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Can Direct Vocabulary Instruction Increase Student's Background Knowledge in Mathematics?

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St. John Fisher College

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A common problem found among classrooms is the lack of effective direct vocabulary instruction. A strong correlation has been found between a student's knowledge of vocabulary and their academic achievement. Content area vocabulary, particularly mathematics vocabulary, has been found to be some of the most difficult concepts for children to master. Direct vocabulary instruction has been studied, and six common characteristics have been found to be effective when implemented in the classroom. These six characteristics were implemented in a 5th grade classroom during a preexisting math unit on geometry. Student engagement and comprehension increased throughout this unit. As a result, student success rates nearly doubled when compared to a unit in mathematics taught without direct vocabulary instruction.

Dedication

I dedicate this paper to all of the people in my life who have supported me throughout my education.

- My husband, Rich, who has been there for me through this whole process, helping whenever and wherever he can. Thank you for everything you have done for me. Your support has helped me accomplish this monumental goal, and I couldn't have done it without you! I love you!

- My parents, Kim and Ken, who instilled in me the values and beliefs that have helped me succeed in life. You two always pushed me to do my best, and to never stop believing in myself. Thank you for all of your support. You have made me who I am today.

- My sister, Erin, who was a constant cheerleader and sounding board for frustrations and stress. You have helped me to become a better student and teacher because of the high expectations you have set for yourself and others around you. Thank you for all of your help and support.

- My daughter, MacKenzie, who has taught me what unconditional love is. You were the one who made all of my stresses and frustrations disappear once I saw your smiling face. Thank you for loving, kissing and hugging me, no matter what kind of mood I was in, or what kind of day I had. You make everything I do more special! I love you with all of my heart!

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Can Direct Vocabulary Instruction Increase Students' Background Knowledge in Mathematics?

A widespread area of need throughout classrooms, elementary through high school, is the absence of vocabulary instruction. Research has shown a direct connection between a student's vocabulary knowledge and academic achievement. The larger and better developed the vocabulary a student has, the better that child will do academically. Why then is vocabulary instruction one of the activities that often gets overlooked in schools?

Content area vocabulary, such as science and mathematics, has been suggested to be the most difficult vocabulary to master. This vocabulary is more difficult because it is not only very abstract, but students rarely encounter this type of vocabulary in their everyday lives. If students have a better understanding of this content area vocabulary, will they do better in those subject areas? Can direct vocabulary instruction increase student's background knowledge in mathematics? By directly teaching mathematics vocabulary, teachers are also increasing their students' background knowledge.

The purpose of this research is to increase students' background knowledge in mathematics. Forty-seven fifth-grade students from Longridge Elementary School in Greece, New York will be the active participants for this research. Assessments and student work from units taught without direct vocabulary instruction will be compared to units taught with direct vocabulary instruction to examine the benefits and student gains. From these findings,

further teaching implications will be adjusted to better meet the needs of all students in class.

A common problem throughout classrooms is the lack of effective direct vocabulary instruction. There is a strong correlation between vocabulary knowledge and academic achievement. The larger the vocabulary a student has, the better that child will do academically. After reading about students' background knowledge and the direct correlation to vocabulary instruction, the thought of how vocabulary instruction takes place in schools came to mind. As an educator, one must constantly strive to improve educational experiences for students, as well as increase the effectiveness of instruction. While researching information regarding building background knowledge, the following question will try to be answered; how can educators effectively use direct vocabulary instruction to increase students' background knowledge?

Literature Review

When students enter the classroom, they are confronted with the overwhelming task of learning new concepts and material in all of the core subject areas. Students are expected to know and understand a multitude of facts and concepts, and be able to apply them effortlessly. Although the amount of information students learn is dependent on many different variables, such as the teacher, student interests, and motivation of the student, much of the information students learn is dependent upon what they already know; their background knowledge.

Background knowledge is one of the strongest indicators of how well a student will learn new information. When students are introduced to new material, the teacher must provide a way for the students to make a meaningful and personal connection to that new information. In order to promote a deeper understanding of course material, teachers must incorporate direct vocabulary instruction into their everyday activities.

According to Robert Marzano (2004), students acquire background knowledge through a combination of two factors, academically oriented experiences and their ability to process and store information.

Academically Oriented Experiences

Academically oriented experiences are experiences a student encounters that will "directly add to our knowledge of content we encounter in school"(Marzano, 2004, p. 5). An example of an academically oriented experience would be going to the museum. When a child is at the museum,

there are ample opportunities to learn new information through many different venues. As the child is learning new information, he/she is also learning new vocabulary terms that are related to that subject.

