,(1980) place problems into

two categories: standard textbook problems, and process problems. The former is used to

practice an application of an algorithm, while the latter is designed to use problem

solving strategies to devise a method for finding a solution. The focus of these types of

problems is the method, not the solution. Butt (1980) classifies problems even further

into four categories:

1. Recognition exercises

   (Used to practice a definition, theorem or fact.)

2. Algorithmic exercises

(Given to practice 'step-by-step' procedures, computations.)

3. Application problems

    (Known as the typical word problems. Students formulate a symbolic

    representation of the problem, and manipulate the symbols to acquire a solution.)

4. Open-search problems

    (Often these are problems that need proofs or require pattern recognition.)

5. Problem situations

    (Situations for which students need to devise a plan, strategies and come up with a

    solution or possibly many solutions.)

There is no one definition of a problem, but there are many repeated themes. As stated

earlier, I myself was not sure how I could define a problem. From the culmination of the

above definitions I have put together the following definition for myself.

A problem is a situation, which is novel, so it requires a search. An obvious algorithm is

not presented (or this would make it an exercise) so strategies are needed to gather prior

knowledge to devise a plan to attain the solution. This could take time.

Intertwined with the definition of a problem, is act of problem solving.

Meanings of "Problem Solving"

Once again we return to Pólya, this time for a definition of problem solving.

> "Solving a problem is finding the unknown means to a distinctly
>
> conceived end. If the end by its simple presence does not instantaneously
>
> suggest the means, if, therefore, we have to search for the means,
>
> reflecting consciously how to attain the end, we have to solve a problem.
>
> To solve a problem is to find a way, where no way is known off hand, to

find a way out of a difficulty, to find a way around an obstacle to attain a

desired end, that is not immediately attainable, by appropriate means."

(1949)

Halmos, (1980, in Schoenfeld, 1992) believes that the, "heart of mathematics" is solving

problems. By solving more problems, of greater difficulty, students will become better

problem solvers. Orton (1987) refers to problem solving as a "process by which the

learner combines previously learned elements of knowledge, rules, techniques, skills, and

concepts provided to a solution to a situation."

To aid students in achieving this goal of problem solving, Pólya developed the famous,

"How To Solve It." Pólya's heuristic method is a basis for many, many other strategies

offered by other authors. It is presented here as an example of strategies that teachers can

offer students. For an inquiry into other approaches, one has only to view the numerous

papers published by the National Council of Teachers of Mathematics, and the volumes

of other publications from Teacher Education Universities world-wide.

Pólya's model has four phases:

1. Understanding the problem.

2. Devising a plan.

3. Carrying out the plan.

4. Reflecting over the result.

Under every step Pólya provides strategies for the problem solver.

1. Understanding the Problem

This student understands all parts of the problem in this step. He/she is to recognize the known data, and conditions, and the unknown(s). He/she determines if there is sufficient information to solve the problem, and what other information is needed. Redundant, and or contradictory data should be shifted. If called for, a diagram can be illustrated. Notation is introduced. All conditions can be laid out separately, so that all the steps are clearly displayed.

2. Devising a Plan

In this step the student searches for links between the data and the unknown. To aid in discovering these connections, similar problems, or simpler problems can be brought into the scenario as a starting point. If the entire problem is unclear, then parts of the problem can be solved. Can missing information be derived? Related theorems or definitions can be useful.

3. Carrying out the Plan

The student carries out his/her plan, making sure to check their steps along the way for correctness. The student should be able to prove that the steps are correct.

4. Reflecting on the Solution

The student looks back over the entire problem. Does the answer make sense? Were all parts covered? Can the solution be used elsewhere for another similar problem?

Pólya strongly believed that teachers could only teach problem solving as well as they had it themselves. "No teacher can impart to his students the experience of discovery if he has not got it himself" (1949). Although he was an educator, "he worked in many

diverse areas of mathematics- real and complex analysis, number theory, probability, geometry, combinatorics, and mathematical physics. (Alexanderson,1987)

Curricular Goals of Problem Solving

1. Curricular Goals from Literature

Since the 1980's curriculum reform after curriculum reform has stressed the importance of teaching problem solving. Synonymous to problem solving are terms such as critical thinking and trouble-shooting. Stanic and Kilpatrick (1988, in Schoenfeld, 1992) have identified how problem solving is used to meet some curricular goals; a justification for teaching mathematics, recreational, taught to develop new skills, and for the purpose of practice.

a.) Problem Solving as a Justification for Teaching Mathematics

Real-life examples are given in class to motivate students into believing that it is absolutely pertinent that they learn math so as to succeed in life. The 'problem' is that most school examples are contrived, and work out to precise answers, which rarely does occur in real life.

b.) Problem Solving for Recreation or for Competition

Schools will often hold "Math Olympics", or competitions to motivate students to enjoy math.

c.) Problem Solving Taught to Develop New Skills

Often problems are brought into the classroom to introduce new topics, and provide insight and interest for the content that will be presented next.

d.) Problem Solving for the Purpose of Practice

The most common use of problems in the classroom is for practice. Students are

given a structure, method or "recipe" if you will, to follow. Then they practice a set

of problems to master this technique.

The above curriculum visions are mostly goal oriented. A student is presented a task.

The student uses a technique from his/her "bank of knowledge" (as I like to call it) and if

the problem is solved correctly, the goal is achieved. However, problem solving can also

be viewed as an art form, or an invaluable skill, which is used not only in mathematics,

but also in life.

Branca (1980) highlights three interpretations for teaching problem solving; as a goal, as

a process, and as a basic skill. Since problem solving as a goal has already been covered

above I'll skip ahead to the latter two.

Problem Solving as a Process

With this interpretation, problem solving is looked at with regards to the process that the

student uses to determine the solution. The actual solution is not as important as the

methods that the student uses to come to the final answer.

Problem Solving as a Basic Skill

Problem solving is considered a necessary basic skill, along with arithmetic, and

computation in the required basic math skills necessary to function as a member of

society.

2. Curricular Goals of the National Council of Teachers of Mathematics (NCTM)

In April 2000, the NCTM published Principles and Standards for School Mathematics. Under Problem Solving, it states that instructional programs from pre-kindergarten through grade 12 should enable all students to:

- Build new mathematical knowledge through problem solving;
- Solve problems that arise in mathematics and in other contexts;
- Apply and adapt a variety of appropriate strategies to solve problems;
- Monitor and reflect on the process of mathematical problem solving.

The "disposition" of a problem solver should be one of "confidence, and willingness." Successful problem solvers should:

- Be resourceful
- Seek relevant information to make use of what they know.
- Have a knowledge of all their options
- Be able to make a plan, but also be able to change that plan when necessary.
- Emerge from high school with a repertoire of problem solving strategies. (pp.334-341)

3. Curricular Goals of the Ministère de l'Education (MEQ), and the Lester B. Pearson School Board

Since my research is situated in the province of Quebec, I have to assume that views of problems and problem solving, held by my students –participants in the study, could be influenced by the local curriculum goals as found in official documents published by the Government. In the Mathematics Curriculum 314 and 416 (grades nine and ten) guiding

principles of the courses are laid out. The second of these principles deals with "Problem Solving at all stages of learning." (Ministère de l'Education 1996) Two categories of problems are given:

1. "Problems with solutions requiring students to choose an appropriate combination of knowledge or skill among several combinations seen in the past."

2. "Problems requiring students to create a new combination of knowledge and skills, exercise a great deal of intellectual independence and use plausible reasoning in order to solve them." (pp. 5-6)

It is expected that the minimum requirement should be that students be able to solve problems of the first type. Problem Solving is not defined, but it is suggested to be "used to introduce students to a new concept or skill, to help them develop this knowledge or ability or to help them review what they have learned." (p.6) The document proceeds to discuss the use of a variety of problem solving strategies available to the student, such as "patterns recognition, representation by means of a figure, graph, table, reference to a known model, use of a formula, formulation of an equation or working backwards." (p.6)

Students in my study could also be influenced by curriculum goals put out by the Lester B. Pearson School Board (LBPSB) to which their school belongs. During a LBPSB in-service professional development session, a handout (Lester B. Pearson School Board, 2002) entitled "Teaching Problem Solving in Mathematics," was provided. Goals for teaching problem solving were outlined. Students should be systematic in their approach, make use of different strategies, persevere at finding solutions, try a variety of problems, and become more confident. Problem Solving was defined as "the process of moving

towards a goal when the path to that goal is uncertain. [It] is the attempt to find a solution when the method to that solution is not evident."

Although the words differ a little, and the techniques that can be used in the classroom will change to incorporate the latest technology, I think it is pretty evident that the motivation behind the goal of teaching, and learning problem solving has really not changed since Pólya's first release of "How To Solve It." By summarizing the meanings and goals of problem solving discussed above. I have developed the following description for myself.

Problem solving is a process which starts with a student's correct understanding of the problem. The student must search for a possible method, from their acquired prior knowledge, to solve the problem. Strategies available to the student are the use of patterns, formulation of an equation, table or graph, comparison with simpler or similar problems, or working from the solution. The student should check his/her work routinely and reflect on the solution. Problem solving is an acquired skill that takes time and can only be strengthened with practice. Students and teachers can use this approach to learn and teach new concepts and tone their ability to reason.

So we know what Problem Solving means to mathematicians, teachers, governments, and school boards – how about what it means to students?

Student Beliefs on Problems and Problem Solving

Students' perceptions of mathematics come from their experience in the mathematics classroom (Lampert, 1990, in Schoenfeld, 1992). Since the majority of time students are given routine exercises to perfect a skill, they tend to have very limited experience of problem solving as understood by Pólya or the NCTM. These school questions tend to be short, and have concise right or wrong answers, which are worked out by their teachers. Consequently students tend to feel that a method for solving a problem should be at their immediate disposal, and they tend not to persevere (Carpenter et al., 1983; National Assessment of Educational Progress, 1983; Schoenfeld 1988, 1989, in Schoenfeld, 1992). In a study relating time to perseverance, students were asked how much time is considered reasonable to work on a problem. The mean amount of time given was 2.2 minutes. For problems that were considered "impossible to figure out." The mean time was 11.7 minutes (Schoenfeld, 1988, in Schoenfeld, 1992). The issue of perseverance will be revisited in this study as well.

I am brought back to my original question, what do my students believe problems and problem solving to be. Will their perceptions dictate their actions? The next chapter will discuss student perceptions, and student realities in general (i.e. not necessarily related to mathematics.)

Chapter II

Phenomenography

Phenomenography is a field of research which "aims at the description, analysis, and understanding of experience" (Marton ,1981). In the previous chapter we saw that students' perception of problems comes from their reality of actually having to solve problems in a mathematics classroom. As such I thought it would be interesting to use a phenomenographical approach to problems, and problem solving.

The description of Phenomenography presented in this chapter comes primarily from the article "Summary of: Phenomenography - Describing Conceptions of The World Around Us," by Ference Marton (1981). Marton presents the viewpoint that people understand information primarily because of their perceptions of what reality is, not simply because of the reality that exists. In actuality it is not possible to know what an individual's reality (exclusive to their experiences) is, since the experiences that people have, influence their perception of reality. Taking this notion into account, he believes that these realities are useful because they make up the "collective mind" of all individuals. Even though we are not able to determine, or classify exactly how certain individuals see the world, we can develop an ever-changing culmination of the different ways that all humans perceive their reality, which in turn becomes a collective reality.

Reality and Experience

Marton's paper distinguishes between a "first order perspective", and a "second order perspective." The first order perspective of the world, consists of claims about the reality

of how the world actually is. The second order perspective of the world, consists of

claims about our perception of how the world is. Both perspectives complement each

other, and are dependent, and dynamic. Our personal view of the world will effect our

perception of it, which will in effect change what we believe the world to be. This will

continually be evolving. We now apply these perceptions to the manner in which students

learn information in a classroom.

There are different ways in which a student will process, "interpret, understand,

apprehend, perceive, and conceptualize information" (Marton 1981, p.178). There is an

entire field of research based on how students learn, and why certain students learn better

in certain subjects than others. One possible answer could be the student's *perceptions* of

certain topics. Differences in thinking come from different social class (Schatzman and

Strauss, 1966) and different social strata (Bulk-Morss, 1975) They are prevalent in

different cultures. People's realities are molded by their perceptions of their reality. If

this is evident in everyday, then it must also be prevalent in our math classrooms. As

teachers we can not assume that our students' everyday realities will be left behind once

the door is shut, and the bell rings.

Teachers study educational psychology to learn how students learn. Our goal is to apply

the general principles of learning to the subject matter that we want our students to learn.

For instance, if I assume that I want to teach my students how to problem solve, I will

assume that if I understand what steps students need to take to set up a problem, then

teach these steps to my students, they can follow the steps and solve problems. This is a

"notion that you can transfer ready-made concepts and principles into the empty head of students" (Marton, 1981, p.182). It is a first order perspective. Should we not also look at what students perceive problem solving to be? What is their reality? There has been some research in this area by Lefrere (1981, in Marton, 1981) in science instruction. He believes that it is also important to view what students already know about a topic, and make use of this knowledge to build on. So, we not only need to know how the mind actually works, but also what is in the mind. But how could we possibly know all of that? Even if we were able to get a broad enough picture of the mind, it is always changing. We would be trying to perceive our students' world and the *culmination* of the perceptions that make their reality.

Conceptions of the World Around us

Students all conceptualize information in their individual ways. All too often in a math classroom, it is assumed that the "right" way to solve a problem is the way presented by the teacher. In some cases this can be true, but it is not always the case. The students that learn this "right" way end up succeeding, and those that don't end up not succeeding. This leads students to believe that either you get it or you don't, and that there is only one way to get it. They interpret problem solving to be an innate ability. Unfortunately this is quite opposite to how science has worked through time. The differences in the way people actually view the world, has brought about many changes in what is generally accepted to be true.

Marton (1981) provides an example about the theory of Evolution by Darwin that supports different views. Originally Darwin "began with a stable, harmonious natural order, in which all organic beings were adapted to each other and to their physical environment in a fashion ordained by the creator" (p.186). As his research progressed, Darwin came to see that species actually adapted to their changing environments, and needed to change with these environments in order to keep evolving. Just because there exists a generally accepted fashion in what we believe, does not mean that is the only correct belief or idea.

Relating this back into mathematics classroom, just because the text, or the teacher presents a solution in one particular fashion, does not mean that is the only correct way to solve a problem. Moreover, there cannot be a generally accepted fashion that individuals learn, process, or accept solutions to problems, as students come from varying cultural, social, economic backgrounds, which will change their reality, and how they conceptualize information. How students conceptualize information, is related to how students learn and process information. One particular researcher that comes to mind is Howard Gardner. Gardner (1989) developed a theory on multiple intelligences (Gardiner's Theory of Multiple Intelligences) which categorizes students, in varying degrees, into seven possible different "intelligences." If students have such varying ways to process content given to them, and their reality is shaped by their own personal strengths (intelligences) how can we possibly expect that one method of problem solving can apply to an entire class. Are we really teaching students to think, and solve problems, or are we teaching students to simply regurgitate generally accepted

principles? The future students of mathematics (at a secondary level) will be those who can give back the perfect solution, as put forward by the teacher, or the text. But then how is that encouraging progress? Students need to be encouraged to find their own solutions, from their own perspective. Whether or not that solution was similar to the one presented is irrelevant (given that it is a correct solution). What is relevant is that it came from the student's mind. The task at hand is how to do that.

We see that the second-order perception (our perception of how the world is) seems to be the most prevalent in how we process information (Marton, 1981) What is difficult from an educational point-of-view is how to overcome this perception since it is so individualistic. How do we understand what is in brain for each separate student? The aim of this study is to do just that. The proceeding chapters will outline the study which attempts to discover the perceptions of 46 students on Problems and Problem Solving, and draw links to their achievement.

Chapter III

Analysis and Interpretation of the Pilot Project

Section 3.1: Setting Up The Study

Problem and Problem Solving Definitions by Students

In an attempt to determine how a student's perception of what

1. A Problem or

2. Problem Solving

is, related to his/her achievement. I asked students in two of my classes to complete a questionnaire which asked them two distinct questions:

1. Please define (in your own words) a problem. Think of it in the mathematical sense.

2. Please define (in your own words) problem solving. Think of it in the mathematical sense.

Students from my secondary III (Math 314), and secondary IV (Math 416) classes (46 students altogether) participated in the survey. I told the students that I was not going to evaluate them. I explained that I was reading an article which discussed these two terms. It occurred to me that I myself was not clear on the two terms, and wanted to know what they thought. Many students came up to me and asked me to review their results, but I told them that this was not a test, and that it was purely for interest's sake. No students were coached or assisted, not even with vocabulary (as you will no doubt observe in their responses). It is interesting to note that my relationship with my students was integral to receiving "honest" answers. They took their time, and really wanted to disclose what

they believed. This was in complete contradiction to what happened when I asked another class, which I did not teach, to participate. Students from the other class returned vulgar comments, and quite silly answers, which were meant to let me know that they believed the exercise to be a waste of time. I did not use these results. It was poignantly clear that a strong relationship between a teacher and his/her students is essential in a secondary school classroom to receive useable feedback.

The students' responses were tabulated and sorted according to the students' academic ranking. This table is entitled "Master Table." It is found in Section 3.2, pages 33 to 39. I decided that I wanted to analyze the data for some of the characteristics that were brought out in some of the research, discussed in Chapters I and II, with regard to the students' achievement. Responses are organized in terms of:

- A student's end of year **quintile placement** in their respective (Math 314 or Math 416) class. This is used as the indicator of the students' achievement.

- A student's ability to **persevere** at a problem.

- A student's **classification** or definition of a "Problem."

- A student's **personal attachment** in solving problems.

- A student's **interpretation** of a "Problem" or "Problem Solving."

- A student's mention of the **different methods** available to actually solve a problem.

The above terms, highlighted in bold, are explained below.

For the following sections, please refer to the Master Table.

Quintile Placement

Since the results from two different grade levels were combined, I decided that the results would be more "smooth" if students' quintiles were used instead of their actual raw scores. Also the grade nine students are not streamed, whereas the grade ten students are streamed. The use of quintiles would also solve the discrepancy in this factor. The following two tables display the distribution of the quintiles at each grade level.

Math 314 Quintile Ranking

Rank 1:	90	87	84	81	81	80	
Rank 2:	79	79	78	76	76		
Rank 3:	72	72	70	68	68		
Rank 4:	65	65	60	60	60	60	60
Rank 5:	57	56	47	47			

Math 416 Quintile Ranking

Rank 1:	83	81	79		
Rank 2:	75	75	74	74	74
Rank 3:	73	72	71	70	
Rank 4:	68	65	60	60	
Rank 5:	46	39	18		

These grades are made up of 80% class mark, and 20% uniform board finals. The class marks are typically calculated in the following format:

Unit Final:	40%
Class Tests:	30%
Quizzes and Assignments	10%
Homework:	10%
Organization of Binder:	<u>10%</u>
Total:	100%

The ranking will be used to measure a student's achievement. As can be seen above, achievement is primarily measured in a test format. Only 16% (20%*0.8) of the students' grades are based on daily routine tasks (homework and organization). Each variable, "perseverance", "problem classification", "personal attachment", "interpretation of a Problem and Problem Solving", and "methods mentioned", will be measured against achievement to determine if there are observable relations. Please keep in mind that I am measuring students' *perceptions* of problems and problem solving against their achievement.

Perseverance and Work Habits

I rated each student as to their ability to persevere in a **classroom environment**. The following were the criteria that I designed to test *my perception* of my students' perseverance. This variable, and the ranking are the only two variables which do **not** deal with *student perceptions* of problems and problem solving.

Criteria to Test Perseverance

1. The student will **not** ask for assistance, the minute that he/she is not sure what to do.

2. The student will **not** leave a test question or homework question completely blank.

3. The student will make more than one attempt, showing their work.

4. The student will try different methods (use diagrams, tables, graphs, trial and error), when trying a question that he/she is having difficulties with.

5. The student will review his/her notes before asking for assistance. (It is surprising how few students actually use those classroom notes.)

6. The student will proceed to the next question, if they have difficulties, with the intention of revisiting the 'problem question.'

7. The student completes his/her homework most of the time.

8. The student will check his/her answer, for correctness.

9. The student will try to discuss the problem with a peer, without getting into personal chats.

10. The student will ask for extra examples of difficult questions.

11. The student asks for a hint, only after he/she has tried the above.

Some students follow this behavior on a regular basis, some only sporatically. As such I added a note under this column in the Master Table, which outlines whether the student is consistent, or inconsistent in their behavior. If a student was classified as consistent, he

or she regularly completed homework, and participated in classroom discussions. If a student was classified as inconsistent, he or she was irregular in completing homework, and participating in classroom discussions. The inconsistent student had a whimsical approach – completion of tasks was based on emotions, not requirements.

Perseverance Scale

If a student met **9 or more** of the above mentioned, that student was rated **high** on my perseverance scale.

If a student met **7-8** of the above mentioned, that student was rated **high-medium** on my perseverance scale.

If a student met **5-6** of the above mentioned, that student was rated **medium** on my perseverance scale.

If a student met **3-4** of the above mentioned, that student was rated **medium-low** on my perseverance scale.

If a student met **2 or less** of the above mentioned, or the student **gives up** (does not believe he/she has the knowledge available after reading a problem), that student was rated **low** on my perseverance scale.

Classification of a Problem

Recall Question #1:

Please define (in <u>your</u> own words) a <u>problem</u>. Think of it in the mathematical sense.
Quite surprisingly, students used very similar terminology when describing what they believed a problem was. All responses fall into one of the four following classifications:

1. A problem is a **question**, (35% of the responses)

2. A problem is **something**, (24% of the responses)

3. A problem is a **situation**, (22% of the responses)

4. A problem is an **equation** (19% of the responses)

Later, these four variables will be related to achievement to observe if conclusions can be made.

Personal Attachment

From reviewing all the responses, it was apparent that certain students were personally detached from the "Problem", or the process of "Problem Solving", and others were personally attached to it. In some cases students believed that problems were obstacles, dilemmas, a quest, something personal meant for them. Others believed that problems simply existed to be solved. Since I have known these students for at least 1 school year, and in some cases much longer, it was difficult to remain completely objective when reviewing their comments. Knowing their personal background (in some cases baggage) such as family deaths, learning disorders, physical impediments, confidence levels, personal and social natures, I found this classification to be a little subjective. I used the following criteria to determine personal attachment in a student's perception of a mathematical problem, or in the process of problem solving.

Criteria to Test Personal Attachment

The student used any of the following statements or words:

- "...you must *figure out* the answer.."

- application of skills, knowledge, or sense

- working out obstacles, dilemmas

- complex, difficult situation

- word problems that need answers

I realize that one very large obstacle to really knowing what students think, lies in the recognition that students have a difficult time in expressing themselves. However, I found that these responses did fit the "personal baggage" or "personal reality" that these students bring into the class. The use of the word "you" is particularly interesting. For instance, M.T. states that a problem is "an equation that does not have an answer," whereas C.C. states, "a problem is a question and you have to answer it." C.C. added the "you", personalizing it. Now it could be looked upon as simply a language issue. But let us explore further. Both C.C. and M.T. are weak achievers. Both students have low perseverance. Both students also have inconsistent work habits. However C.C. ranked 4 in achievement, and M.T. ranked 5. In actuality M.T. is quite able to achieve far greater results than C.C. but he is easily distracted. He also never accepts responsibility for his actions. Thus he does not take math personally. He believes it is something that happens to him. Grades are not within his control. They are in the teacher's control. C.C. on the other hand takes math very personally. He often blames himself for poor achievement. C.C. tends to get overwhelmed by school in general, hence is inconsistent in his work habits. Here is another example, this time using the definition of Problem Solving.

M.E.'s definition of Problem Solving is, "some thing that you need to solve." M.F.'s definition is "problem solving is when you try to figure out the answer to a question using different methods." Both students make use of the word "you." However M.F. adds that you must *try to figure it out*. Both students have consistent work habits. However, if we look at their perseverance classifications, M.F. is rated high, whereas M.E. is rated low. Again, M.E. is the type of student who does not believe that he has the ability to succeed. He weighs his results on the level of difficulty of a test. This is where my subjectivity came in handy. I have noted that the student who seems uninvolved in the problem, or the process believes the problem will exist if he/she answers it or not. Those that are involved believe that it is their task to solve the problem. We will delve into these results later, to uncover how the level of personal attachment is related to achievement. All students were then categorized in either of the following groups:

Personal Attachment Scale

PO: The student has no personal attachment to a mathematical "Problem", or the process of "Problem Solving."

P1: The student shows a sign of personal attachment either in the definition of a mathematical "Problem", or of the process of "Problem Solving," but not in both.

P2: The student shows signs of personal attachment in both definitions.

Interpretation of a Problem and Problem Solving

The most striking occurrence from this data is that the students' actual definitions can be classified as either theoretical, or procedural. Those students that see problems in a

procedural manner, either believe that the problem is itself a procedure, or that the procedure is a tool to solve the problem.

Classification of the Interpretation of a Problem and Problem Solving

Theoretical: This student will define "problem" and "problem solving" using general categories or synonyms.

Procedural: This student will focus on things that one does when faced with a "problem."

Tool: This student will answer that problems can be solved using a series of steps, manipulation, equations, formulae, knowledge, or skills. They separate the procedure from the problem. They recognize the procedure to be the tool. The abbreviation for this (in the tables) is prcd.=tool.

Problem: This student will answer that the problem is the procedure. They do not distinguish between the procedure as a tool to solve the problem and the problem. T.D. gives a perfect example of this type of classification, "a problem is an equation." The abbreviation for this (in the tables) is prbm=prcd.

It turned out that this variable was the most revealing at distinguishing between student perceptions of problems and problem solving, and their achievement.

Mention of Methods Used

Finally I noticed that students either mentioned that problems could be solved using a variety of different methods, or not. I found this interesting since, as math teachers, we

want our students to leave with some problem solving skills, or a "bank of math

knowledge" as I like to call it. I wanted to see if those students who achieved well (or did

not achieve well) believed that they needed (or did not need) to have this knowledge to

solve problems. The possible answers are listed below.

Criteria to Test if Students Mentioned "How to Solve It"

Students mentioned the use of:

- formulae
- mathematics
- equations
- manipulation of numbers
- different methods
- solving variables
- mathematical skills
- knowledge, logic
- basic operations

This classification was simple. Either students mentioned different methods, or they did

not.

Classification of Different Methods Mentioned in Solving a Problem

Yes: Students mention (that) different methods that can be used to solve a problem.

No: Students do not mention (that) different methods that could be used to solve a

problem.

This is how the study was set up. Now let us review the results of the study.

Section 3.2: The Data

The responses from this survey were tabulated, and placed into Table 1, the Master Table. It is found on the next few pages (pp.33-39). The Master Table is sorted by the students' ranking. To look for the existence of relations, this table was sorted according to the different variables (indicated below in bold) and charted. There are 5 such tables, which can be found in the Appendix:

Table 2:   **Perseverance vs. Rank Sort**   pp.68-74

Table 2 sorts the different perseverance levels (high, high-medium, medium, medium- low, and low) with the student ranking from 1-5.

Table 3:   **Classification vs. Rank Sort**   pp.77-83

Table 3 sorts the different classification of the term problem, (something, situation, question, equation) with the student ranking from 1-5.

Table 4 :   **Personal Attachment vs. Rank Sort**   pp.88-94

Table 4 sorts the degree of personal attachment (P0, P1, P2) with the student ranking from 1-5.

Table 5:   **Interpretation vs. Rank Sort**   pp.96-102

Table 5 sorts the different interpretations of problems and problem solving (theoretical, prcd.=tool, prbm.=prcd.) with the student rankings from 1-5.

Table 6 :   **Methods Mentioned vs. Rank Sort**   pp.104-110

Table 6 sorts the positive (yes) or negative (no) mention of different

methods that can used to solve problems.

Each of these tables is set up in the same fashion, as presented below.

Column 1:   Enumeration of students.

Column 2:   These are the **student initials**. Where a student has the same initials, the

second (or third) set of initials has been enumerated.

Column 3:   Student **rankings** from 1-5 can be found here. A ranking of 1 represents

the highest, whereas a ranking of 5 represents the lowest.

Column 4:   **Perseverance** is rated from high, medium-high, medium, medium-low,

and low. Also found in this column are **Work Habits**. These are denoted

either inconsistent, or consistent. These were not sorted, just available as

further information on the student.

Column 5:   **Problem Classification** is indicated by either something, situation,

question, or equation.

Column 6:   Students responses were classified in terms of **Personal Attachment**,

indicated by a P0, P1, or P3.

Column 7:   **Interpretation** of the definitions of a Problem, and Problem Solving are

distinguished as either theoretical or procedural. Procedural are further

denoted as prcd.=tool or prbm.=prcd.

Column 8:   **Mention of Methods Used** in their definitions are categorized by either a

positive (yes) or a negative (no) response.

The last two columns 9 and 10, are actual student responses, recopied in their own words, without alteration (as you will notice the spelling errors).

Column 9:   The student response for Question #1 from the survey, "Please define (in your own words) a <u>problem</u>. Think of it in the mathematical sense." This column is labeled, **Problem Definition**.

Column 10:   The student response for Question #2 from the survey, "Please define (in your own words) <u>problem solving</u>. Think of it in the mathematical sense." This column is labeled, **Problem Solving Definition**.

Table 1 Muster Table

Student	Rank	Perseverance & Work Habits	Classification of a Problem	Personal Attachment	Interpretation of a Problem & Problem Solving	Mention of Methods Used	Problem Definition	Problem Solving Definition
1	V.M.	1	high consistent	question	P0	theoretical	yes	A problem in a mathematical sense is a question or a statement for which you need to use mathematics to solve	Problem solving is the use of mathematics to solve a mathematical problem
2	A.M.1	1	high consistent	something	P0	prod =tool	yes	A problem is something has to be solved a quest that must be answered mathematical formulas	It is problem solving is using mathematical using formulas to solve something
3	S.G.1	1	high consistent	equation	P0	prod =tool	yes	is being ask to manipulate numbers and values using an equation	Solving (in a mathematical sense) means actually apply the equation to manipulate the numbers.
4	T.M.	1	high consistent	question	P2	prod =tool	yes	A problem is a question, that to solve it, you really need to think and use your mathematical knowledge to solve it	Problem solving is using your knowledge to figure out a question
5	M.F.	1	high consistent	something	P1	prod =tool	yes	A problem is something without an answer that you have to solve	Problem Solving is when you try to figure out the answer to a question using different methods
6	L.H.	1	high consistent	situation	P0	prod =tool	no	it's a mathematical situation of variables that can be made more simple	it's the process of making the mathematical situation more simple/
7	V.E.	1	high consistent	situation	P0	theoretical	no	A problem is a situation in which something is unknown and must be figured out	Problem solving is finding the solution to the problem, solving the unknown and finding the answer

Table 1 Master Table

Student	Rank	Perseverance & Work Habits	Classification of a Problem	Personal Attachment	Interpretation of a Problem & Problem Solving	Mention of Methods Used	Problem Definition	Problem Solving Definition
8 MB 2	1	medium consistent	equation	P1	prcd =tool	yes	an equation, a group of numbers in need of being solved	applying skills and knowledge to a problem and solving it, finding the answer.
9 A W	1	high consistent	situation (missing part of story or equation)	P0	prcd =tool	yes	A missing part in an equation or a story problem is to find it.	The Finding the logic way to find the answer. If there is a way of solving the problem. Finding the missing part (logically)
10 S G 2	2	high-medium consistent	question	P0	prcd =tool	yes	A problem is a Mathematical Question that needs to be solved by following a series of question or steps	Problem Solving is answering a mathematical question by using a series of steps.
11 S M	2	high consistent	something	P1	prcd =tool	yes	a problem is something that you try to solve to figure out the solution. Equation that needs to be solved and variables that come together to form an answerer	Solving a problem
12 M D	2	medium consistent	situation (dilemma)	P2	prcd =tool	yes	A problem is a dilemma that has to be solved by doing an equation	Problem solving is when you are trying to find a solution to your problem.
13 K.B	2	medium consistent	situation	P2	prcd =tool	yes	A problem is a mathematical situation, where problem variables are given. You must solve this behind a mathematical situation problem with your knowledge	Problem Solving is figuring out the sense behind a mathematical situation
14 MB 1	2	high consistent	question	P0	theoretical	no	A problem is a question that you need to answer	Problem Solving is finding the solution to a question

Table 1 Master Table

Student	Rank	Perseverance & Work Habits	Classification of a Problem	Personal Attachment	Interpretation of a Problem & Problem Solving	Mention of Methods Used	Problem Definition	Problem Solving Definition
15 R.M.	2	high consistent	something	P0	prod =tool	no	something that requires a solution	The steps it takes to eventually solve the problem
16 V.T.	2	medium inconsistent easily distracted	question	P0	prod =tool	yes	A problem is an arithmatical question with givin values to which, a certain value, measurement equation is needed to be found	problem solving is a procedure with steps to which we want to find the missing value, solve the problem. By using equations, multiplying, dividing, adding, subtracting
17 S.C.	2	medium consistent	question	P0	theoretical	no	a question or a statement/asking in numbers or by words	a question or a answer to a question or a statement in numbers or in words)
18 S.G.3	2	medium inconsistent easily distracted	question	P0	prod =tool	no	A question that you need to answer	A series of steps used to find the answer to a problem
19 N.S	2	high-medium consistent	something	P1	prod =tool	yes	a problem is something where you have to find/solve sumthing a problem has something missing, which you have to find	problem solving is solving a problem using many different formulas, whether you are solving for x, finding an angle, or a word problem
20 M.E	3	low consistent	something	P0	theoretical	no	Some thing you have to solve	Some thing you have to solve
21 C.J	3	medium-low consistent	situation	P0	prod =tool	no	A series of words, equations, or numbers placed together in a situation were an answer is not clear	Prosees of finding the answer to a problem.

Table 1 Master Table

Student	Rank	Perseverance & Work Habits	Classification of a Problem	Personal Attachment	Interpretation of a Problem & Problem Solving	Mention of Methods Used	Problem Definition	Problem Solving Definition
22 J.K.	3	high-medium inconsistent	question	P2	prcd =tool	yes	A problem is essentially a question lacking a solution, a question that you must break down, analyze it and, use basic operations, analyze a ultimately, use basic or compund operations to find a solution	The process of breaking down a problem solution, analyzing it and, using basic operations, make answer or amount that can be easily interpreted by the human mind, essentially a representation of an undefined amount.
23 S.R.	3	high-medium consistent	situation (goal/ obstacle)	P2	prcd =tool	yes	A problem is somewhat like having a goal, but there's an obstacle(the problem)that stands in your way and in order to achieve your goal you need to overcome the obstacle(the problem)	By using tricks and stuff you've learned throughout your education you can solve your problem or a calculation; This is known as problem solving.
24 J.C.	3	medium-low inconsistent	situation	P2	prbm =prcd	no	A problem comes in one or more sentences that makes you think of a situation The points of this situation are gathered in thought, and are used to conclude the "problem."	Problem Solving is a complex situation, you The many would have to explain the calculations made in thought, for your conclusion
25 D.W.	3	medium-low inconsistent easily distracted	situation	P0	prcd =tool	no	A problem is a situation which must be solved to aquire an answer	Problem solving are the steps taken to solve a problem.
26 A.M 2	3	high-medium consistent	question	P0	prbm =prcd	no	I think a problem is a question with variables missing and you need to answer with the variable (fill in the blanks)	problem solving is filling in the blanks
27 B.A.	3	medium-low inconsistent	question	P0	theoretical	no	Normally in the form of a question	Figuring out a question
28 S.J	3	medium consistent	something	P2	prbm =prcd	yes	A problem in my opinion is variables that has to be solved It is something that you don't understand but can use your mind and figure it out	Problem Solving is how you solve the problem The steps to take to come to your answer

Table 1 Master Table

Student	Rank	Perseverance &Work Habits	Classification of a Problem	Personal Attachment	Interpretation of a Problem & Problem Solving	Mention of Methods Used	Problem Definition	Problem Solving Definition
28 A.C.1	4	medium-low inconsistent	equation	P0	prbm =prcd	yes	A problem is a equation where you are to find a the solution	a problem solving is a equation that you must use a mathematical formula to get the solution
30 C.K.	4	medium-low inconsistent	something	P2	prbm =prcd	yes	A problem is something that needs to be solved its something that you need to solve	be problem Solving is when you mathematically find the answer to a question or solve that is unknown
31 T.W.	4	low inconsistent easily distracted	equation	P0	prbm =prcd	no	A problem is an unsolved equation that needs to be worked on to get an answer.	'problem solving' are the steps you take in solving a mathematical problem or equation.
32 A.K.	4	low consistent	something	P2	prbm =prcd	no	A problem is something that needs to be solved When faced with a problem especially it is after working on a problem, the solution in math it is an obstacle that can be conquered in math we are generally faced with word Math is full of problems whether they are problems and then we have to solve them arithmetic or words problems, we all face them Problem solving comes in handy when we each day	be Problem solving is the solution to a problem have to face the obstacle
33 R.B.2	4	low inconsistent very easily distracted	equation (variables)	P0	prbm =prcd	no	two variable that come to gether to create an answer	the solution to two variables
34 C.C.	4	low inconsistent	question	P1	prbm =prcd	no	A problem is a question and you have to answer it	to problem solving is a question that you have to answer, like a sentense and solve it
35 V.P.	4	low inconsistent easily distracted	something	P0	prbm =prcd	no	a problem is something that must be solved, a people question	problem solving is the mathimatical way of with numbers it's a mathimatical Question not solving a problem It's a way of showing your steps

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Table 1 Master Table

Student	Rank	Perseverance & Work Habits	Classification of a Problem	Personal Attachment	Interpretation of a Problem & Problem Solving	Mention of Methods Used	Problem Definition	Problem Solving Definition
36 F.S.	4	low inconsistent easily distracted	question	P1	prblm=prcd	yes	a mathematical question which you are challenged to find the answer	A mathematical problem that you have a formula to try and solve.
37 M.W.	4	low inconsistent easily distracted	something	P1	prblm=prcd	no	A problem is something that needs an answer but has many or few ways of answering	Problem solving is when you have worked around the obstacles and made it to the finish line
38 A C 2	4	medium-low consistent	question	P2	prblm=prcd	yes	1 problem is a question that there is no answere displayed or you don't know the answer. Even with calculation the problem is fixable.	To use mathematical skills (ie B "H/2) to find out the answer.
39 J L	4	medium-low consistent	equation	P0	prblm=prcd	no	An eqation with numbers	An equation with a situatioon in words.
40 K.T.	5	low inconsistent	question	P2	theoretical	no	A problem to me would be a question without a straightforward answer	Problem solving is solving a question that hasn't got a straightforward answer
41 M.T.	5	low inconsistent easily distracted	equation	P0	prblm=prcd	no	an equation that doesn't have an answer	steps that will lead you towards the right Answer
42 R B 1	5	low consistent	equation	P0	prblm=prcd	no	A problem can be an equation	problem solving is mostly word problems

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Table 1 Master Table

Student	Rank	Perseverance &Work Habits	Classification of a Problem	Personal Attachment	Interpretation of a Problem & Problem Solving	Mention of Methods Used	Problem Definition	Problem Solving Definition
43 T.D.	5	low inconsistent easily distracted	equation	P0	prbm =prcd	no	a problem is an equation	problem solving is when you find the answer to an equation
44 K.M.	5	low inconsistent easily distracted	situation	P0	prbm =prcd	no	A situation that needs to be solved or a situation that's incomplete and it needs to be completed	Problem solving is completeing or "solving" an "problem" or situation. I think "problem solving" defines itself
45 M.R.	5	low inconsistent easily distracted	question	P1	prbm =prcd	no	A problem is a mathematical question that you have to find out in Mathematical terms	Problem solving is a question, and you have to use mathematical sense to prove
46 R.A.	5	low inconsistent	question	P1	theoretical	no	a mathimatical question that involves figuring out problem	An answer that requires a sentence to complete

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Section 3.3: Analysis of Students' Responses

Conclusions

The main conclusions from my analysis of the students' responses were:

1. Students that persevere at solving problems are more likely to succeed.

2. Students that do **not** have a clear idea of what a problem is are less likely to succeed.

3. This study did not find conclusive results that personal attachment to a problem, or the problem solving process effects student achievement. What may be relevant is whether (or not) this personal attachment leads them to persevere (or not) at the problem-solving task.