Even though academically oriented experiences are the most straightforward, clear-cut way to build background knowledge, schools are often limited in resources required to provide direct experiences. Luckily, virtual experiences can be just as influential as direct experiences when building background knowledge. Three types of virtual experiences are reading, language interaction, and educational television.

As students are reading, they are making connections between the texts they are reading, and their own lives and experiences. By visualizing what is occurring in the text, students are able to actually 'place' themselves into many different 'virtual' experiences and places that they may never get to actually experience themselves. This is also true for watching educational television. Through language interaction, talking and listening to others, students can also expand their background knowledge. When students talk with and listen to others about an experience they have had, they are in a sense reliving that moment. Everything that they encountered and learned is being accessed and engaged in their memory (Marzano 2004). As a result of these academically oriented experiences, students will now be able to pull information from and connect information to the new knowledge and vocabulary they have encountered.

Processing and Storing Information

The second factor that plays an important role in students acquiring background knowledge is the ability to process and store information in permanent memory. According to John Anderson (1995), the common understanding of memory as having two different types, long-term and short-term, has been replaced with a theory that there is only one type of memory that has three distinct functions. These three functions of memory are sensory, permanent, and working memory.

Three Functions of Memory

Sensory memory pertains to the temporary storage of data that we acquire through our senses. The amount of information that we acquire through sensory memory depends on what we pay attention to. Anderson (1995) stated "The environment typically offers much more information at one time than we can attend to and encode. Therefore, much of what enters our sensory [memory] results in no permanent record" (p. 160). Although much of the information we obtain through sensory memory never makes it to permanent memory, the more complex the sensory input we receive from a new experience is, the better the chances it will be absorbed and stored. Therefore, experiences and activities that allow a student to see, hear, touch, and smell lead to a rich sensory experience that will help them connect to previous experiences, learn and remember.

Permanent memory is where people store information in ways that allow that information to be readily available when needed. Marzano (2004) described

permanent memory as "all that we know and all that we understand" (p. 22).

Permanent memory is the 'filing cabinet' where all of our background knowledge

is stored. Once information is stored in permanent memory, it can be accessed

and activated without conscious effort. The information that resides in

permanent memory can be activated by any similar stimuli we are processing in

our working memory. This leads to making further connections between what we

already know, our background knowledge, and what we are experiencing and

processing in both sensory and working memory.

Working memory refers to where we consciously work new and old

information, make connections between the two, and add new details to old

memories and information. As illustrated in Figure 1, working memory can

receive information and data from sensory memory, permanent memory, or from

both.

The storage of information in permanent memory is dependent upon the

quality of processing that occurs in working memory. If processing goes well, the

information makes it into our 'filing cabinet' or permanent memory, but if

processing doesn't go well, the information is lost. Two factors that determine

the quality of processing are the number of experiences students have to

process and engage new information, and the depth at which they process that

information.

Figure 1 - Three Functions of Memory

| Permanent Memory | ← → | Working Memory | ← | Sensory Memory |
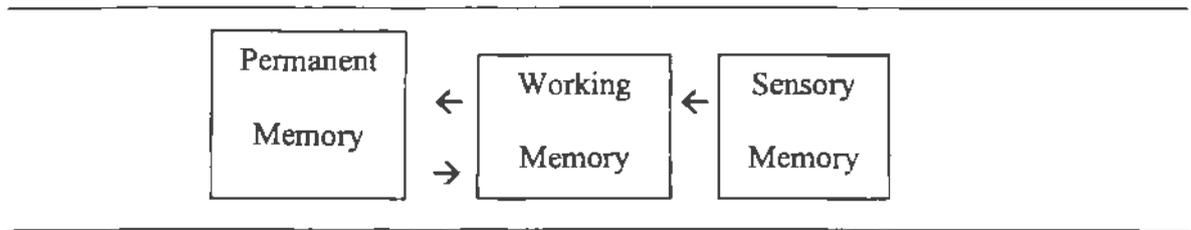
According to Marzano (2004) the number of times students are exposed to information plays a large role in the transfer of information from working memory into permanent memory. The more times a student is exposed to and engaging information in working memory, the more likely that information will become embedded in their permanent memory. Through repeated practice, a student will make stronger connections between the new learning and information already stored in permanent memory. Bruce Perry (2005) supported John Anderson's theory (1995) of repeated teachings and multiple exposures to new information. Perry stated (2005), "Because the brain stores new experiences through repetition...ten five-minute exposures to a new learning experience lead to more learning than one 50-minute exposure" (p. 70). In the article "The Way Students Learn: Acquiring Knowledge from an Integrated Science and Social Studies Unit" written by Graham Nuthall (1999) described similar findings regarding repeated teaching and multiple exposures to new information. He found that students required a minimum of three to four exposures to new information for it to be integrated into their permanent memory.

The second factor that determines the quality of processing is the depth at which a student processes information. Deep processing of information adds new and more details to our preexisting understanding of information. By making new associations and adding detail to our understanding of information, we are enhancing the likelihood that new information will reach our permanent memory.

Vocabulary Knowledge

Vocabulary knowledge is directly correlated with our permanent memory, or background knowledge. Instead of thinking of our background knowledge as a web or 'filing cabinet', Marzano (2004) referred to it as "our packets of knowledge" (p. 32). Marzano also stated that in order to access our packets, we must 'tag' them with appropriate vocabulary.

> The actual words (vocabulary) we know are tags or labels for our packets of knowledge. Thus it makes intuitive sense that the more words we have, the more packets of knowledge, and hence, the more background knowledge we have. The understanding that a word is the representation for a packet of knowledge enhances our understanding of vocabulary and greatly expands its usefulness. (p. 33)

The greater our vocabulary is, the more background knowledge we have. But what happens when we don't have a large vocabulary in a certain content area, such as math, to 'tag' our packets of knowledge with? Will our overall conceptual understanding be negatively impacted?

Of all the content areas, mathematics is one of the most difficult. The shear volume of conceptual density is one of the major hurdles that students need to overcome. In the article "Learning Partners: Reading and Mathematics" by Vicki Schell (1982), Schell supported the idea that mathematics is one of the most difficult content areas because of the large volume of concepts. "Research indicates that math is the most difficult content area material to read, with more concepts per word, per sentence, and per paragraph than any other area" (p.

544). As educators, we must find a way to make learning and understanding mathematics more meaningful for our students. In order to develop and enhance student learning, teachers need to be constantly building background knowledge and student vocabulary. One way that teachers can enhance a student's vocabulary in math and all other content areas is through direct vocabulary instruction.

Direct Vocabulary Instruction

Seeing the strong correlation between vocabulary development and background knowledge, one might assume that direct vocabulary instruction would be one of the main focuses in the classroom. However, research indicates that that is not the case. In the article "What Classroom Observations Reveal About Reading Comprehension Instruction" by Dolores Durkin (1979) she described her findings for the lack of vocabulary instruction in the classroom. In Durkin's 4,469 minutes of classroom observations throughout the year, she observes only 19 minutes of classroom time that were devoted to direct vocabulary instruction. In a similar study, Roser and Juel (1982) found that during their classroom observations of third, fourth and fifth grade classrooms, only 1.67 minutes were devoted to direct vocabulary instruction each day. If educators know that direct vocabulary instruction will lead to an increase in background knowledge, why then are they only spending minutes a day teaching vocabulary? Two common arguments against direct vocabulary instruction are that students will encounter more vocabulary words through independent

reading, and that the estimates of vocabulary size for each grade level varies drastically.

Independent Reading

One argument against direct vocabulary instruction is that students will encounter more words through independent reading than they could through direct vocabulary instruction (Marzano 2004). Although this may be true, the number of words a student encounters is dependent upon the student's skill at reading. A student who is classified as a poor reader is going to encounter fewer words than a student who is a proficient reader. In the article "How Many Words Are There in Printed School English?" by William Nagy and Richard Anderson (1984), they estimate that a poor reader in middle school may read 100,000 words per year, while an average reader might read closer to 1,000,000 words per year. In another study by Anderson, Wilson and Fielding (1986) researchers found that an average fifth grade reader read an average of 650,000 words per year, while a proficient reader read 5.85 million words. Although the numbers in these studies vary, there is a wide discrepancy of words students will encounter during independent reading, based on the reader's level of proficiency.

Another argument against students acquiring their vocabulary through independent reading is the fact that most students will not be encountering the content area vocabulary while reading books of their choice. In the article "Developing Mathematical Vocabulary", Eula Monroe and Michelle Orme (2002) discussed the importance of direct vocabulary instruction because of the high incidence of unfamiliar words. They go on to further discuss the fact that

independent, or wide reading is not an effective way for students to learn mathematical vocabulary. "A key component in understanding mathematics is learning the vocabulary...[and] because much of the vocabulary used in the mathematics classroom is rarely encountered in everyday life, students are not likely to have a background knowledge for these words" (p. 140). Although students can encounter hundreds of thousands of words each year through independent reading, this is an ineffective way to teach mathematics vocabulary because of the discrepancy in words encountered, and also the fact that students will rarely encounter any content area specific vocabulary.