4. Students that do **not** have a clear idea of what problem solving is, are less likely to succeed.

5. Students that *realize* that they need to have some problem solving tools at their disposal, are more likely to succeed, and persevere.

These results confirmed most of the literature that I have read.

The Relation Between Perseverance and Achievement

Although this relation did not relate to students' *perceptions* of Problems and Problem Solving, I thought it would be interesting to confirm what I already suspected. There is a definite link between a student's perseverance level, and their achievement. We know this as teachers, but it is imperative to point it out to students. I will often hear my weak students earmark achievement to ability. This is also supported in research. North

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Americans are more likely to believe that students have an "innate" ability with regards to mathematics, than say the Japanese, who believe that hard work and effort will get good results. (Schoenfeld 1989). Obviously natural ability helps, but it is a variable that **cannot** be controlled. Perseverance is. Let us look at the results.

Grade vs. Perseverance
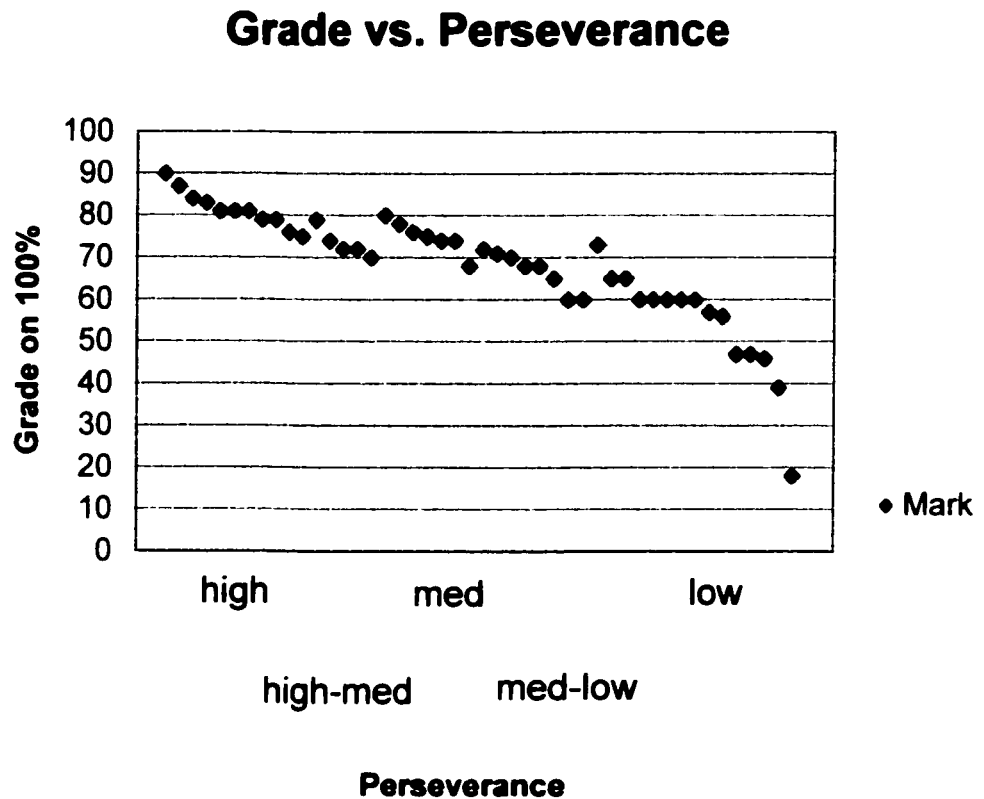
Figure 1: Grade vs. Perseverance Scatter-Plot

(A magnification of this figure can be found in the appendix on page 66.) For the above scatter-plot, I used the student raw scores. A linear function would approximate the data quite nicely. It is obvious that as the level of perseverance declines, so does the student

grade. It would be interesting to share this knowledge with a class. It might encourage

students to want to learn how to persevere.

There are of course a few anomalies which can be found at the boundary of each

classification. We notice jumps at these boundaries. Since these are raw scores of two

different grade levels, one that is streamed, and one that is not, I repeated this scatter-plot,

this time plotting perseverance against rank.

Rank vs. Perseverance
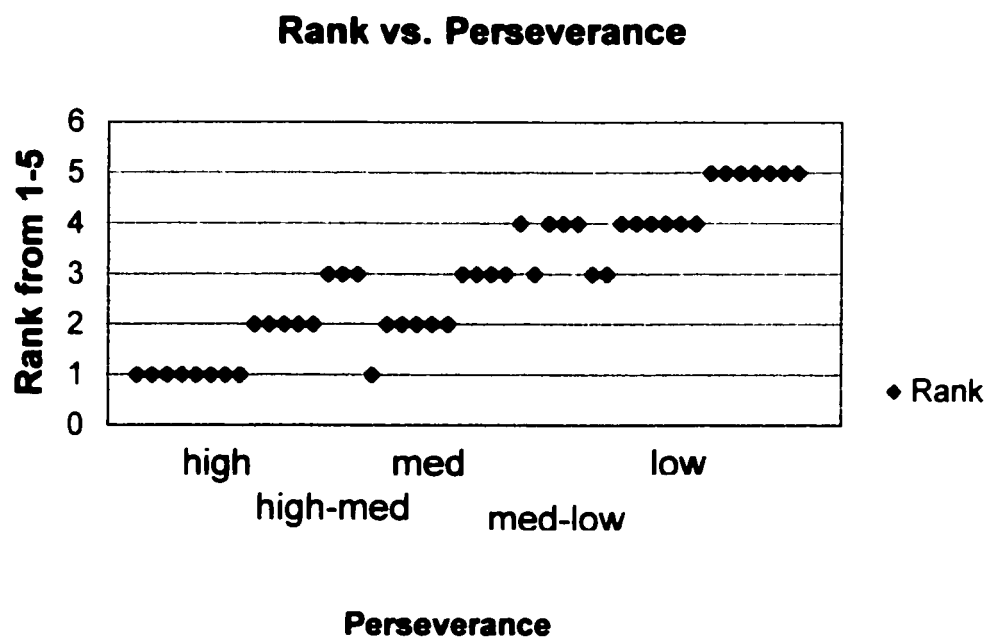
Figure 2: Rank vs. Perseverance Scatter-Plot

(A magnification of this figure can be found in the appendix on page 67.) From the data

we can organize the findings as such:

Perseverance Level	Corresponding Rank
High	1-2
Medium-High	2-3
Medium	1-2-3
Medium-Low	3-4
Low	3-4-5

With this classification, we can see the anomalies more clearly. The medium and low perseverance level has the widest range of dispersion. Please refer to Table 2, (pp. 68-74) in the Appendix. Students in the medium perseverance ranking have very similar approaches to math. The 17th student (first anomaly) M.B.2, is a classic example of the students in this category. She is ranked 1, with medium perseverance and consistent work habits. Also note that M.B.2 interprets problem solving as a procedure in which the answer is found using skills, and knowledge. M.B.2 was rated medium in perseverance because although she does her homework routinely, checks her solutions, will discuss the homework problems with peers, she gets stumped when faced with thought provoking, or difficult problems and will ask for assistance immediately. M.B.2 is the type of student who covers all the material presented in class, and categorizes questions as types. Then in a test situation, if a question matches her "type" she will be able to solve it. However if it does not, she will not attempt it. M.B.2 reviews, and studies well. The same can be said for S.C. (#18), V.T. (#19) M.D (#21) K.B. (#22) and S.J. (#23). S.G.3 (#20) is the only exception. It is my opinion that he should be a rank 1, based on his insight in classroom discussions. But he has his sights on a professional baseball career and math is

not a priority for him. For students in the medium perseverance classification, achievement is related to their ability to prepare for tests effectively.

Students in the low category also have many similar traits. Notice that 9 out of 15 (60%) of these students are rated as quite easily distracted. (It is difficult to persevere when your social life is most important). Also 12 out of the 15 have a weaker understanding of what it means to solve a problem. (I will explore this factor later. For now, suffice it to say that their views are weak). Finally, 14 out of the 15 made **no** mention of different methods available to solve problems. Again it would be difficult to persevere at a problem when alternatives are not available. The two anomalies are A.K. (#32) and M.E. (#33). A.M. (rank 3) would be a rank 4 student if it were not for the 16% homework and organization mark that is incorporated into class marks. She attempts homework on a regular basis, but the homework is most often incomplete – not because of laziness, but low problem solving ability. She does not persevere in any of the other categories presented. According to my scale she could have been a medium-low perseverance, but I chose to place her in low since her homework, although routinely attempted, was always incomplete. The second anomaly was M.E. (#33). He has the opposite problem from A.K. M.E. (rank 3) should be a rank 2. His perseverance story is the same as A.K., however his reason for the lack of perseverance is immaturity, and lack of interest. As long as he is able to show his mom that the homework is "complete," he may *play*. When M.E. finds his calling, I have no doubt that he will succeed.

From these results, I would conclude that, generally speaking, there is conclusive evidence that student achievement is directly related to the student's ability to persevere.

The Relation Between the Classification of a Problem and Achievement

This is where "Phenomenography of Problem Solving" starts. Does what students believe a problem is, influence how they perform? There appears to be a link between low achievers, and their classification of a problem .

Classification Vs. Rank
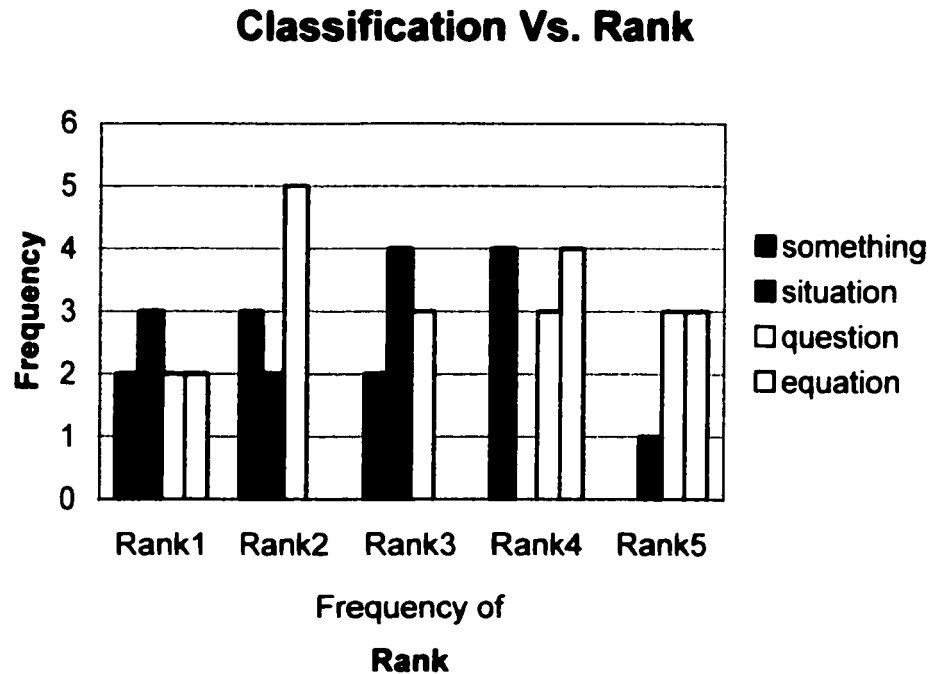
Figure 3: Classification of a Problem vs. Rank Bar Chart

(A magnification of this figure can be found in the appendix on page 75.) From the chart we can organize the findings as such:

Problem Classification	Rank
A Problem is **Something**	1-4
A Problem is a **Situation**	1-3 and 5

| A Problem is a **Question** | 1-5 |
| A Problem is an **Equation** | 1, 4-5 |

Although it may appear that there is no conclusive evidence here, I believe there is for

low achievers. The majority of students, who believe that a problem is an equation, are

low achievers, with the exception of 2 students who are of rank 1. Please refer to Table

3, (pp.77) in the Appendix. If we look at those anomalies, we find M.B.2 (#39) and

S.G.1 (#38). If we read their statements they refer to problems as equations, however

both give further explanations. S.G.1 says a problem "is being asked to *manipulate*

numbers and values *using* an equation." Further still in her definition of problem solving

she believes it to mean "[to] actually apply the equation to manipulate the numbers." She

does not believe that the problem is the equation, rather equations can be used to solve

problems. M.B.2 refers to a problem as "an equation, a group of numbers in need of

being solved." Further she believes problem solving to mean "applying skills and

knowledge to a problem and solving it to finding the answer." I believe both these

students believe equations are tools. M.B.2 and S.G.1's responses are in stark contrast to

the other students (in this grouping) who specifically state, "problems are equations that

need to be solved." These students seem to believe that problems are arithmetic in

nature. It is not surprising that the weaker students would have this perception. They

tend to also be in the medium to low perseverance rank. If these students see problems as

equations, then when they read word problems (for instance), if an equation does not

jump out at them, they will not persevere, and hence perform poorly. Again with the

exception of S.G.1 and M.B.2, all students in this grouping have a weaker interpretation

of problem solving. (Again, I will detail "weak" and "strong" interpretations of Problem

Solving later. For now it is suffice to say that they are weak interpretations).

Classifying a problem as a situation, is probably the most abstract view. With the

exception of one student, only those students who ranked 3 and above used this

classification. The anomaly is K.M. (#21), who has a ranking of 5. I believe K.M. is

capable of achieving a rank of 3, if it were not for personal problems that interfered with

her school work. She would be the type of student that has trouble persevering, but who

could memorize different types of problems, and effectively write tests. This year K.M.'s

parents have decided to get divorced. K.M. was forced to switch schools. I am not

surprised that K.M. sees problems as situations. However, I am not convinced that she

would see problems in the abstract sense. Her classification is more likely due to her

current life events. Her real life problem has affected her view of problems in general.

The most common classification (35%) of a problem is that it is a question. Most

exercises that students are asked to solve in school are in the form of a question. I

suspect the visual representation that comes to mind when students reflect on problems,

is a text book question, or an exam question. It is not surprising that so many of them

made this reference.

Suppose that we are to regroup these classifications even more. I believe that viewing

problems as a "situation", or "something" is more abstract, or "open." It could mean that

a problem would encompass, a difficult question, a word problem, a calculation, a

dilemma, an obstacle... Whereas viewing a problem as a "question" or an "equation" is more concrete or "closed." The following bar chart provides a visual of this "open" and "closed" classification.

Classification vs. Rank
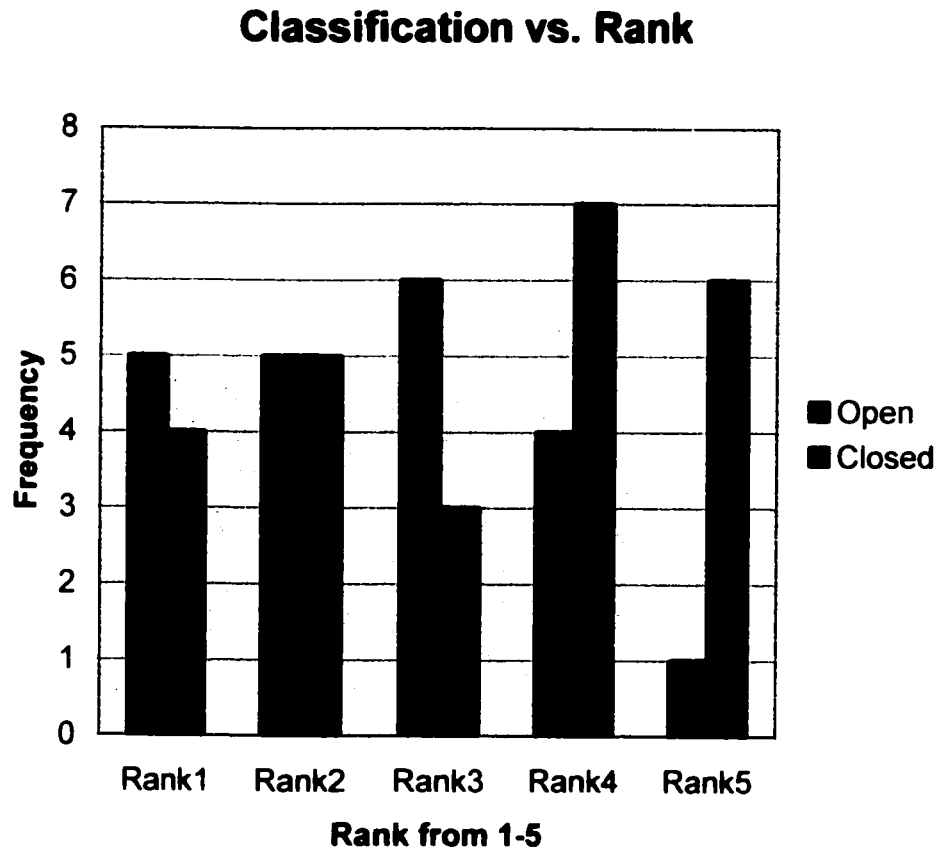

Figure 4: Classification vs. Rank (regrouped) Bar Chart

(A magnification of this figure can be found in the appendix on page 76.)

There are definitely more students in the lower ranks that have a closed view of a problem. But I can't say that any concrete conclusions can be made about stronger students. There is an almost even split between those who have an open view on the classification of a problem (46%) and those that have a closed view (54%).

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One last interesting remark: Out of the 46 students surveyed, all but 4 believed that a problem has a solution, an answer, could be completed, overcome, or figured out. I must admit that I did not present any problems during the year that did not have solutions. Over the past 11-12 years of their mathematical experience, I doubt they came across many problems that were not solvable. I suspect this belief also comes from the naivety of youth.

The Relation Between Personal Attachment and Achievement

Without a doubt this was the most painstakingly difficult part of my analysis. There is no apparent relation between a student's personal attachment to problems or the problem solving process, and their achievement. As mentioned earlier, there is a definite difference in the manner in which students express their definitions of problems and problem solving. Some students seemed to take ownership of the problems, while others remained completely detached. My objective in this section of the analysis was to discover if students who appeared to have a personal attachment to solving problems, performed better than (or worse) than those who did not. I was pursuing the answer to two opposing beliefs. If one detaches himself or herself from the problem, he or she is more likely to find a solution because the problem is not about them, but about the solution. Alternatively a student could have a personal attachment to problem solving. In such case the student would show greater commitment, thus perform better. Neither of these points of view were proven more effective, or ineffective. Below is the graph of

my results. These results come from Table 4, Personal Rank Sort, (pp. 88-94) found in

the Appendix

Personal Attachment Vs. Rank
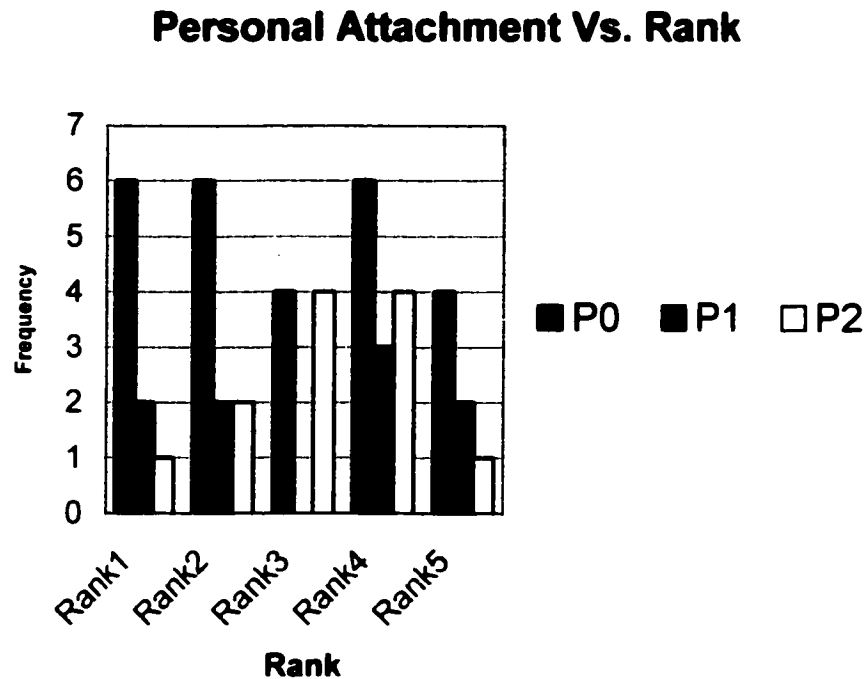
Figure 5: Personal Attachment vs. Rank Bar Chart

(A magnification of this figure can be found in the Appendix on page 84.)