Vocabulary Size

Along with the argument that students can acquire the vocabulary needed through independent reading instead of direct vocabulary instruction, is the argument that the estimates of the size of a student's vocabulary vary considerably. Many educators feel that meeting the high vocabulary size could and would put a limitation on the time and quality of their instruction. In the article "How Many Words Are There in Printed School English?" by William Nagy and Richard Anderson (1984), they estimated that the number of words in "printed school English" is about 88,500. With this many words to teach, it would be impossible to do anything else but teach vocabulary.

When looking at these estimates, it does seem impossible to effectively teach vocabulary through direct vocabulary instruction. However, estimates in the size of a student's vocabulary vary immensely. In Table 1, the variability of estimates of student's vocabulary size is listed. The grade levels range from first

grade up through seventh grade, and in any given grade level, the student's vocabulary size can vary as much as 23,000 words. Depending upon which estimate we look at, the concept of direct vocabulary instruction can range from practical and feasible to utterly impossible. When analyzing the estimates in vocabulary size, if we assume that from first grade to seventh grade a student learns 9520 words (26,520 – 17,000), students would need to learn approximately 1,587 words per year. However, if we assume that from first grade to seventh grade a student learns 25,000 words (51,000 – 26,000), students would need to learn approximately 4,167 words per year. If students are learning only 1,587 words per year, as opposed to 4,167, direct vocabulary instruction seems much more possible.

Now that the arguments against direct vocabulary instruction have been countered, what are the characteristics of effective direct vocabulary instruction? Robert Marzano (2004) provided six common characteristics of effective vocabulary instruction which include not relying on definitions, representing knowledge of words in linguistic and nonlinguistic ways, gradual shaping of word meanings through multiple and varied exposures, teaching the parts of words, student discussion of terms, and allowing students to play with words.

Table 1

Estimates of Vocabulary Size

Grade level	Study	Estimated number of words in student's vocabulary
1	Dolch (1936)	2,703
	Ames (1964)	12,400
	Smith (1941)	17,000
	Shibles (1959)	26,000
3	Dupuy (1974)	2,000
	Terman (1916)	3,600
	Bradenburg (1918)	5,429
	Cuff (1930)	7,425
	Smith (1941)	25,000
7	Dupuy (1974)	4,760
	Terman (1916)	7,200
	Bradenburg (1918)	11,445
	Cuff (1930)	14,910
	Bonser, Burch, and Turner (1915)	26,520
	Smith (1941)	51,000

Descriptions, Not Definitions

One of the most common ways that a new vocabulary term is taught in a classroom is to have the students listen to, look up, copy down, and memorize the definition from the dictionary. This method is one of the most ineffective ways that vocabulary can be taught. According to Judith Irvin (1990) when students learn new vocabulary terms this way, it leads to minimal understanding. Dictionary definitions often don't have enough information for students to construct and understand the meaning of a new word. Also, often times, the definitions of the words are too vague or too broad for students to fully comprehend the definition. Margaret McKeown (1993) agreed that students should not be taught definitions by looking up definitions in the dictionary because students often cannot understand the definition that is given.

Judith Irvin (2001) went on to further explain that learning a word is a very involved procedure, which requires much more than simply looking up and memorizing a definition from a dictionary. "Word knowledge involves a complex process of integrating new words with ideas that exist in the schema of the [student]" (p. 39). One successful alternative to dictionary definitions is descriptions of a word.

According to Beck, McKeown, and Kucan (2002), when people first learn words, they understand them more when they are given as descriptions instead of definitions. By presenting the definition into everyday language, students are better able to understand new definitions and connect them to prior knowledge. In Figure 2, some examples of descriptions versus definitions have been given.

Figure 2 - Word Meanings Given as Descriptions Versus Definitions

Word	Description	Definition
Disrupt	To cause difficulties that stop something from continuing easily	Break up; split up
Illusion	Something that looks like one thing but is really something else, or is not there at all	Appearance or feeling that misleads because it is not real
Improvise	To make something you need by using whatever is available at the moment	To make, invent, or arrange whatever is on hand

By putting a terms definition into a type of conversational explanation, example, and description, students will be able to better understand, learn, and use the new vocabulary term in everyday life.

Linguistic/Nonlinguistic Representations

Another common practice for learning new vocabulary is to have students write out the definition of a word. Although this is not one of the most successful ways to teach vocabulary, when paired with a nonlinguistic representation, this method can be quite effective. When processing information, the goal is to have that information be stored in permanent memory. By having students represent their new information in both linguistic (language based) and nonlinguistic (imagery based) ways, the likelihood that that information will be stored in permanent memory increases. In the book, Theoretical Models and Processes of Reading by Robert B. Ruddell, Martha Rapp Ruddell and Harry Singer (1994) the dualistic nature of our memory is described. According to the authors, our memory is bimodal, meaning that we must use both linguistic and nonlinguistic representations in order to have new information anchored in permanent memory. Students should be encouraged to represent new vocabulary they are learning not only in their own words, but also in pictures, pictographs, and through the use of graphic organizers.

Graphic organizers are one of the most frequently used nonlinguistic representations when teaching vocabulary. Graphic organizers help to represent important concepts and their relationships in a visual approach. According to 'Pamela Dunston (1992) graphic organizers are a beneficial nonlinguistic way to

represent new vocabulary because of the way the human brain organizes information into categories determined by past experience. New knowledge must be incorporated with ideas in our prior knowledge. Barbara Schirmer (1997) supports Dunston's theory on the use of graphic organizers. "Graphic organizers help students to point out relationships between concepts, and add information on the topic" (p. 55).

The most frequently used graphic organizer is the 'web'. This graphic organizer consists of a circle with the topic written inside. From the topic, branches are drawn, and details about the topic are given. In the article "Vocabulary Instruction in a Balanced Reading Program" by William Rupley, John Logan, and William Nichols (1999) the authors discussed the educational benefits to using webbing.

> Webbing is a method that graphically illustrates how to associate words meaningfully and allows students to make connections between what they know about words and how words are related…it allows students to see the relationship between words and concepts they have previously experienced. (p. 341)

Some other graphic organizers that are frequently used in vocabulary instruction are semantic maps and the Frayer model.
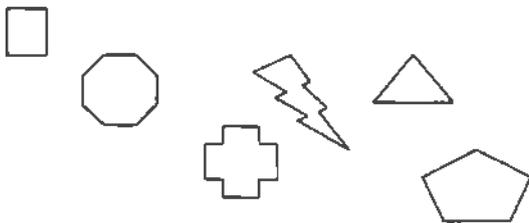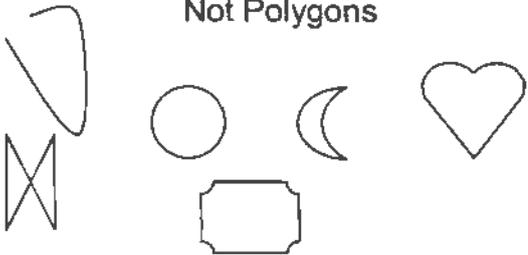
Semantic mapping is a method in which the teacher gives a concept or vocabulary term. Students must then list as many related words as possible, and categorize the words as they go. According to Martha Rekrut (1996) this procedure helps students relate new concepts to their background knowledge.

Semantic mapping provides students with a visual way to organize content information and encourages students to make connections between what they already know, and a larger idea or concept.

The Frayer model is a model most often used to teach individual words or terms that are related to very complex concepts. The Frayer model involves 4 steps which include identifying the word and its relevant attributes, identifying irrelevant attributes, examples are given, and lastly, examples of what the word is not are given. Figure 3 gives an example of a Frayer model graphic organizer regarding the word polygons.

Although all of these graphic organizers can be used to effectively teach vocabulary in mathematics, research has shown that student constructed graphic organizers are more beneficial than graphic organizers constructed by the teacher. According to Eula Monroe (1998) "when students construct their own graphic organizers, they participate actively and process ideas themselves" (p. 539). One further benefit to student constructed graphic organizers is that teachers are able to observe and assess the student's level of understanding of the given terms or concepts.

Figure 3 - Frayer Model: Polygons

Must Have	Cannot Have
• Straight lines • At least three sides • At least three vertices • Connected lines	• Curved lines • Less than three sides • Less than three vertices • "Holes" or gaps in sides • Sides that crisscross

Polygons	
Polygons	Not Polygons

Multiple and Varied Exposures

The third characteristic of effective direct vocabulary instruction is the gradual shaping of word meanings through multiple exposures. As previously stated, the more times a student is exposed to and engaging information in working memory, the more likely that information will become embedded in their permanent memory. In addition to repeated exposures to vocabulary terms, students also need to have varied exposures to words. Through repeated and varied exposures, students are able to adapt and revise their understanding of specific vocabulary terms. Marzano (2004) supported this idea and states, "to understand the word at deeper levels, students require repeated and varied exposure to words, during which they revise their initial understandings" (p. 73). He continues to state, "multiple exposures to information are necessary to anchor that information in permanent memory...[and] learning is greatly enhanced if students interact with vocabulary in a variety of ways" (p.74). One way to vary how students interact with vocabulary is to identify similarities and differences between the words. Four instructional strategies that require students to identify the similarities and differences are comparing, classifying, creating metaphors, and creating analogies.