Almost all three personal attachment classifications, PO (no personal attachment),

P1(some personal attachment), and P2(much personal attachment) are distributed across

all ranks. I proceeded to see if there existed a relation between a student's perseverance

and their personal attachment to problems, or the problem solving process. An

interesting outcome presented itself.

Personal Attachment Vs. Perseverance
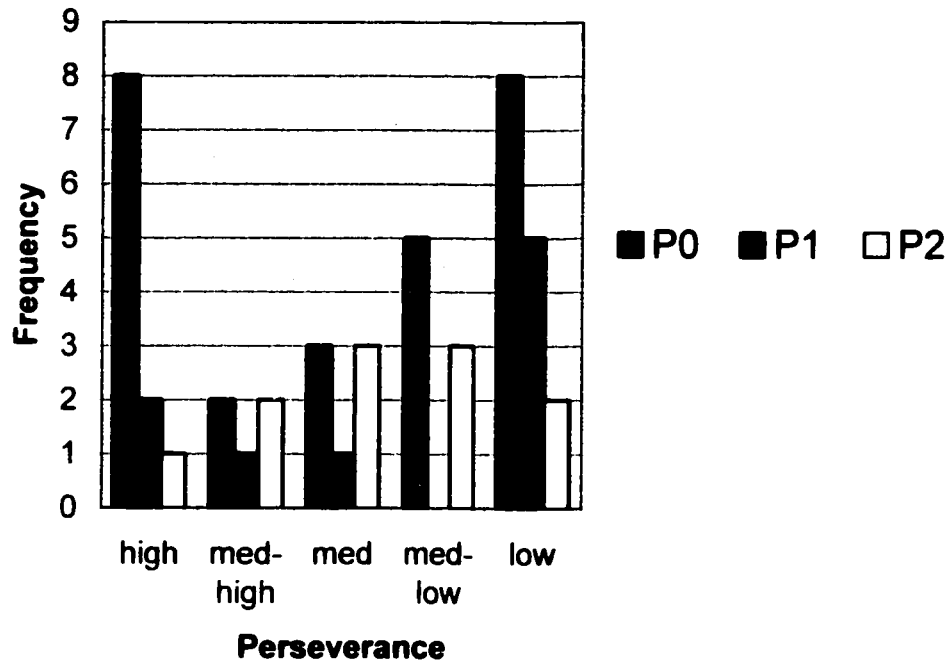
Figure 6: Personal Attachment vs. Perseverance Bar Chart

(A magnification of this figure can be found in the Appendix on page 85.)

Students with less personal attachment to problems and problem solving seem to

persevere either much more or much less. This led me to wonder if there is actually no

need for students to become personally involved in the problem solving process at all.

Instead, perhaps the key to success solely lies in perseverance. a skill which can be

taught. To discover further evidence of this theory, I regrouped the student responses. I

took all students (35 in all) with little or no (P1 & P0) personal attachment to problems or

the problem solving process, and looked at the relation between their rank and

perseverance.

Perseverance vs. Rank
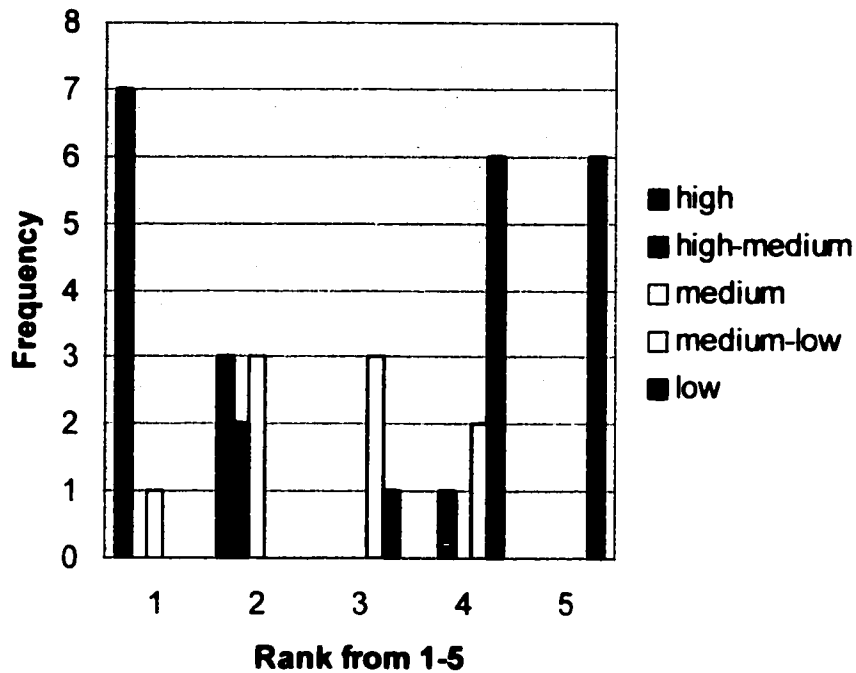
Figure 7: P1 P0 Perseverance vs. Rank Bar Chart

(A magnification of this figure can be found in the Appendix on page 86.)

We see this extreme situation again. Many students, with little or no personal attachment to problems or problem solving, with high perseverance ranked high, and students with low perseverance ranked low. Compare this chart to those of the students with a personal attachment (students in the P2 category) below.

Perseverance vs. Rank
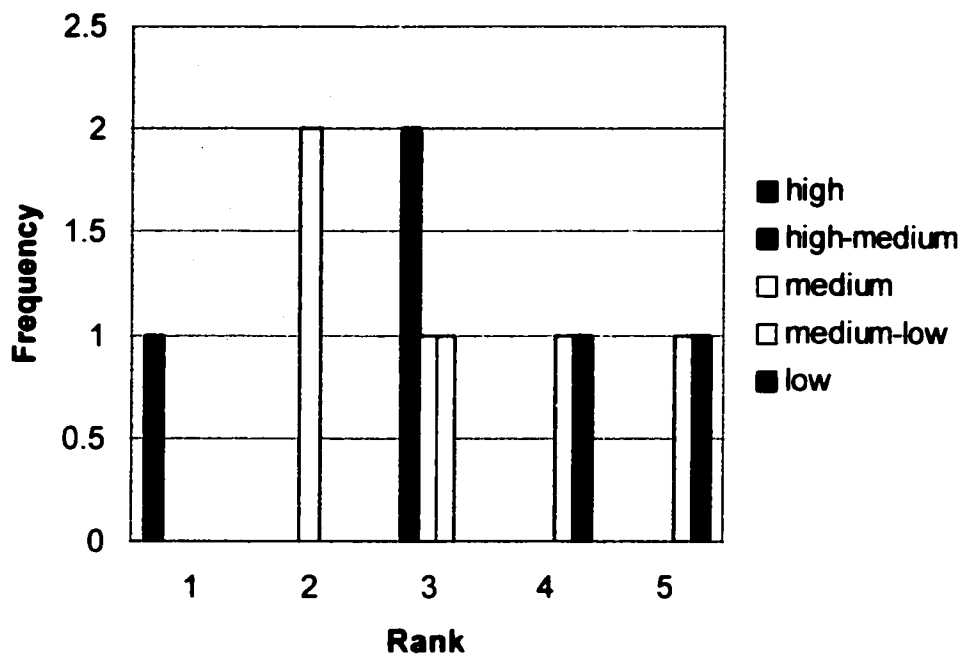
Figure 8: P2 Perseverance vs. Rank Bar Chart

(A magnification of this figure can be found in the Appendix on page 87.)

Not too much can be said about students who have a personal attachment to problems, or problem solving. It is difficult to draw conclusions from either of these data sets, as the sample sizes start becoming increasingly small. The P2 groups consist only of 11 students.

This section did not present apparent conclusions, however it did point out areas of further interest and research. Is it possible that students should actually detach themselves from the actual problem, and focus more on learning strategies to solve problems?

Relation between the Interpretation of Problem Solving and Achievement

The final two sections of this study have proved to be the most rewarding. Here I analyze

whether a student's interpretation of problem solving will effect his or her achievement.

The answer is yes, but again, primarily if they have a **weaker** understanding. Students

either gave answers that were theoretical in nature, or procedural in nature. Table 5,

Interpretation Rank Sort, (pp.96-102), located in the Appendix illustrated the following

results.

Interpretation Vs. Rank
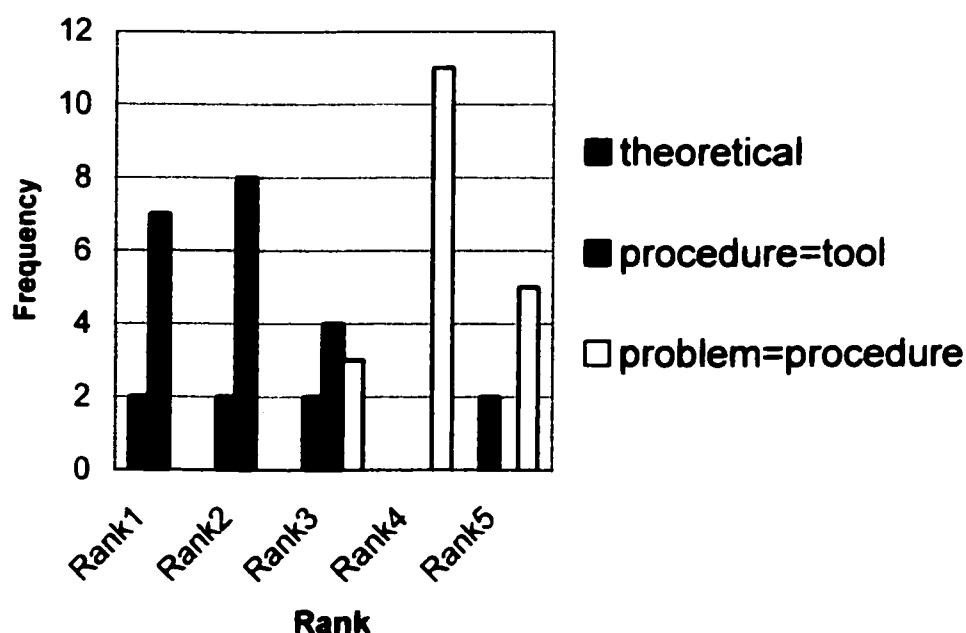
Figure 9: Interpretation vs. Rank Bar Chart

(A magnification of this figure can be found in the Appendix on page 95)

Notice that students with a theoretical view of problem solving did not necessarily

achieve better or worse. This was an interesting finding, as I have long had the ideal that

it is absolutely necessary to have a conceptual view of subject material in order to fully

understand, and hence succeed. A current research study of "Relationships Between Theoretical Thinking and High Achievement in Linear Algebra" (Sierpinska 2002), concluded that:

> "assessment in these linear algebra courses did not strongly discriminate between theoretically and practically minded students, and therefore, high achievement did not imply understanding of linear algebra Not only understanding was not a necessary condition of high achievement, but being unable to temporarily suspend understanding while learning "small steps" was such a traumatic experience for one of the students that she decided to give up mathematics altogether."

This observation certainly confirmed my findings.

The findings that are most interesting from this chart is that students with a procedural approach to solving problems have two distinct views:

1. Students believe that a procedure is a *tool* to solving a problem (denoted by the abbreviation prcd.=tool).

2. Students believe that the problem is itself a procedure (denoted by the abbreviation prbm.=prcd.).

These perceptions strongly influence their achievement. Students with the first belief, rank in the top three, whereas students with the second belief rank in the last three. There are no exceptions in this data. Students who believe that a problem is itself a procedure have a weaker understanding of problem solving. They also persevere less-90% of these students are rated at a perseverance level of medium-low to low. Again not surprising since there is a direct relation between perseverance and achievement. Intrinsically

speaking, it would seem logical that students who don't have a clear understanding of what it means to solve problems cannot persevere, because they would not know how to persevere. I think these results prove to be the strongest indicators that in fact, there does exist a strong relationship between a student's perception of problem solving, and their achievement.

Relation Between Mention of Methods Used and Achievement

Finally, I wanted to know if my students were "ingesting" that "bank of mathematical knowledge" that I was trying so desperately to teach them, or if they were internalizing that they were learning some math skills, which would be used to problem solve. As such, I sorted (Table 6, Methods Mentioned Rank Sort, pp.104-110) the students in two categories.

1. In the "yes"(43%) category students made mention of the availability of formulae, skills, equations... in either their definition of a problem, or problem solving.

2. In the "no" (57%) category students made no mention at all of any method available to solve problems in either one of their definitions.

The chart below depicts the results of this classification.

Methods Used vs. Rank
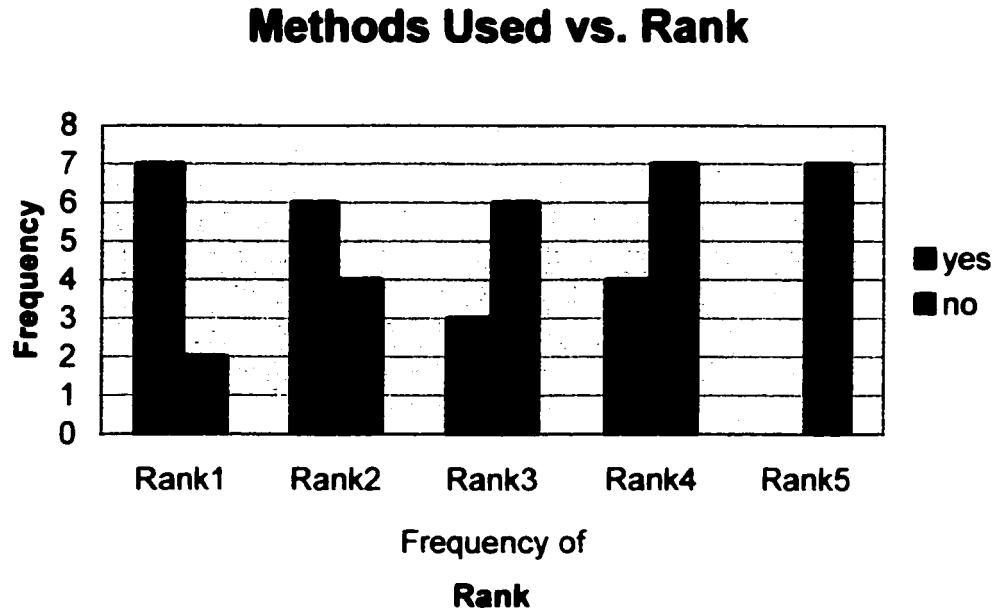
Figure 10: Methods Mentioned vs. rank Bar Chart

(A magnification of this figure can be found in the Appendix on page 103.)

These results are almost symmetric. Students in a higher ranking are more likely to make mention of methods that are available to solve problems than students in a lower ranking. Students that perceive problem solving as a process that needs some "tool"; an equation. manipulation, a formula, skills, knowledge, logic, operations, are more likely to achieve greater results. Just over half (55%) of the students who fall into the "yes" category fall into the high to high-medium perseverance range. Again intrinsically this makes sense as students who recognize that there are a variety of different techniques, also recognize that problem solving is about perseverance.

These last two findings might persuade students that achievement is far more linked to perseverance than it is ability, and in turn change perception.

Chapter IV

Conclusions and Recommendations

Conclusions

My aspiration for this research was to determine, through a pilot study, if there exists a relation between what students *believe* a Problem and Problem Solving is, and their actual achievement in mathematics. My analysis brought forth the following conclusions.

The Relation Between Perseverance and Achievement

Generally speaking, there is conclusive evidence that student achievement is directly related to the student's ability to persevere. The greater the perseverance levels, the greater the student achievement. Students with medium perseverance levels are able to effectively write tests. Students in the lower perseverance levels have two common traits; they tend to be more easily distracted and they have a weaker understanding of what it means to solve a problem. As such it should be a primary goal for teachers to provide students with strategies to be able to persevere with problem solving.

The Relation Between the Classification of a Problem and Achievement

Most low achievers see problems as equations that need to be solved. The majority of students thought problems were questions. Almost all students thought that problems have solutions. It is vital for teachers to point out the difference between textbook rote questions intended to give students practice in mastering a procedure, and true problems that are meant to challenge and provoke interest in a student. If students are truly to

understand what a mathematical problem is, they need to explore a variety, including those with no answers.

The Relation Between the Personal Attachment and Achievement

The data from this study found inconclusive results relating personal attachment to achievement. There is some evidence that suggests students who are more detached from problems and problem solving seem to persevere either **much** more or **much** less. But the sample sizes were small. In eastern culture it is believed that success only comes to those that are completely detached from the *results* of an action. I wonder if this plays a role here. This could be an area of further research.

The Relation Between the Interpretation of Problem Solving and Achievement

Students have either a theoretical or procedural approach to mathematical problem solving. Those with a theoretical understanding do not necessarily achieve better or worse. Students with a procedural approach tend to achieve better results if they perceive the procedure as a tool in the problem solving process. Perseverance levels are low in students with a weak interpretation to problem solving. Clearly some students would benefit from changing their misperceptions. It would be interesting to ask whether or not students believe problem solving can be learned, or if it is an innate ability.

The Relation Between the Mention of Methods Used and Achievement

Students that make mention of methods that can be used to solve problems are more likely to suceed, than those who do not. Moreover those students are also more likely to

persevere in solving problems. Although students are taught many different skills to

solve problems, the majority of them, (57%) do not make mention of these skills.

Recommendations

The analysis in this study illustrates that a phenomenographical approach to problem solving, that is a study of students' perceptions of Problems and Problem Solving, will present insight to students past experience with problems and solving problems, and their beliefs of the same. The next step would be to discover if it would be possible to alter these perceptions. I would not presume to make recommendations based on these results. Although this study did present some area where further research is needed.

To alter perceptions, would require a longer time frame than the one that was used for this study. It would be ideal to follow students through their secondary school experience, however one full school year might show some improvement. The teacher should discover what his or her students know about problems and problem solving from the beginning of the year.

"The most important single factor influencing learning is what the learner already knows. Ascertain this and teach accordingly"(Ausubel, D.P. 1968).