Comparing and classifying are two processes, which require students to identify both the similarities and differences among or between terms and concepts, and categorizing them based on their findings. Research indicates that these activities not only help students better understand the concepts and

content being classified, but they also helps students look at the content in different ways and from different perspectives.

Two other instructional strategies recommended for varied student exposure are creating metaphors and analogies. When students are creating metaphors, they are identifying a pattern that connects unrelated information. Through doing this, students are able to better understand the abstract concepts of the new information. As students are creating analogies, they are identifying the relationships between relationships (A is to B as C is to D). Creating analogies is one of the most abstract, complex activities that students can do, requiring students to make a detailed analysis of their new understandings.

Parts of Words

Teaching root words and affixes, also known as prefixes and suffixes, has long been a tradition of vocabulary instruction. The theory behind teaching vocabulary this way is that when students are familiar with root words and affixes, they will be able to determine the meaning of unknown, unfamiliar words. In the article "Learning Words: Large Group Time as a Vocabulary Development Opportunity" by Han, Roskos, Christie, Mandzuk and Vukelich (2005) the authors discussed the benefits of teaching root words and word parts during direct vocabulary instruction. "Root words literally help children 'grow' more words and keep pace with peers in developing age-normal vocabularies..." (p. 333).

Although this is a common practice in teaching vocabulary in middle and high school, it has proven to be an effective instructional strategy in elementary school also. A study done by Thomas White, Joanne Sowell and Alice

Yanagihara (1989) proved the theory that teaching root words and affixes can improve student comprehension of new vocabulary terms. In this study, a third grade teacher taught three of her reading groups their vocabulary using root and affix instruction. A fourth group, the control group was taught their vocabulary in different ways. When the students were assessed on their understanding of root identifications and affix meanings, the three groups significantly outperformed the control group. On the assessment of root identifications, the instructed group answered 71% of the questions correct, where as the control group answered only 53% correct. On the assessment of affix meaning, the instructed groups again outperformed the control group by answering 84% of the questions accurately, while the control group answered only 43%.

As the results from this study show, teaching students roots and affixes can drastically improve their understanding of vocabulary terms. By teaching vocabulary to students using root words, prefixes and suffixes, we are enabling them to decipher and construct meaning from unknown, unfamiliar words.

Student Discussion of Terms

One of the easiest characteristics of direct vocabulary instruction to implement in the classroom is to allow students the time and opportunity to discuss the terms that they are learning. By allowing students the opportunity to discuss what they are learning about, teachers are giving students yet another experience to be actively engaged with new terms. As discussed earlier, repeated and varied exposures to new learning helps to ensure that the new learning will be stored in permanent memory. Marzano (2004) stated that

Discussion helps students encode information in their own words, help them view things from different perspectives, and allows for self-expression. As students discuss new terms, they gain deeper understanding and increase the probability that they will store the words in permanent memory. (p. 86)

Research supports the benefits of discussion of new vocabulary. In the article "Discussion is What Makes Semantic Maps Work in Vocabulary Instruction" by Stahl and Vancil (1986) the authors described findings from their study based on discussion of terms used in a semantic mapping exercise. In this study, three classes of fifth graders were taught meteorology concepts using different variations of semantic mapping. The first class went through the process of creating a semantic map using discussion only, the second created a semantic map and discussed what they were doing, and the third class simply created the semantic map. When they assessed the learning of the students, there was no difference found between the two classes that had discussion as a variable in creating a semantic map. However, both of these groups significantly outperformed the map-only group.

Although discussion about content and vocabulary naturally occur throughout a typical school day, students need to be given specific times to talk about new vocabulary. Teachers need to put students into groups with the sole purpose of discussing what they have learned.

Play with Words

The final characteristic of effective direct vocabulary instruction is that students should be allowed to play with words. One way that students can be

permitted to play with word is through games. Games are one instructional technique that is often overlooked and under utilized in the classroom. Far too often, teachers bypass games because there isn't enough time to play and the students may not get enough learning from playing the game. However, games have been shown to have positive effects on learning in the classroom. In his book, Making the Grade: a Self-Worth Perspective on Motivation and School Reform (1992) Martin Covington discussed how games present manageable challenges for students and how they arouse curiosity.