Since perseverance has a direct relation with achievement, I would suggest that students be asked how much time they would spend to solve a problem. It would then be necessary to provide students with problems that require more than a few minutes to solve. Many students were not able to persevere, simply because they did not know how. It would be necessary for the teacher to model perseverance strategies, or problem solving strategies. One such approach is to use research findings, and resources, such as George Polya's book, "How To Solve It." The NCTM has produced three volumes especially focused on Problem Solving, "Problem Solving in School Mathematics,"

a1980 Yearbook, "Teaching Learning-A Problem Solving Focus," and "The Teaching and Assessing of Mathematical Problem Solving," not to mention the numerous articles that can be found in its magazines. There are also seemingly endless volumes from many other sources. The attitude taken by the teacher will be the most influencing factor. If a teacher believes in a problem solving approach, it will greatly influence the class' attitudes (Cooney, 1985; Thompson, 1985, in Schoenfeld, 1992). One probable stumbling block will be the time factor. Teachers have a limited amount of time to teach the content at hand. It is difficult, and somewhat frightening to bring new techniques into the classroom. Even without these time constraints, they them selves need to take the time to research, set up, implement and test these techniques. Volumes of research has been documented on the topic of problem solving, but not much of this research finds its way back to the class.

Trying to change one's perceptions of problem solving is however a grand and perhaps even arrogant goal. The small inquiry of Phenomenography has pointed out that students' perceptions are made up of a reality which encompasses the aggregate of all of their experiences positive and negative. Teaching skills in problem solving could indeed give students another tool that they may use to help in their achievement. But the experience that a student will receive from this is just one experience amongst all the many that already exist in their reality. So maybe it is not at all possible to change one's perception of problem solving, but to add a positive experience to their reality with the hope that one day they will be able to draw on this experience.

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<u>Appendix</u>

Figure 11: Magnification of Grade vs. Perseverance Scatter-Plot

Grade vs. Perseverance
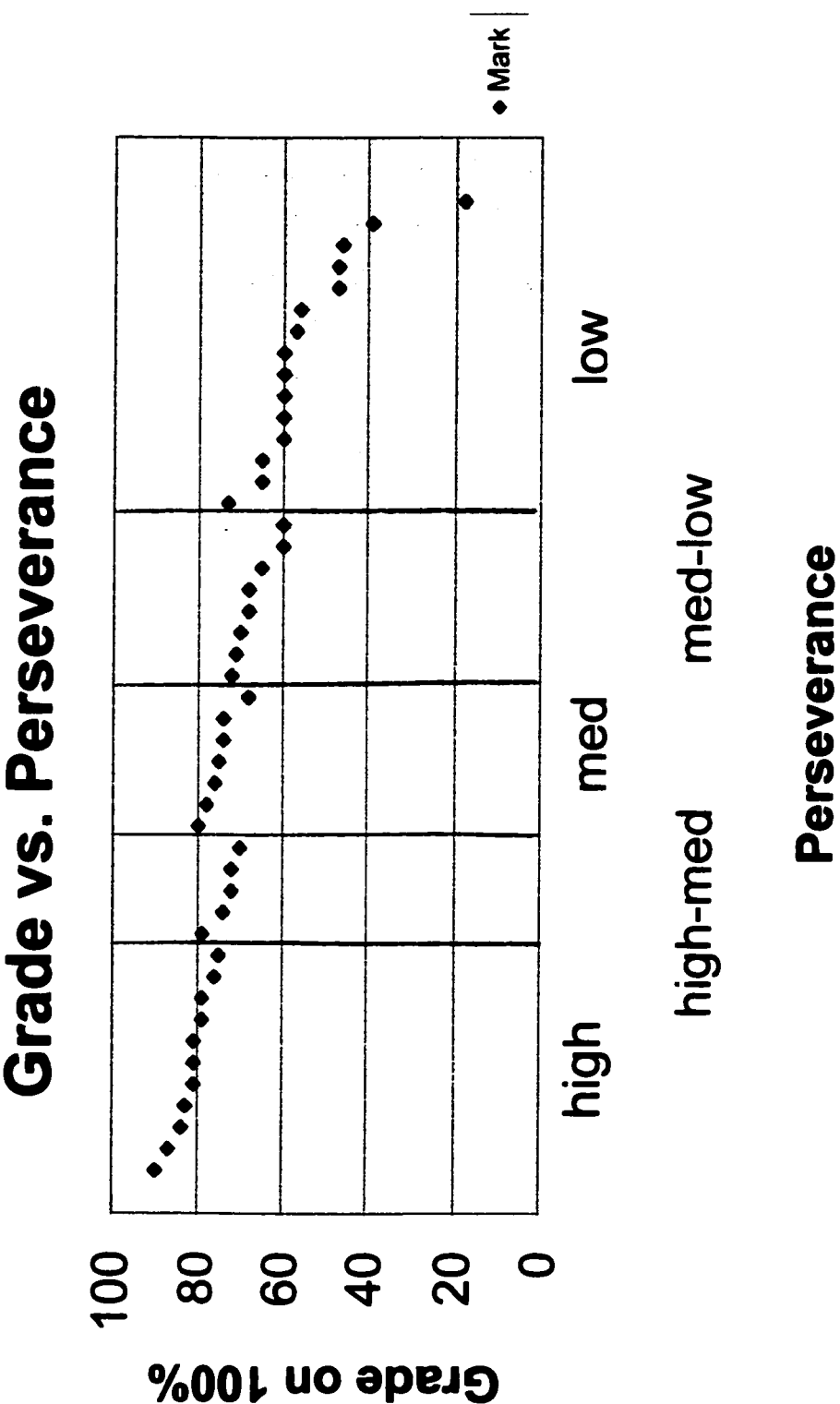
Figure 12: Magnification of Rank vs. Perseverance Scatter-Plot
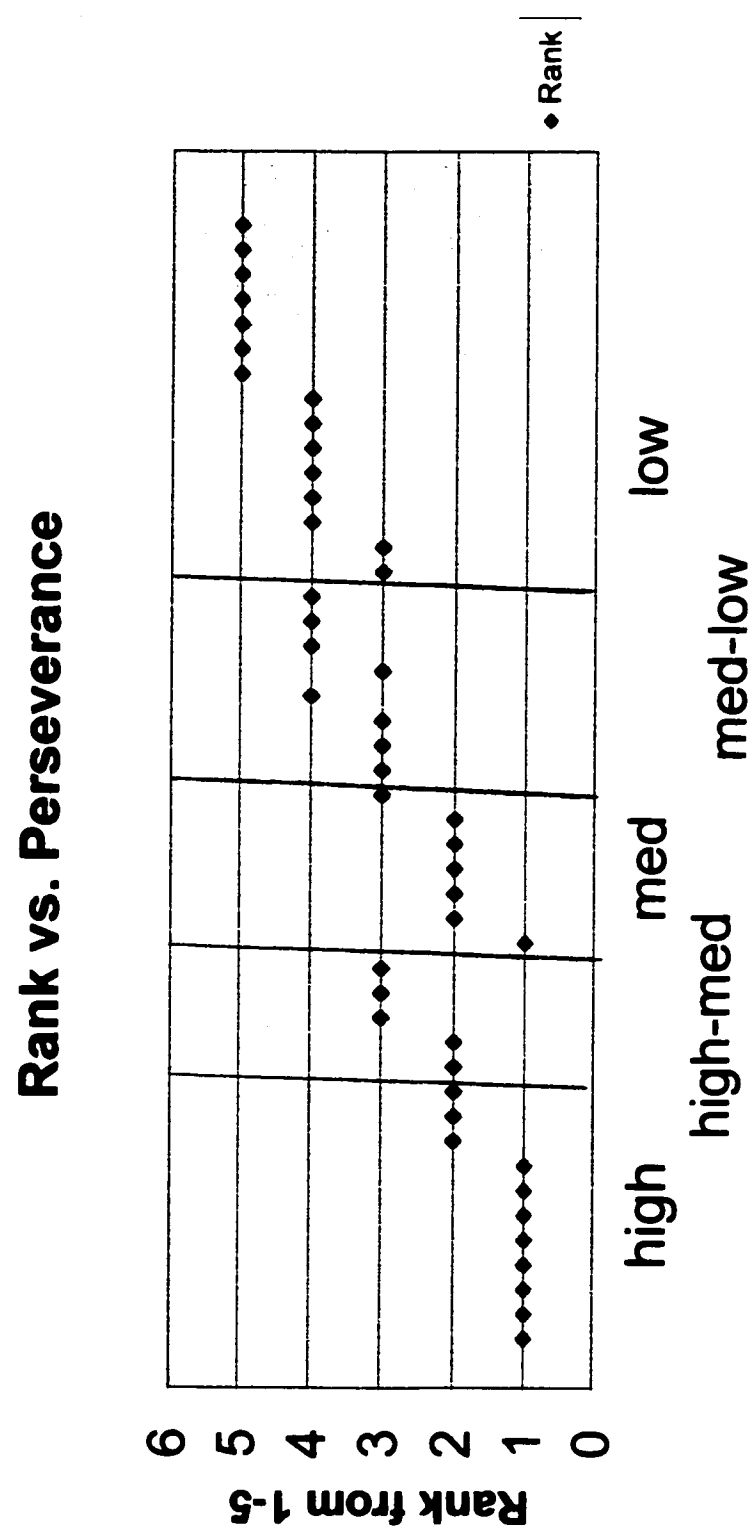
Rank vs. Perseverance

Table 2 Perseverance and Rank Sort

	Student	Rank	Perseverance & Work Habits	Classification of a Problem	Personal Attachment	Interpretation of a Problem & Problem Solving	Mention of Methods Used	Problem Definition	Problem Solving Definition
1	T.M.	1	high consistent	question	P2	prcd =tool	yes	A problem is a question, that to solve it, you really need to think and use your mathematical knowledge to solve it.	Problem solving is using your knowledge to figure out a question
2	V.E	1	high consistent	situation	P0	theoretical	no	A problem is a situation in which something is unknown and must be figured out	Problem solving is finding the solution to the problem, solving the unknown and finding the answer
3	A.W.	1	high consistent	situation (missing part of story or equation)	P0	prcd =tool	yes	A missing part in an equation or a story problem is to find it.	The Finding the logic way to find the answer. If there is a way of solving the problem. Finding the missing part (logically)
4	V.M.	1	high consistent	question	P0	theoretical	yes	A problem in a mathematical sense is a question or a statement for which you need to problem use mathematics to solve	The steps it takes to eventually solve the problem
5	S.G 1	1	high consistent	equation	P0	prcd =tool	yes	is being ask to manipulate numbers and values using an equation	Problem solving is the use of mathematics to solve a mathematical problem
6	M.F	1	high consistent	something	P1	prcd =tool	yes	A problem is something without an answer that you have to solve.	Solving (in a mathematical sense) means actually apply the equation to manipulate the numbers
7	L.H	1	high consistent	situation	P0	prcd =tool	no	it's a mathematical situation of variables that can be made more simple	Problem Solving is when you try to figure out the answer to a question using different methods

Table 2 Perseverance and Rank Sort

Student	Rank	Perseverance & Work Habits	Classification of a Problem	Personal Attachment	Interpretation of a Problem & Problem Solving	Mention of Methods Used	Problem Definition	Problem Solving Definition
8 A.M.1	1	high consistent	something	P0	prcd =tool	yes	A problem is something has to be solved It is it's the process of making the mathematical a quest that must be answered using situation more simple/ mathematical formulas.	
9 R.M.	2	high consistent	something	P0	prcd =tool	no	something that requires a solution	Solving a problem.
10 S.M.	2	high consistent	something	P1	prcd =tool	yes	a problem is something that you try to solve to figure out the solution Equation that needs to be solved and variables that come together to form an answerer	Problem Solving is finding the solution to a question
11 M.B.1	2	high consistent	question	P0	theoretical	no	A problem is a question that you need to problem solving is using mathematical answer	formulas to solve something.
12 N.S	2	high-medium consistent	something	P1	prcd =tool	yes	a problem is something where you have to find/solve sumthing a problem has something missing, which you have to find	problem solving is solving a problem using many different formulas, whether you are solving for x, finding an angle, or a word problem
13 S.G.2	2	high-medium consistent	question	P0	prcd =tool	yes	A problem is a Mathematical Question that needs to be solved by following a series of question by using a series of steps	Problem Solving is answering a mathematical
14 S.R	3	high-medium consistent	situation (goal/ obstacle)	P2	prcd =tool	yes	A problem is somewhat like having a goal, but there's an obstacle(the problem)that stands in your way and in order to achieve your goal you need to overcome the obstacle(the problem)	By using tricks and stuff you've learned throughout your education you can solve a problem or a calculation. This is known as problem solving

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Table 2 Perseverance and Rank Sort

Student	Rank	Perseverance &Work Habits	Classification of a Problem	Personal Attachment	Interpretation of a Problem & Problem Solving	Mention of Methods Used	Problem Definition	Problem Solving Definition
15 A.M.2	3	high-medium consistent	question	P0	prbm.=prcd	no	I think a problem is a question with variables problem solving is filling in the blanks missing and you need to answer with the variable (fill in the blanks)	
16 J.K	3	high-medium inconsistent	question	P2	prcd =tool	yes	A problem is essentially a question lacking a solution, a question that you must break down, analyze it and, use basic or compund operations to find a solution.	The process of breaking down a problem, analyzing it and, using basic operations, make a answer or amount that can be easily interpreted by the human mind, essentially a representation of an undefined amount.
17 M.B.2	1	medium consistent	equation	P1	prcd =tool	yes	an equation, a group of numbers in need of being solved	of applying skills and knowledge to a problem and solving it, finding the answer
18 S.C	2	medium consistent	question	P0	theoretical	no	a question or a statement/asking in numbers or by words	a answer to a question or a statement in numbers or in words)
19 V.T	2	medium inconsistent easily distracted	question	P0	prcd =tool	yes	A problem is an arithmatical question with givin equation is needed to be found	problem solving is a procedure with steps to values to which, a certain value, measurement which we want to find the missing value, solve the problem. By using equations, multiplying, dividing, adding, subtracting.
20 S.G.3	2	medium inconsistent easily distracted	question	P0	prcd =tool	no	A question that you need to answer	A series of steps used to find the answer to a problem
21 M.D	2	medium consistent	situation (dilemma)	P2	prcd =tool	yes	A problem is a dilemma that has to be solved by doing an equation	Problem solving is when you are trying to find a solution to your problem

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Table 2 Perseverance and Rank Sort

Student	Rank	Perseverance & Work Habits	Classification of a Problem	Personal Attachment	Interpretation of a Problem & Problem Solving	Mention of Methods Used	Problem Definition	Problem Solving Definition
22 K.B.	2	medium consistent	situation	P2	prcd =tool	yes	A problem is a mathematical situation, where variables are given. You must solve this problem with your knowledge	Problem Solving is figuring out the sense behind a mathematical situation
23 S.J.	3	medium consistent	something	P2	prbm =prcd	yes	A problem in my opinion is variables that has to be solved. It is something that you don't understand but can use your mind and figure it out	Problem Solving is how you solve the problem The steps to take to come to your answer
24 J.C.	3	medium-low inconsistent	situation	P2	prbm =prcd	no	A problem comes in one or more sentences that makes you think of a situation. The points of this situation are gathered in thought, and are used to conclude the "problem."	Problem Solving is a complex situation, you many would have to explain the calculations made for your conclusion
25 D.W.	3	medium-low inconsistent easily distracted	situation	P0	prcd =tool	no	A problem is a situation which must be solved to aquire an answer.	Problem solving are the steps taken to solve a problem.
26 C.J.	3	medium-low consistent	situation	P0	prcd =tool	no	A series of words, equations, or numbers placed together in a situation were an answer is not clear	Proses of finding the answer to a problem.
27 B.A	3	medium-low inconsistent	question	P0	theoretical	no	Normally in the form of a question	Figuring out a question
28 J.L.	4	medium-low consistent	equation	P0	prbm =prcd	no	An eqation with numbers	An equation with a situatioon in words.

Table 2 Perseverance and Rank Sort

Student	Rank	Perseverance & Work Habits	Classification of a Problem	Personal Attachment	Interpretation of a Problem & Solving	Mention of Methods Used	Problem Definition	Problem Solving Definition
29 A.C.1	4	medium-low inconsistent	equation	P0	prbm =prcd	yes	A problem is a equation where you are to find the solution	A problem solving is a equation that you must use a mathematical formula to get the solution
30 A.C.2	4	medium-low consistent	question	P2	prbm =prcd	yes	1 problem is a question that there is no answers displayed or you don't know the answer Even with calculation the problem is fixable	To use mathematical skills (ie B *H/2) to find the out the answer.
31 C.K	4	medium-low inconsistent	something	P2	prbm =prcd	yes	A problem is something that needs to be solved Its something that you need to solve	problem Solving is when you mathematically find the answer to a question or solve that is unknown
32 A.K.	3	low consistent	something	P2	prbm =prcd	no	A problem is something that needs to be solved When faced with a problem especially in math it is an obstacle that can be conquered Math is full of problems whether they are arithmetic or words problems, we all face them each day. Some thing you have to solve	Problem solving is the solution to a problem It is after working on a problem, the solution In math we are generally faced with word problems and then we have to solve them Problem solving comes in handy when we have to face the obstacle Some thing you have to solve
33 M.E	3	low consistent	something	P0	theoretical	no	a problem is something that must be solved. problem solving is a mathematical Question not solving a problem a people question	
34 V.P.	4	low inconsistent easily distracted	something	P0	prbm =prcd	no	a problem is something that must be solved. problem solving is the mathematical way of with numbers it's a mathematical Question not solving a problem it's a way of showing your a people question steps	
35 F.S	4	low inconsistent easily distracted	question	P1	prbm =prcd	yes	a mathematical question which you are challenged to find the answer	A mathematical problem that you have a formula to try and solve.

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Table 2 Perseverance and Rank Sort

Student	Rank	Perseverance & Work Habits	Classification of a Problem	Personal Attachment	Interpretation of a Problem & Problem Solving	Mention of Methods Used	Problem Definition	Problem Solving Definition
36 M.W	4	low inconsistent easily distracted	something	P1	prbm = prcd	no	A problem is something that needs an answer	Problem solving is when you have worked around the obstacles and made it to the finish line
37 C.C	4	low inconsistent	question	P1	prbm = prcd	no	A problem is a question and you have to answer it	problem solving is a question that you have to answer, like a sentence and solve it.
38 T.W	4	low inconsistent easily distracted	equation	P0	prbm = prcd	no	A problem is an unsolved equation that needs to be worked on to get an answer	problem solving are the steps you take in solving a mathematical problem or equation
39 R.B.2	4	low inconsistent equation very easily (variables) distracted	easily (variables)	P0	prbm = prcd	no	two valuable that come to gether to create an the solution to two variables answer	
40 R.B.1	5	low consistent	equation	P0	prbm = prcd	no	A problem can be an equation	problem solving is mostly word problems
41 M.T	5	low inconsistent easily distracted	equation	P0	prbm = prcd	no	an equation that doesn't have an answer	steps that will lead you towards the right Answer
42 K.T	5	low inconsistent	question	P2	theoretical	no	A problem to me would be a question without a straightforward answer	Problem solving is solving a question that hasn't got a straightforward answer

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Table 2 Perseverance and Rank Sort

Student		Rank	Perseverance & Work Habits	Classification of a Problem	Personal Attachment	Interpretation of a Problem & Problem Solving	Mention of Methods Used	Problem Definition	Problem Solving Definition
43	R.A	5	low inconsistent	question	P1	theoretical	no	a mathmatical question that involves figuring out problem	An answer that requires a sentence to complete
44	T.D	5	low inconsistent easily distracted	equation	P0	prbm =prcd	no	a problem is an equation	problem solving is when you find the answer to an equation
45	K.M	5	low inconsistent easily distracted	situation	P0	prbm =prcd	no	A situation that needs to be solved or completed	a Problem solving is completeing or "solving" an situation that's incomplete and it needs to be incomplete "problem" or situation I think "problem solving" defines itself
46	M.R	5	low inconsistent easily distracted	question	P1	prbm =prcd	no	A problem is a mathematical question that you have to find out in Mathematical terms	Problem solving is a question, and you have to use mathematical sense to prove

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Classification Vs. Rank

Figure 14: Magnification of Classification vs. Rank (regrouped) Bar Chart

Classification vs. Rank

Table 3 Classification and Rank Sort

Student	Rank	Perseverance & Work Habits	Classification of a Problem	Personal Attachment	Interpretation of a Problem & Problem Solving	Mention of Methods Used	Problem Definition	Problem Solving Definition
A.M.1	1	high consistent	something	P0	prcd =tool	yes	A problem is something has to be solved It is a quest that must be answered mathematical formulas	problem solving is using mathematical using formulas to solve something
M.F	1	high consistent	something	P1	prcd =tool	yes	A problem is something without an answer that you have to solve	Problem Solving is when you try to figure out the answer to a question using different methods.
S.M	2	high consistent	something	P1	prcd =tool	yes	a problem is something that you try to solve figure out the solution Equation that needs to be solved and variables that come together to form an answerer	Solving a problem
R.M	2	high consistent	something	P0	prcd =tool	no	something that requires a solution	The steps it takes to eventually solve the problem
N.S	2	high-medium consistent	something	P1	prcd =tool	yes	a problem is something where you have to problem solving find/solve sumthing a problem has something missing. which you have to find	solving is solving a problem using many different formulas, whether you are solving for x, finding an angle, or a word problem
M.E	3	low consistent	something	P0	theoretical	no	Some thing you have to solve	Some thing you have to solve
S.J	3	medium consistent	something	P2	prbm =prcd	yes	A problem in my opinion is variables that has to be solved It is something that you don't understand but can use your mind and figure it out	Problem Solving is how you solve the problem The steps to take to come to your answer

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Table 3 Classification and Rank Sort

Student	Rank	Perseverance & Work Habits	Classification of a Problem	Personal Attachment	Interpretation of a Problem & Problem Solving	Mention of Methods Used	Problem Definition	Problem Solving Definition
8 A.K.	4	low consistent	something	P2	prbm = prcd	no	A problem is something that needs to be solved. When faced with a problem especially it is an obstacle that can be conquered. Math is full of problems whether they are arithmetic or words problems, we all face them each day	Problem solving is the solution to a problem. It is after working on a problem, the solution in math we are generally faced with word problems and then we have to solve them. Problem solving comes in handy when we have to face the obstacle.
9 C.K.	4	medium-low inconsistent	something	P2	prbm = prcd	yes	A problem is something that needs to be solved. Its something that you need to solve	Problem. Solving is when you mathematically find the answer to a question or solve that is unknown
10 V.P.	4	low inconsistent easily distracted	something	P0	prbm = prcd	no	a problem is something that must be solved. Its a mathematical Question not a people question	problem solving is the mathimatical way of solving a problem. It's a way of showing your steps
11 M.W.	4	low inconsistent easily distracted	something	P1	prbm = prcd	no	A problem is something that needs an answer but has many or few ways of answering	Problem solving is when you have worked around the obstacles and made it to the finish line.
12 A.W.	1	high consistent	situation (missing part of story or equation)	P0	prcd = tool	yes	A missing part in an equation or a story. The problem is to find it	Finding the logic way to find the answer. If there is a way of solving the problem. Finding the missing part (logically)
13 V.E.	1	high consistent	situation	P0	theoretical	no	A problem is a situation in which something is unknown and must be figured out	Problem solving is finding the solution to the problem, solving the unknown and finding the answer.
14 L.H.	1	high consistent	situation	P0	prcd = tool	no	It's a mathematical situation of variables that can be made more simple	Problem solving is the process of making the mathematical situation more simple/

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Table 3 Classification and Rank Sort

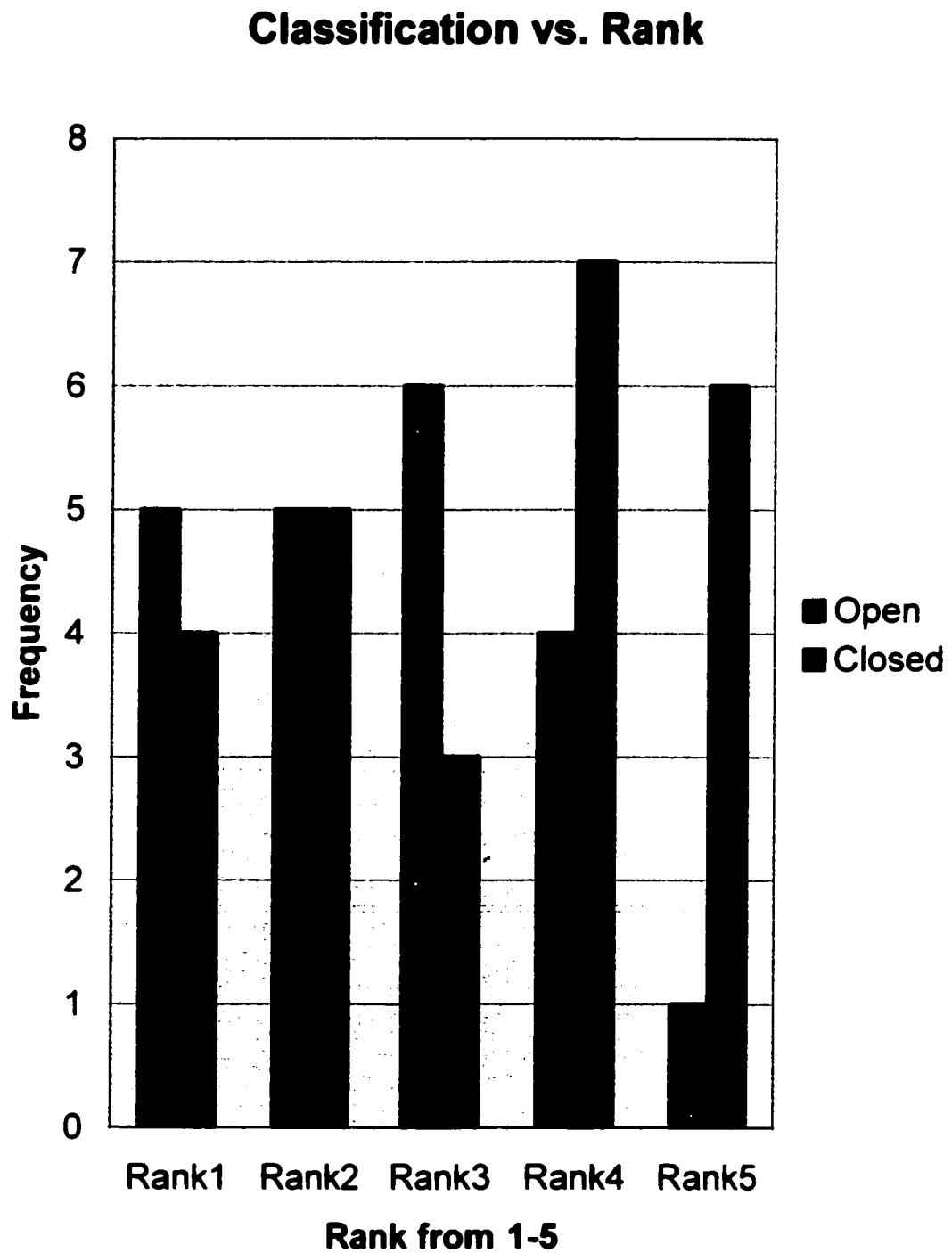| Student	Rank	Perseverance & Work Habits	Classification of a Problem	Personal Attachment	Interpretation of a Problem & Problem Solving	Mention of Methods Used	Problem Definition	Problem Solving Definition
15 M.D.	2	medium consistent	situation (dilemna)	P2	prcd =tool	yes	A problem is a dilemna that has to be solved	Problem solving is when you are trying to find a solution to your problem.
16 K.B.	2	medium consistent	situation	P2	prcd =tool	yes	A problem is a mathematical situation, where variables are given. You must solve this problem with your knowledge	Problem Solving is figuring out the sense behind a mathematical situation.
17 S.R.	3	high-medium consistent	situation (goal/ obstacle)	P2	prcd =tool	yes	A problem is somewhat like having a goal, but there's an obstacle(the problem)that stands in your way and in order to achieve your goal you need to overcome the obstacle(the problem)	By using tricks and stuff you've learned throughout your education you can solve a problem or a calculation; This is known as problem solving
18 C.J.	3	medium-low consistent	situation	P0	prcd =tool	no	A series of words, equations, or numbers placed together in a situation were an answer is not clear	Prosses of finding the answer to a problem.
19 J.C.	3	medium-low inconsistent	situation	P2	prbm =prcd	no	A problem comes in one or more sentences that makes you think of a situation. The many points of this situation are gathered in thought and are used to conclude the "problem."	Problem Solving is a complex situation, you would have to explain the calculations made, for your conclusion.
20 D.W.	3	medium-low inconsistent easily distracted	situation	P0	prcd =tool	no	A problem is a situation which must be solved to aquire an answer	Problem solving are the steps taken to solve a problem
21 K.M	5	low inconsistent easily distracted	situation	P0	prbm =prcd	no	A situation that needs to be solved or a situation that's incomplete and it needs to be completed	Problem solving is completeing or "solving" an incomplete "problem" or situation. I think "problem solving" defines itself.

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Table 3 Classification and Rank Sort

Student	Rank	Perseverance & Work Habits	Classification of a Problem	Personal Attachment	Interpretation of a Problem & Problem Solving	Mention of Methods Used	Problem Definition	Problem Solving Definition
22 V.M.	1	high consistent	question	P0	theoretical	yes	A problem in a mathematical sense is a question or a statement for which you need to use mathematics to solve	Problem solving is the use of mathematics to solve a mathematical problem
23 T.M	1	high consistent	question	P2	prcd =tool	yes	A problem is a question, that to solve it, you really need to think and use your mathematical knowledge to solve it.	Problem solving is using your knowledge to figure out a question
24 S.G.2	2	high-medium consistent	question	P0	prcd =tool	yes	A problem is a Mathematical Question that needs to be solved by following a series of question steps	Problem Solving is answering a mathematical by using a series of steps
25 M.B.1	2	high consistent	question	P0	theoretical	no	A problem is a question that you need to answer	Problem Solving is finding the solution to a question
26 V.T	2	medium inconsistent easily distracted	question	P0	prcd =tool	yes	A problem is an arithmetical question with givin values to which, a certain value, measurement which we want to equation is needed to be found	problem solving is a procedure with steps to find the missing value, solve the problem. By using equations, multiplying, dividing, adding, subtracting
27 S.C.	2	medium consistent	question	P0	theoretical	no	a question or a statement/asking in numbers or a by words	answer to a question or a statement in numbers or in words)
28 S.G.3	2	medium inconsistent easily distracted	question	P0	prcd =tool	no	A question that you need to answer	A series of steps used to find the answer to a problem

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Table 3 Classification and Rank Sort

Student	Rank	Perseverance & Work Habits	Classification of a Problem	Personal Attachment	Interpretation of a Problem & Problem Solving	Mention of Methods Used	Problem Definition	Problem Solving Definition
29 J.K.	3	high-medium inconsistent	question	P2	prcd =tool	yes	A problem is essentially a question lacking a solution, a question that you must break down, analyze a ultimately, use basic or compund operations to find a solution	The process of breaking down a problem, analyzing it and, using basic operations, make or amount that can be easily interpreted by the human mind, essentially representation of an undefined amount
30 A.M.2.	3	high-medium consistent	question	P0	prbm =prcd	no	I think a problem is a question with variables missing and you need to answer with the variable (fill in the blanks)	problem solving is filling in the blanks
31 B.A.	3	medium-low inconsistent	question	P0	theoretical	no	Normally in the form of a question	Figuring out a question.
32 F.S.	4	low inconsistent easily distracted	question	P1	prbm =prcd	yes	a mathematical question which you are challenged to find the answer	A mathematical problem that you have a formule to try and solve
33 C.C.	4	low inconsistent	question	P1	prbm =prcd	no	A problem is a question and you have to answer it	problem solving is a question that you have to answer, like a sentense and solve it.
34 A.C.2	4	medium-low consistent	question	P2	prbm =prcd	yes	1 problem is a question that there is no answere displayed or you don't know the answer Even with calculation the problem is fixable	To use mathematical skills (ie B *H/2) to find out the answer.
35 K.T.	5	low inconsistent	question	P2	theoretical	no	A problem to me would be a question without a straightforward answer.	Problem solving is solving a question that hasn't got a straightforward answer.

Table 3 Classification and Rank Sort

Student	Rank	Perseverance & Work Habits	Classification of a Problem	Personal Attachment	Interpretation of a Problem & Problem Solving	Mention of Methods Used	Problem Definition	Problem Solving Definition
36 M.R.	5	low inconsistent easily distracted	question	P1	prbm =prcd	no	A problem is a mathematical question that you have to find out in Mathematical terms	Problem solving is a question, and you have to use mathematical sense to prove
37 R.A.	5	low inconsistent	question	P1	theoretical	no	a mathematical question that involves figuring out problem	An answer that requires a sentence to complete
38 S.G.1	1	high consistent	equation	P0	prcd =tool	yes	is being ask to manipulate numbers and values using an equation	Solving (in a mathematical sense) means actually apply the equation to manipulate the numbers
39 M.B.2	1	medium consistent	equation	P1	prcd =tool	yes	an equation, a group of numbers in need of being solved	applying skills and knowledge to a problem and solving it, finding the answer
40 R.B.2	4	low inconsistent very easily distracted	equation (variables)	P0	prbm =prcd	no	two variable that come to gether to create an answer	the solution to two variables
41 A.C.1	4	medium-low inconsistent	equation	P0	prbm =prcd	yes	A problem is a equation where you are to find the solution	a problem solving is a equation that you must use a mathematical formula to get the solution
42 T.W.	4	low inconsistent easily distracted	equation	P0	prbm =prcd	no	A problem is an unsolved equation that needs to be worked on to get an answer	"problem solving" are the steps you take in solving a mathematical problem or equation

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Table 3 Classification and Rank Sort

Student	Rank	Perseverance & Work Habits	Classification of a Problem	Personal Attachment	Interpretation of a Problem & Problem Solving	Mention of Methods Used	Problem Definition	Problem Solving Definition
43 J.L.	4	medium-low consistent	equation	PO	prbm =prcd	no	An eqation with numbers	An equation with a situatioon in words.
44 M.T.	5	low inconsistent easily distracted	equation	PO	prbm =prcd.	no	an equation that doesn't have an answer	steps that will lead you towards the right Answer
45 R B 2	5	low consistent	equation	PO	prbm =prcd	no	A problem can be an equation	problem solving is mostly word problems
46 T.D.	5	low inconsistent easily distracted	equation	PO	prbm =prcd	no	a problem is an equation	problem solving is when you find the answer to an equation

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Figure 15: Magnification of Personal Attachment vs, Rank Bar Chart

Personal Attachment Vs. Rank
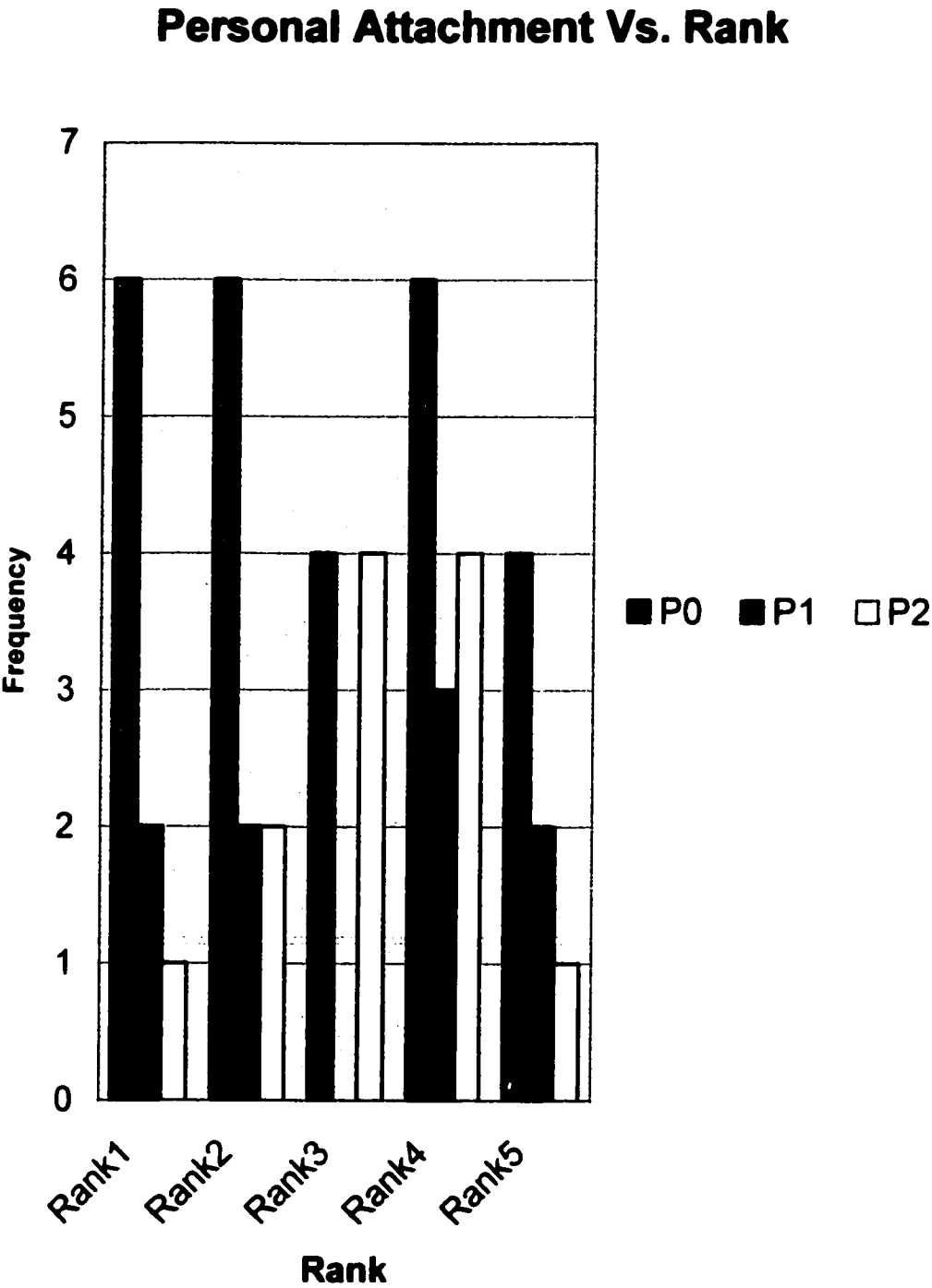
Figure 16: Magnification of Personal Attachment vs. Perseverance Bar Chart

Personal Attachment Vs. Perseverance

■P0   ■P1   □P2

Perseverance

Perseverance vs. Rank

Perseverance vs. Rank

Table 4 Personal and Rank Sort

Student	Rank	Perseverance & Work Habits	Classification of a Problem	Personal Attachment	Interpretation of a Problem & Problem Solving	Mention of Methods Used	Problem Definition	Problem Solving Definition
V.M	1	high consistent	question	PO	theoretical	yes	A problem in a mathematical sense is a question or a statement for which you need to use mathematics to solve	Problem solving is the use of mathematics to solve a mathematical problem.
A.M.1	1	high consistent	something	PO	prod =tool	yes	A problem is something has to be solved it is a quest that must be answered using mathematical formulas	problem solving is using mathematical using formulas to solve something
S.G.1	1	high consistent	equation	PO	prod =tool	yes	is being ask to manipulate numbers and values using an equation.	Solving (in a mathematical sense) means actually apply the equation to manipulate the numbers.
V.E.	1	high consistent	situation	PO	theoretical	no	A problem is a situation in which something is unknown and must be figured out.	Problem solving is finding the solution to the problem, solving the unknown and finding the answer.
L.H.	1	high consistent	situation	PO	prod =tool	no	It's a mathematical situation of variables that can be made more simple.	it's the process of making the mathematical situation more simple/
A.W.	1	high consistent	situation (missing part of story or equation)	PO	prod =tool	yes	A missing part in an equation or a story problem is to find it.	The Finding the logic way to find the answer. If there is a way of solving the problem. Finding the missing part (logically)
S.G.2	2	high-medium consistent	question	PO	prod =tool	yes	A problem is a Mathematical Question that needs to be solved by following a series of steps	Problem Solving is answering a mathematical Question by using a series of steps.