By providing manageable challenges for students, games "provide tasks that challenge the individual's present capacity, yet permit some control over the level of challenge faced" (p.160). Games also arouse curiosity in children. By making students curious about the different possible outcomes, students are intrigued and motivated to play.

There are numerous games that can be played to increase vocabulary awareness and understanding. Some common games that have been adapted and played in classrooms are bingo, concentration, and I have…Who has?. Games are just yet another way to get students interacting with words. Learning vocabulary doesn't need to be systematic and tedious. On the contrary, it should be fun, engaging, and stimulating. When students are playing vocabulary games, they are not only having fun, but they are experiencing terms in a new context.

Summary

Direct vocabulary instruction has been found to be very effective in teaching students content area vocabulary terms. As students become more familiar with these terms, their background knowledge in mathematics will expand. When planning and organizing for direct vocabulary instruction, educators need to keep in mind that students need to be actively engaged in working with the terms. Students need to be able to discuss terms, represent terms in linguistic and non-linguistic ways, learn the parts of words, and play with words. Students need to have not only repeated exposures to the words, but also varied exposures. The more times and the more ways a student interacts with a vocabulary term or concept, the more likely the it will be stored in permanent memory, and become part of that student's background knowledge.

Methodology

A prevalent issue effecting classrooms, elementary through high school, is the lack of effective vocabulary instruction. Research has shown a direct correlation among a student's vocabulary knowledge and academic achievement. The larger and better developed the vocabulary a student has, the better that child will do academically. Content area vocabulary is among the most difficult vocabulary to master. This vocabulary is more difficult because it is very abstract and students seldom encounter this type of vocabulary in their everyday lives. By following the six characteristics found to effectively teach vocabulary, the researcher hoped to gain insight as to how much direct vocabulary instruction increased students' background knowledge in mathematics.

Participants

Forty-seven fifth-grade students from Longridge Elementary School in Greece, New York were the active participants for this research. Twenty-nine of the students were male, while only 18 were female. The students' ages ranged from 10 to 11 years old. Of these 47 students, 35 were ten years old, and 12 were eleven years old at the time of the research.

In the team-taught classroom this research was conducted in, there was a plethora of varying needs among the students. Seven of the students had Individualized Education Programs, which required their math instruction to occur in a small pullout group that occurred in a different classroom. Five students out of the 47 had 504 plans, which often required additional instruction with numerous accommodations and modifications made by the teacher for those

students to be successful. Two students in the classroom had recently been declassified, and 1 student was also receiving ESOL (English for Speakers of Other Languages) services.

On account of the varying needs and abilities in this classroom, groupings were constantly changing. Students would sometimes work in homogeneous groups, and at other times be working in heterogeneous groups. At times, students would work in pairs, while at other times students would work in groups ranging from 3 to 5 students. The grouping procedures would change according to activities, student understanding, student needs, and the topic being covered. For most of the grouping practices, the teachers in the classrooms would select whom the students would be working with, but on occasion, the students would be able to pick their own partners or groups.

Materials

The materials that were needed for this research were all provided in the math program, Math Investigations. All of the sheets that the students needed were found in the back of the teacher's manual for the unit Picturing Polygons. At the beginning of this unit, the teacher provided the students with a copied packet of all the student sheets to be kept in their math binders. For each lesson, students would need to have their math binders, lined paper and a pencil. If students were ever unprepared for class, the teacher provided the materials that each students would need for that lesson.

Procedure

To assess understanding and student achievement, the researcher compared varying assignments and assessments from a unit that used direct vocabulary instruction to a unit previously taught without emphasis on vocabulary building strategies. Assignments and assessments were collected and analyzed from both units in addition to anecdotal notes and teacher observations. Work was kept anonymous throughout this investigation. Student names were removed in order to protect the identity of all students. The data that was collected was used only to gain further insight into direct vocabulary instruction and was destroyed when finished.

Results

Effective direct vocabulary instruction has six common characteristics which includes giving descriptions instead of definitions, representing knowledge of words in linguistic and nonlinguistic ways, providing multiple and varied exposures to the vocabulary, teaching parts of the words, allowing for student discussion of the terms, and allowing students to play with words. Throughout this entire Picturing Polygons unit, all of these characteristics were integrated into math instruction, and the increase in student performance was astounding.

Descriptions, Not Definitions

This geometry unit started off by having the students become familiar with different types of polygons, by having the students define each polygon based on the number and length of sides, number and size of angles and the total number of degrees found in each polygon. Instead of having students look up the definitions and copy them into their notes, students were given the opportunity to describe the polygons they were looking at, paying close attention to the number and size of sides and angles.