Table 4 Personal and Rank Sort

Student	Rank	Perseverance & Work Habits	Classification of a Problem	Personal Attachment	Interpretation of a Problem & Problem Solving	Mention of Methods Used	Problem Definition	Problem Solving Definition
8 M.B 1	2	high consistent	question	PO	theoretical	no	A problem is a question that you need to answer	Problem Solving is finding the solution to a question
9 V.T.	2	medium inconsistent easily distracted	question	PO	prcd =tool	yes	A problem is an arithmatical question with givin values to which, a certain value, measurement equation is needed to be found	problem solving is a procedure with steps to which we want to find the missing value, solve the problem. By using equations, multiplying, dividing, adding, subtracting
10 R.M.	2	high consistent	something	PO	prcd =tool	no	something that requires a solution	The steps it takes to eventually solve the problem
11 S.C	2	medium consistent	question	PO	theoretical	no	a question or a statement/asking in numbers or by words	a answer to a question or a statement in numbers or in words).
12 S.G 3	2	medium inconsistent easily distracted	question	PO	prcd =tool	no	A question that you need to answer	A series of steps used to find the answer to a problem
13 M.E	3	low consistent	something	PO	theoretical	no	Some thing you have to solve	Some thing you have to solve
14 C.J	3	medium-low consistent	situation	PO	prcd =tool	no	A series of words, equations, or numbers placed together in a situation were an answer is not clear	Prosses of finding the answer to a problem

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Table 4 Personal and Rank Sort

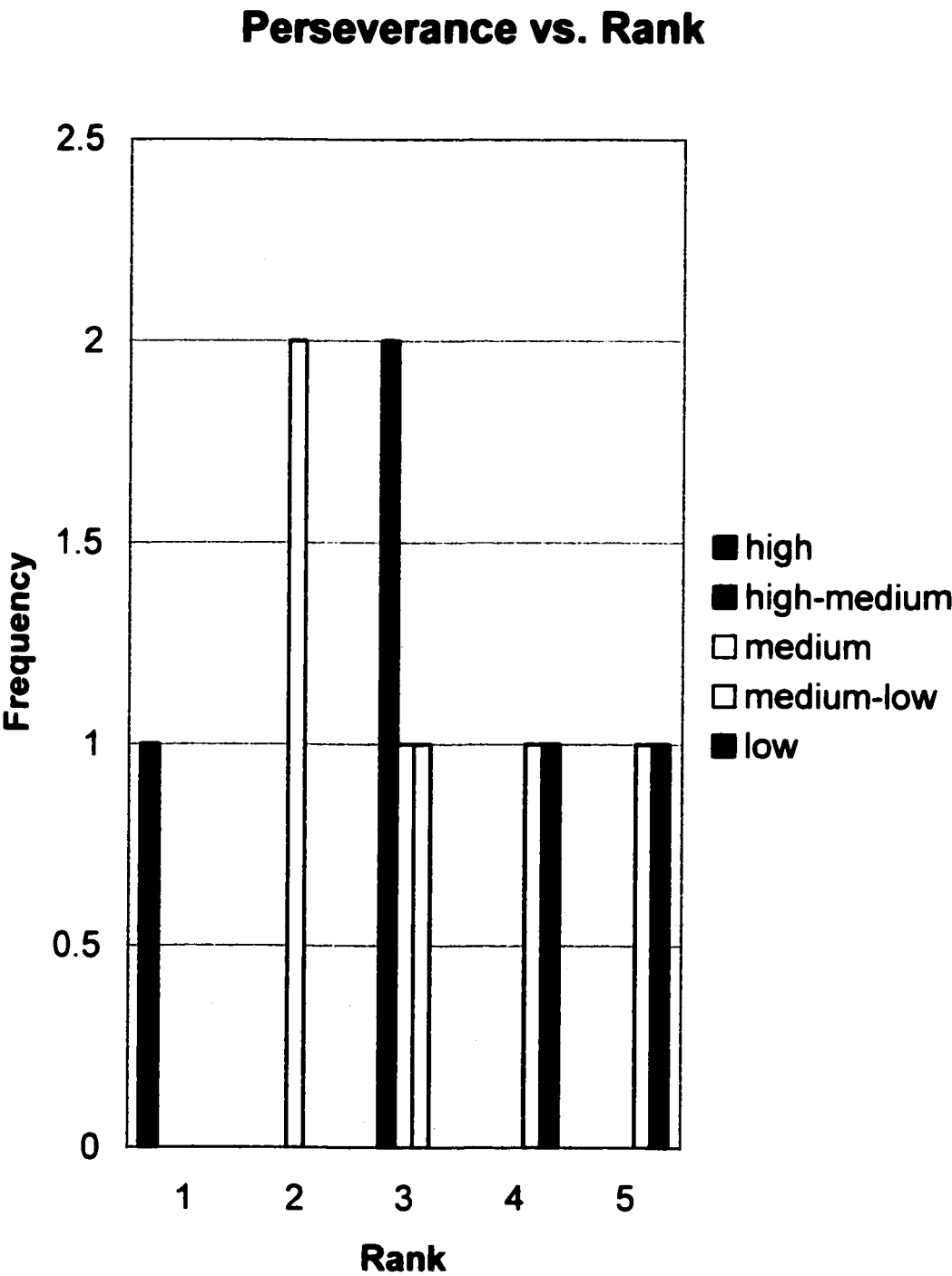| Student	Rank	Perseverance & Work Habits	Classification of a Problem	Personal Attachment	Interpretation of a Problem & Problem Solving	Mention of Methods Used	Problem Definition	Problem Solving Definition
15 D.W.	3	medium-low inconsistent easily distracted	situation	P0	prcd =tool	no	A problem is a situation which must be solved to aquire an answer.	Problem solving are the steps taken to solve a problem
16 B.A.	3	medium-low inconsistent	question	P0	theoretical	no	Normally in the form of a question	Figuring out a question.
17 A.M 2	4	high-medium consistent	question	P0	prbm =prcd	no	I think a problem is a question with missing and you need to answer with the varaible (fill in the blanks)	problem solving is filling in the blanks
18 A.C.1	4	medium-low inconsistent	equation	P0	prbm =prcd	yes	A problem is a equation where you are to find the solution	a problem solving is a equation that you must use a mathematical formula to get the solution
19 T.W.	4	low inconsistent easily distracted	equation	P0	prbm =prcd	no	A problem is an unsolved equasion that needs to be worked on to get an answer.	"problem solving" are the steps you take in solving a mathematical problem or equation.
20 V.P.	4	low inconsistent easily distracted	something	P0	prbm =prcd	no	a problem is something that must be solved, with numbers it's a mathimatical Question not a people question	problem solving is the mathimatical way of solving a problem It's a way of showing your steps
21 R.B.2	4	low inconsistent very easily distracted	equation (variables)	P0	prbm =prcd	no	two variable that come to gether to create an answer	the solution to two variables

Table 4 Personal and Rank Sort

Student	Rank	Perseverance & Work Habits	Classification of a Problem	Personal Attachment	Interpretation of a Problem & Problem Solving	Mention of Methods Used	Problem Definition	Problem Solving Definition
22 JL	4	medium-low consistent	equation	P0	prbm =prcd	no	An eqation with numbers	An equation with a situation in words.
23 M.T.	5	low inconsistent easily distracted	equation	P0	prbm =prcd	no	an equation that doesn't have an answer	steps that will lead you towards the right Answer
24 R.B.1	5	low consistent	equation	P0	prbm =prcd	no	A problem can be an equation	problem solving is mostly word problems
25 T.D.	5	low inconsistent easily distracted	equation	P0	prbm =prcd	no	a problem is an equation	problem solving is when you find the answer to an equation
26 K.M	5	low inconsistent easily distracted	situation	P0	prbm =prcd	no	A situation that needs to be solved or situation that's incomplete and it needs to be completed	or a Problem solving is completing or "solving" an incomplete "problem" or situation. I think "problem solving" defines itself
27 M.F.	1	high consistent	something	P1	prcd =tool	yes	A problem is something without an answer that you have to solve	that Problem Solving is when you try to figure out the answer to a question using different methods
28 M.B.2	1	medium consistent	equation	P1	prcd =tool	yes	an equation, a group of numbers in need of being solved	an equation, a group of numbers in need of applying skills and knowledge to a problem and solving it. finding the answer.

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Table 4 Personal and Rank Sort

Student	Rank	Perseverance & Work Habits	Classification of a Problem	Personal Attachment	Interpretation of a Problem & Problem Solving	Mention of Methods Used	Problem Definition	Problem Solving Definition
29 S.M	2	high consistent	something	P1	prcd =tool	yes	a problem is something that you try to solve to figure out the solution. Equation that needs to be solved and variables that come together to form an answerer	Solving a problem
30 N.S	2	high-medium consistent	something	P1	prcd =tool	yes	a problem is something where you have to problem solving find/solve sumthing. a problem has something missing, which you have to find	problem solving is solving a problem using many different formula, whether you are solving for x, finding an angle, or a word problem.
31 F.S	4	low inconsistent easily distracted	question	P1	prbm =prcd	yes	a mathematical question which you are challenged to find the answer	A mathematical problem that you have a formula to try and solve
32 M.W	4	low inconsistent easily distracted	something	P1	prbm =prcd	no	A problem is something that needs an answer but has many or few ways of answering	Problem solving is when you have worked around the obstacles and made it to the finish line
33 C.C.	4	low inconsistent	question	P1	prbm =prcd	no	A problem is a question and you have to answer it	problem solving is a question that you have to answer, like a sentence and solve it
34 M.R	5	low inconsistent easily distracted	question	P1	prbm =prcd	no	A problem is a mathematical question that you have to find out in Mathematical terms	Problem solving is a question, and you have to use mathematical sense to prove
35 R.A	5	low inconsistent	question	P1	theoretical	no	a mathematical question that involves figuring out problem	An answer that requires a sentence to complete.

Table 4 Personal and Rank Sort

Student	Rank	Perseverance & Work Habits	Classification of a Problem	Personal Attachment	Interpretation of a Problem Solving	Mention of Methods Used	Problem Definition	Problem Solving Definition
36 T.M.	1	high consistent	question	P2	prcd =tool	yes	A problem is a question, that to solve it, you really need to think and use your mathematical figure out a question knowledge to solve it.	Problem solving is using your knowledge to
37 M.D.	2	medium consistent	situation (dilemna)	P2	prcd =tool	yes	A problem is a dilemna that has to be solved by doing an equation	Problem solving is when you are trying to find a solution to your problem.
38 K.B.	2	medium consistent	situation	P2	prcd =tool	yes	A problem is a mathematical situation, where variables are given. You must solve this problem with your knowledge	problem Solving is figuring out the sense behind a mathematical situation.
39 S.R.	3	high-medium consistent	situation (goal/ obstacle)	P2	prcd =tool	yes	A problem is somewhat like having a goal, but there's an obstacle(the problem)that stands in your way and in order to achieve your goal you need to overcome the obstacle(the problem)	By using tricks and stuff you've learned throughout your education you can solve a problem or a calculation; This is known as problem solving.
40 J.K.	3	high-medium inconsistent	question	P2	prcd =tool	yes	A problem is essentially a question lacking a solution, a question that you must break down analyze a ultimately, use basic or compund operations to find a solution	The process of breaking down a problem, analyzing it and, using basic operations, make answer or amount that can be easily interpreted by the human mind, essentially a representation of an undefined amount
41 J.C.	3	medium-low inconsistent	situation	P2	prbm =prcd	no	A problem comes in one or more sentences that makes you think of a situation The many points of this situation are gathered in thought, and are used to conclude the "problem."	Problem Solving is a complex situation, you would have to explain the calcuations made for your conclusion
42 S.J.	3	medium consistent	something	P2	prbm =prcd	yes	A problem in my opinion is variables that has to be solved It is something that you understand but can use your mind and figure it out	Problem Solving is how you solve the problem don't The steps to take to come to your answer.

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Table 4 Personal and Rank Sort

Student	Rank	Perseverance & Work Habits	Classification of a Problem	Personal Attachment	Interpretation of a Problem & Problem Solving	Mention of Methods Used	Problem Definition	Problem Solving Definition
43 C.K.	4	medium-low inconsistent	something	P2	prbm =prcd	yes	A problem is something that needs to be solved Its something that you need to solve	problem Solving is when you mathematically find the answer to a question or solve that is unknown
44 A.K.	4	low consistent	something	P2	prbm =prcd	no	A problem is something that needs to be solved When faced with a problem especially It is after working on a problem, the solution in math it is an obstacle that can be conquered In math we are generally faced with word Math is full of problems whether they are problems and then we have to solve them arithmetic or words problems, we all face them Problem solving comes in handy when we each day have to face the obstacle	A problem is something that needs to be Problem solving is the solution to a problem
45 A C 2	4	medium-low consistent	question	P2	prbm =prcd	yes	1 problem is a question that there is no answers displayed or you don't know the answer Even with calculation the problem is fixable	To use mathematical skills (ie B *H/2) to find the out the answer
46 K.T.	5	low inconsistent	question	P2	theoretical	no	A problem to me would be a question without a straightforward answer	Problem solving is solving a question that hasn't got a straightforward answer

Interpretation Vs. Rank

Table 5 Interpretation and Rank Sort

Student	Rank	Perseverance & Work Habits	Classification of a Problem	Personal Attachment	Interpretation of a Problem & Problem Solving	Mention of Methods Used	Problem Definition	Problem Solving Definition
1 V.M.	1	high consistent	question	P0	theoretical	yes	A problem in a mathematical sense is a question or a statement for which you need to use mathematics to solve	Problem solving is the use of mathematics to solve a mathematical problem
2 V.E.	1	high consistent	situation	P0	theoretical	no	A problem is a situation in which something unknown and must be figured out.	Problem solving is finding the solution to the problem, solving the unknown and finding the answer.
3 M.B.1	2	high consistent	question	P0	theoretical	no	A problem is a question that you need to answer	Problem Solving is finding the solution to a question
4 S.C.	2	medium consistent	question	P0	theoretical	no	a question or a statement/asking in numbers or by words	an answer to a question or a statement in numbers or in words).
5 M.E.	3	low consistent	something	P0	theoretical	no	Some thing you have to solve	Some thing you have to solve
6 B.A.	3	medium-low inconsistent	question	P0	theoretical	no	Normally in the form of a question	Figuring out a question.
7 K.T.	5	low inconsistent	question	P2	theoretical	no	A problem to me would be a question without a straightforward answer	Problem solving is solving a question that hasn't got a straightforward answer.

Table 5 Interpretation and Rank Sort

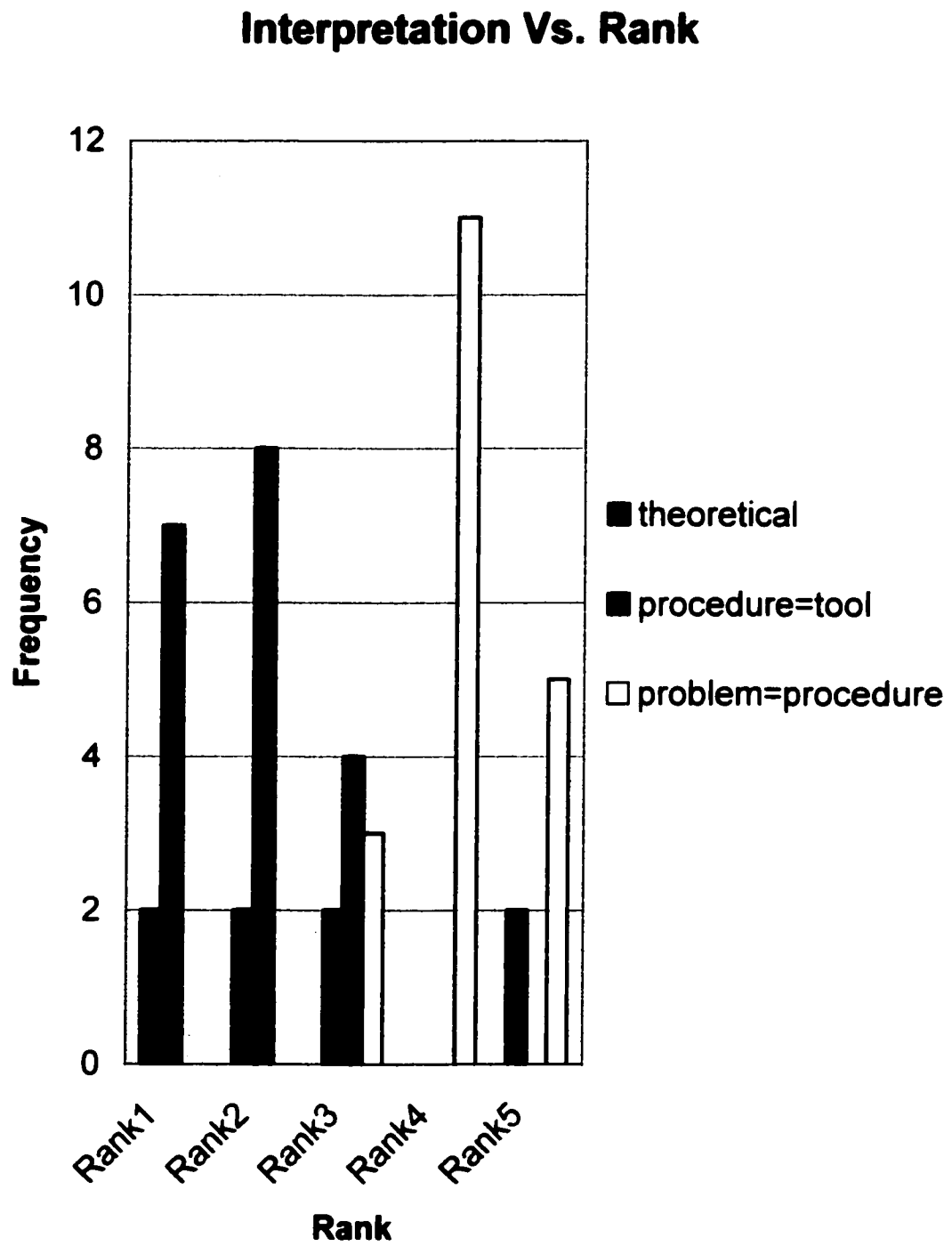| Student	Rank	Perseverance & Work Habits	Classification of a Problem	Personal Attachment	Interpretation of a Problem & Problem Solving	Mention of Methods Used	Problem Definition	Problem Solving Definition
8 R.A.	5	low inconsistent	question	P1	theoretical	no	a mathematical question that involves figuring out problem	An answer that requires a sentence to complete.
9 A.M.1	1	high consistent	something	P0	prod =tool	yes	A problem is something has to be solved a quest that must be answered using mathematical formulas	It is problem solving is using mathematical formulas to solve something.
10 S.G.1	1	high consistent	equation	P0	prod =tool	yes	is being ask to manipulate numbers and values using an equation	Solving (in a mathematical sense) means actually apply the equation to manipulate the numbers.
11 T.M.	1	high consistent	question	P2	prod =tool	yes	A problem is a question, that to solve it, you really need to think and use your mathematical knowledge to solve it	Problem solving is using your knowledge to figure out a question
12 M.F	1	high consistent	something	P1	prod =tool	yes	A problem is something without an answer that you have to solve	Problem Solving is when you try to figure out the answer to a question using different methods
13 L.H	1	high consistent	situation	P0	prod =tool	no	It's a mathematical situation of variables that can be made more simple	it's the process of making the mathematical situation more simple/
14 M.B.2	1	medium consistent	equation	P1	prod =tool	yes	an equation, a group of numbers in need of being solved	of applying skills and knowledge to a problem and solving it, finding the answer

Table 5 Interpretation and Rank Sort

Student	Rank	Perseverance & Work Habits	Classification of a Problem	Personal Attachment	Interpretation of a Problem & Problem Solving	Mention of Methods Used	Problem Definition	Problem Solving Definition
15 A.W.	1	high consistent	situation (missing part of story or equation)	P0	prcd =tool	yes	A missing part in an equation or a story The problem is to find it	Finding the logic way to find the answer. If there is a way of solving the problem Finding the missing part (logically)
16 S.M.	2	high consistent	something	P1	prcd =tool	yes	a problem is something that you try to solve to figure out the solution Equation that needs to be solved and variables that come together to form an answerer	Solving a problem.
17 S.G.2	2	high-medium consistent	question	P0	prcd =tool	yes	A problem is a Mathematical Question that needs to be solved by following a series of question steps	Problem Solving is answering a mathematical by using a series of steps
18 M.D.	2	medium consistent	situation (dilemna)	P2	prcd =tool	yes	A problem is a dilemna that has to be solved by doing an equation	Problem solving is when you are trying to find a solution to your problem
19 K.B.	2	medium consistent	situation	P2	prcd =tool	yes	A problem is a mathematical situation, where problem variables are given. You must solve this problem with your knowledge	Problem Solving is figuring out the sense behind a mathematical situation
20 V.T.	2	medium inconsistent easily distracted	question	P0	prcd =tool	yes	A problem is an arithmatical question with givin values to which, a certain value, measurement equation is needed to be found	problem solving is a procedure with steps to which we want to find the missing value, solve the problem. By using equations, multiplying, dividing, adding, subtracting
21 R.M.	2	high consistent	something	P0	prcd =tool	no	something that requires a solution	The steps it takes to eventually solve the problem

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Table 5 Interpretation and Rank Sort

Student	Rank	Perseverance & Work Habits	Classification of a Problem	Personal Attachment	Interpretation of a Problem & Problem Solving	Mention of Methods Used	Problem Definition	Problem Solving Definition
22 N.S.	2	high-medium consistent	something	P1	prcd =tool	yes	a problem is something where you have to problem solving is solving a problem using find/solve sumthing a problem has something many different formulas, whether you are missing. which you have to find solving for x, finding an angle, or a word problem	
23 S.G 3	2	medium inconsistent easily distracted	question	P0	prcd =tool	no	A question that you need to answer.	A series of steps used to find the answer to a problem
24 S.R.	3	high-medium consistent	situation (goal/ obstacle)	P2	prcd =tool	yes	A problem is somewhat like having a goal, but By using tricks and stuff you've learned there's an obstacle(the problem)that stands in throughout your education you can solve a your way and in order to achieve your goal you problem or a calculation, This is known as need to overcome the obstacle(the problem) problem solving	
25 J.K.	3	high-medium inconsistent	question	P2	prcd =tool	yes	A problem is essentially a question lacking a The process of breaking down a problem. solution, a question that you must break down. analyzing it and, using basic operations, make analyze a ultimately, use basic or compund a answer or amount that can be easily operations to find a solution interpreted by the human mind, essentially a representation of an undefined amount.	
26 C.J.	3	medium-low consistent	situation	P0	prcd =tool	no	A series of words, equations, or numbers Prosses of finding the answer to a problem. placed together in a situation were an answer is not clear.	
27 D.W.	3	medium-low inconsistent easily distracted	situation	P0	prcd =tool	no	A problem is a situation which must be solved Problem solving are the steps taken to solve a to aquire an answer. problem	
28 J.C.	3	medium-low inconsistent	situation	P2	prbm =prcd	no	A problem comes in one or more sentences Problem Solving is a complex situation, you that makes you think of a situation. The many would have to explain the calcualtions made points of this situation are gathered in thought, for your conclusion and are used to conclude the "problem."	

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Table 5 Interpretation and Rank Sort

Student	Rank	Perseverance & Work Habits	Classification of a Problem	Personal Attachment	Interpretation of a Problem & Problem Solving	Mention of Methods Used	Problem Definition	Problem Solving Definition
29 A.M.2	3	high-medium consistent	question	P0	prbm =prcd	no	I think a problem is a question with variables missing and you need to answer with the variable (fill in the blanks)	problem solving is filling in the blanks
30 S.J	3	medium consistent	something	P2	prbm =prcd	yes	A problem in my opinion is variables that has to be solved It is something that you dont understand but can use your mind and figure it out	Problem Solving is how you solve the problem to your answer. The steps to take to come to your answer.
31 A.C.1	4	medium-low inconsistent	equation	P0	prbm =prcd	yes	A problem is a equation where you are to find the solution	a problem solving is a equation that you must use a mathematical formula to get the solution
32 C.K	4	medium-low inconsistent	something	P2	prbm =prcd	yes	A problem is something that needs to be solved Its something that you need to solve	problem Solving is when you mathematically find the answer to a question or solve that is unknown
33 A.K	4	low consistent	something	P2	prbm =prcd	no	A problem is something that needs to be solved When faced with a problem especially it is after working on a problem, the solution in math it is an obstacle that can be conquered In math we are generally faced with word Math is full of problems whether they are problems and then we have to solve them arithmetic or words problems. we all face them Problem solving comes in handy when we each day have to face the obstacle	A problem is something that needs to be Problem solving is the solution to a problem.
34 T.W	4	low inconsistent easily distracted	equation	P0	prbm =prcd	no	A problem is an unsolved equation that needs to be worked on to get an answer	"problem solving" are the steps you take in solving a mathematical problem or equation
35 F.S	4	low inconsistent easily distracted	question	P1	prbm =prcd	yes	a mathematical question which you are challenged to find the answer	A mathematical problem that you have a formula to try and solve

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Table 5 Interpretation and Rank Sort

Student	Rank	Perseverance & Work Habits	Classification of a Problem	Personal Attachment	Interpretation of a Problem & Problem Solving	Mention of Methods Used	Problem Definition	Problem Solving Definition
36 A.C.2	4	medium-low consistent	question	P2	prbm =prcd	yes	1 problem is a question that there is no answers displayed or you don't know the answer. Even with calculation the problem is fixable	To use mathematical skills (ie B *H/2) to find out the answer
37 V.P.	4	low inconsistent easily distracted	something	P0	prbm =prcd	no	a problem is something that must be solved. problem solving is the mathimatical way of with numbers. it's a mathimatical Question not solving a problem. It's a way of showing your a people question	solving. steps.
38 M.W	4	low inconsistent easily distracted	something	P1	prbm =prcd	no	A problem is something that needs an answer but has many or few ways of answering	Problem solving is when you have worked around the obstacles and made it to the finish line.
39 C.C	4	low inconsistent	question	P1	prbm =prcd	no	A problem is a question and you have to answer it	problem solving is a question that you have to answer, like a sentense and solve it.
40 R.B.2	4	low inconsistent very easily distracted	equation (variables)	P0	prbm =prcd	no	two variable that come to gether to create an answer	the solution to two variables
41 J.L	4	medium-low consistent	equation	P0	prbm =prcd	no	An eqation with numbers	An equation with a situatioon in words.
42 M.T	5	low inconsistent easily distracted	equation	P0	prbm =prcd	no	an equation that doesnt have an answer	steps that will lead you towards the right Answer

Table 5 Interpretation and Rank Sort

Student	Rank	Perseverance & Work Habits	Classification of a Problem	Personal Attachment	Interpretation of a Problem & Problem Solving	Mention of Methods Used	Problem Definition	Problem Solving Definition
43 R.B.1	5	low consistent	equation	P0	prbm = prcd	no	A problem can be an equation	problem solving is mostly word problems
44 T.D	5	low inconsistent easily distracted	equation	P0	prbm = prcd	no	a problem is an equation	problem solving is when you find the answer to an equation
45 K.M.	5	low inconsistent easily distracted	situation	P0	prbm = prcd	no	A situation that needs to be solved or a situation that's incomplete and it needs to be completed	a Problem solving is completeing or "solving" an incomplete "problem" or situation. I think "problem solving" defines itself
46 M.R	5	low inconsistent easily distracted	question	P1	prbm = prcd	no	A problem is a mathematical question that you have to find out in Mathematical terms	Problem solving is a question, and you have to use mathematical sense to prove

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Methods Used vs. Rank

Table 6 Methods Mentioned and Rank Sort

	Student	Rank	Perseverance & Work Habits	Classification of a Problem	Personal Attachment	Interpretation of a Problem & Problem Solving	Mention of Methods Used	Problem Definition	Problem Solving Definition
1	V.M.	1	high consistent	question	P0	theoretical	yes	A problem in a mathematical sense is a Problem solving is the use of mathematics to question or a statement for which you need to solve a mathematical problem use mathematics to solve	Problem solving is the use of mathematics to solve a mathematical problem
2	A.M.1	1	high consistent	something	P0	prcd =tool	yes	A problem is something has to be solved It is problem solving is using mathematical a quest that must be answered using formulas to solve something mathematical formulas	problem solving is using mathematical formulas to solve something
3	S.G.1	1	high consistent	equation	P0	prcd =tool	yes	is being ask to manipulate numbers and values Solving (in a mathematical sense) means using an equation actually apply the equation to manipulate the numbers	Solving (in a mathematical sense) means actually apply the equation to manipulate the numbers
4	T.M.	1	high consistent	question	P2	prcd =tool	yes	A problem is a question, that to solve it, you Problem solving is using your knowledge to really need to think and use your mathematical figure out a question knowledge to solve it.	Problem solving is using your knowledge to figure out a question
5	M.F	1	high consistent	something	P1	prcd =tool	yes	A problem is something without an answer that Problem Solving is when you try to figure out you have to solve. the answer to a question using different methods.	Problem Solving is when you try to figure out the answer to a question using different methods.
6	M.B.2	1	medium consistent	equation	P1	prcd =tool	yes	an equation, a group of numbers in need of applying skills and knowledge to a problem being solved and solving it, finding the answer	applying skills and knowledge to a problem and solving it, finding the answer
7	A.W.	1	high consistent	situation (missing part of story or equation)	P0	prcd =tool	yes	A missing part in an equation or a story The Finding the logic way to find the answer. If problem is to find it. there is a way of solving the problem. Finding the missing part (logically)	The Finding the logic way to find the answer. If there is a way of solving the problem. Finding the missing part (logically)

Table 6 Methods Mentioned and Rank Sort

Student	Rank	Perseverance & Work Habits	Classification of a Problem	Personal Attachment	Interpretation of a Problem & Problem Solving	Mention of Methods Used	Problem Definition	Problem Solving Definition
8 S.M.	2	high consistent	something	P1	prcd =tool	yes	a problem is something that you try to solve to figure out the solution. Equation that needs to be solved and variables that come together to form an answerer	Solving a problem
9 S.G.2	2	high-medium consistent	question	P0	prcd =tool	yes	A problem is a Mathematical Question that needs to be solved by following a series of question steps	Problem Solving is answering a mathematical question by using a series of steps.
10 M.D.	2	medium consistent	situation (dilemna)	P2	prcd =tool	yes	A problem is a dilemna that has to be solved by doing an equation	Problem solving is when you are trying to find a solution to your problem.
11 K.B.	2	medium consistent	situation	P2	prcd =tool	yes	A problem is a mathematical situation, where problem variables are given. You must solve this problem with your knowledge.	Problem Solving is figuring out the sense behind a mathematical situation
12 V.T.	2	medium inconsistent easily distracted	question	P0	prcd =tool	yes	A problem is an arithmatical question with givin values to which, a certain value, measurement equation is needed to be found	problem solving is a procedure with steps to which we want to find the missing value, solve the problem. By using equations, multiplying, dividing, adding, subtracting
13 N.S.	2	high-medium consistent	something	P1	prcd =tool	yes	a problem is something where you have to problem find/solve sumthing. a problem has something missing, which you have to find	problem solving is solving a problem using many different formulas, whether you are solving for x, finding an angle, or a word problem
14 S.R.	3	high-medium consistent	situation (goal/ obstacle)	P2	prcd =tool	yes	A problem is somewhat like having a goal, but there's an obstacle(the problem)that stands in your way and in order to achieve your goal need to overcome the obstacle(the problem)	By using tricks and stuff you've learned throughout your education you can solve a you problem or a calculation. This is known as problem solving

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Table 6 Methods Mentioned and Rank Sort

Student	Rank	Perseverance & Work Habits	Classification of a Problem	Personal Attachment	Interpretation of a Problem & Problem Solving	Mention of Methods Used	Problem Definition	Problem Solving Definition
15 J.K.	3	high-medium inconsistent	question	P2	prcd =tool	yes	A problem is essentially a question lacking a solution, a question that you must break down, analyze a ultimately, use basic or compound operations to find a solution	The process of breaking down a problem, analyzing it and, using basic operations, make a answer or amount that can be easily interpreted by the human mind, essentially a representation of an undefined amount.
16 S.J.	3	medium consistent	something	P2	prbm =prcd	yes	A problem in my opinion is variables that has to be solved. It is something that you don't understand but can use your mind and figure it out	Problem Solving is how you solve the problem The steps to take to come to your answer
17 A.C 1	4	medium-low inconsistent	equation	P0	prbm =prcd	yes	A problem is a equation where you are to find the solution	a problem solving is a equation that you must use a mathematical formula to get the solution
18 C.K.	4	medium-low inconsistent	something	P2	prbm =prcd	yes	A problem is something that needs to be solved Its something that you need to solve	problem Solving is when you mathematically find the answer to a question or solve that is unknown
19 F.S	4	low inconsistent easily distracted	question	P1	prbm =prcd	yes	a mathematical question which you are challenged to find the answer	A mathematical problem that you have a formula to try and solve
20 A.C 2	4	medium-low consistent	question	P2	prbm =prcd	yes	1 problem is a question that there is no answere displayed or you don't know the answer Even with calculation the problem is fixable	To use mathematical skills (ie B *H/2) to find out the answer.
21 V.E	1	high consistent	situation	P0	theoretical	no	A problem is a situation in which something is unknown and must be figured out	Problem solving is finding the solution to the problem, solving the unknown and finding the answer.

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Table 6 Methods Mentioned and Rank Sort

Student	Rank	Perseverance & Work Habits	Classification of a Problem	Personal Attachment	Interpretation of a Problem & Problem Solving	Mention of Methods Used	Problem Definition	Problem Solving Definition
22 L.H.	1	high consistent	situation	PO	prcd =tool	no	It's a mathematical situation of variables that can be made more simple	It's a mathematical situation of variables that it's the process of making the mathematical situation more simple/
23 M.B 1	2	high consistent	question	PO	theoretical	no	A problem is a question that you need to answer	A problem is a question that you need to Problem Solving is finding the solution to a question
24 R.M.	2	high consistent	something	PO	prcd =tool	no	something that requires a solution	The steps it takes to eventually solve the problem
25 S.C.	2	medium consistent	question	PO	theoretical	no	a question or a statement/asking in numbers or by words	a question or a statement/asking in numbers or a answer to a question or a statement in numbers or in words).
26 S.G 3	2	medium inconsistent easily distracted	question	PO	prcd =tool	no	A question that you need to answer	A series of steps used to find the answer to a problem
27 M.E.	3	low consistent	something	PO	theoretical	no	Some thing you have to solve	Some thing you have to solve
28 C.J	3	medium-low consistent	situation	PO	prcd =tool	no	A series of words, equations, or numbers placed together in a situation were an answer is not clear	A series of words, equations, or numbers Proses of finding the answer to a problem

Table 6 Methods Mentioned and Rank Sort

Student	Rank	Perseverance & Work Habits	Classification of a Problem	Personal Attachment	Interpretation of a Problem & Problem Solving	Mention of Methods Used	Problem Definition	Problem Solving Definition
29 J.C.	3	medium-low inconsistent	situation	P2	prbm =prcd	no	A problem comes in one or more sentences Problem Solving is a situation which must be solved to acquire an answer.	A problem comes in one or more sentences Problem Solving is a complex situation, you that makes you think of a situation. The many would have to explain the calculations made points of this situation are gathered in thought, for your conclusion. and are used to conclude the "problem."
30 D.W.	3	medium-low inconsistent easily distracted	situation	P0	prcd =tool	no	A problem is a situation which must be solved to acquire an answer.	Problem solving are the steps taken to solve a problem
31 A.M.2	3	high-medium consistent	question	P0	prbm =prcd	no	I think a problem is a question with variables missing and you need to answer with the varaible (fill in the blanks)	problem solving is filling in the blanks
32 B.A.	3	medium-low inconsistent	question	P0	theoretical	no	Normally in the form of a question.	Figuring out a question.
33 A.K.	4	low consistent	something	P2	prbm =prcd	no	A problem is something that needs to be solved. When faced with a problem especially it is after working on a problem, the solution in math it is an obstacle that can be conquered. In math we are generally faced with word Math is full of problems whether they are problems and then we have to solve them arithmetic or words problems, we all face them Problem solving comes in handy when we each day	Problem solving is the solution to a problem have to face the obstacle.
34 T.W	4	low inconsistent easily distracted	equation	P0	prbm =prcd	no	A problem is an unsolved equation that needs to be worked on to get an answer.	"problem solving" are the steps you take in solving a mathematical problem or equation.
35 V.P.	4	low inconsistent easily distracted	something	P0	prbm =prcd	no	a problem is something that must be solved. with numbers it's a mathmatical Question not a people question	problem solving is the mathimatical way of solving a problem it's a way of showing your steps

Table 6 Methods Mentioned and Rank Sort

Student	Rank	Perseverance & Work Habits	Classification of a Problem	Personal Attachment	Interpretation of a Problem & Problem Solving	Mention of Methods Used	Problem Definition	Problem Solving Definition
36 M.W	4	low inconsistent easily distracted	something	P1	prbm =prcd	no	A problem is something that needs an answer but has many or few ways of answering	Problem solving is when you have worked around the obstacles and made it to the finish line
37 C.C	4	low inconsistent	question	P1	prbm =prcd	no	A problem is a question and you have to answer it	problem solving is a question that you have to answer, like a sentence and solve it
38 R.B.2	4	low inconsistent very easily distracted	equation (variables)	P0	prbm =prcd	no	two vairiable that come to gether to create an solution to two variables answer	
39 J.L	4	medium-low consistent	equation	P0	prbm =prcd	no	An eqation with numbers	An equation with a situatioon in words
40 K.T	5	low inconsistent	question	P2	theoretical	no	A problem to me would be a question without a straightforward answer	Problem solving is solving a question that hasn't got a straightforward answer
41 M.T	5	low inconsistent easily distracted	equation	P0	prbm =prcd	no	an equation that doesn't have an answer	steps that will lead you towards the right Answer
42 R.B 1	5	low consistent	equation	P0	prbm =prcd	no	A problem can be an equation	problem solving is mostly word problems

Table 6 Methods Mentioned and Rank Sort

Student	Rank	Perseverance & Work Habits	Classification of a Problem	Personal Attachment	Interpretation of a Problem & Problem Solving	Mention of Methods Used	Problem Definition	Problem Solving Definition
43 T.D.	5	low inconsistent easily distracted	equation	P0	prbm = prcd	no	a problem is an equation	problem solving is when you find the answer to an equation
44 K.M.	5	low inconsistent easily distracted	situation	P0	prbm = prcd	no	A situation that needs to be solved or a situation that's incomplete and it needs to be completed	Problem solving is completeing or "solving" an incomplete "problem" or situation. I think "problem solving" defines itself.
45 M.R.	5	low inconsistent easily distracted	question	P1	prbm = prcd	no	A problem is a mathematical question that you have to find out in Mathematical terms	Problem solving is a question, and you have to use mathematical sense to prove.
46 R.A.	5	low inconsistent	question	P1	theoretical	no	a mathematical question that involves figuring out problem	An answer that requires a sentence to complete

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