At the conclusion of this activity, students had a much more concrete understanding of the polygons they described. Students were also able to connect these descriptions to polygons that they see in everyday life. For example, one student was asked to describe an octagon, and in that description, he included the fact that a stop sign is an octagon. This activity allowed students the opportunity to link their new knowledge about polygons to prior knowledge.

Linguistic/Nonlinguistic Representations

The most commonly used graphic organizer throughout this unit was the Frayer Model. This graphic organizer allowed students to pair linguistic representations of what a polygon must have and cannot have with a nonlinguistic representation or drawing of each. By using this graphic organizer, students were able to not only describe the characteristics that make up a polygon, but they were also able to represent each description with a picture or drawing (Appendix A).

This graphic organizer became a reference that students used to throughout the entire unit, and all students were able to add more characteristics and drawings as we learned new information.

Multiple and Varied Exposures

Throughout this unit, students are immersed in the exploration of a variety of polygons. It is believed that through this immersion, students will become proficient in identifying attributes that these polygons have. To give the students yet another opportunity to work with polygons and identify their attributes, multiple sorting and classifying activities were introduced. Students completed numerous sorting activities with triangles and quadrilaterals. Students were sorting polygons based on angles (Appendix B), sides (Appendix C), parallel lines (Appendix D), regular versus irregular polygons (see Appendix E), and by types of quadrilaterals (Appendix F). By giving students the opportunity to work with these polygons in many different ways, students became experts with identifying and classifying polygons based on common characteristics.

Parts of Words

One expectation of this geometry unit was that students would be able to identify polygons based on the number of sides it has from three sided polygons up to twelve sided polygons. This expectation seemed extremely daunting until students were shown how to break down the words, and examine the prefix assigned to each word.

By breaking the vocabulary words down and examining and teaching the prefixes of each polygon, students were able to relate the new vocabulary to objects they are familiar with in everyday life. For example, when students broke the word triangle down and examined the prefix tri-, they were able to see that the prefix tri- meant three; therefore, a triangle has three angles. From this, students were encouraged to find other objects that had the prefix tri- and to determine how they are related. Students were extremely engaged in this activity and many went for a dictionary to look up words with tri- as a prefix. Some that were discovered included triceratops, a three horned dinosaur, tricycle, and bicycle with three wheels, and a triathlon, a sporting event in which athletes compete in three activities.

Students were given the opportunity to continue with this activity for polygons with up to twelve sides. Students completed a chart (See Appendix G) recording their findings, which also became a resource that was used and added to throughout the rest of this unit. This activity allowed students to make another

connection between new concepts and prior knowledge which lead to a much more solid understanding of the polygons.

Student Discussion of Terms

This geometry unit was an ideal unit in which students could often work with at least one other student. Many of the activities completed in this unit had students working in small groups of at least four. This allowed students ample time to discuss their ideas and new findings. Along with the time to discuss during group work, at the end of each session, the entire class would come together and share out any new learning or connections that were made. The class was surprisingly eager to discuss and share what they had discovered during each lesson. The class that is typically a shy class was now running like an open forum. Students were excited, enthusiastic and supportive of their peers and their learning.

Play with Words

The games that were included throughout all Investigations units do not always help students to see and understand why they are playing games. However, the games in the Picturing Polygons unit do. The games that were introduced to the students in this unit helped the students to make a connection to what concepts they were learning. Students were able to put their newfound knowledge to good use. One game that students were extremely successful with was Guess My Rule. Students had to classify polygons according to similar attributes, and have their partner try to guess their rule by trying to find other polygons to fit into their category (See Appendix H). This game allowed students

the opportunity to use the characteristics they had learned during the different lessons and sorting activities to determine their partner's rule.

Summary of Results

At the end of the Picturing Polygons unit, students had a much more solid understanding of the material covered. The six characteristics of effective vocabulary instruction were all integrated into the lessons, and there was a dramatic increase in student success.

To determine success, the students' Picturing Polygons end of unit assessment scores were compared to a unit previously taught without direct vocabulary instruction, Mathematical Thinking. In the Greece Central School District, students receive a score of a 4, 3, 2, or 1 based on given standards for each grade level. A score of a 4 represents a student who exceeds the given standards, a score of a 3 represents a student who meets the given standards, a score of a 2 represents a student who is working towards meeting standards, and a score of a 1 represents a student who is not meeting standards. In Table 2, the two unit assessments are compared and the results show a dramatic increase in the number of students who scored a 3 or a 4.

Table 2

End of Unit Assessment Grades

End of Unit Assessment Grade	Mathematical Thinking Number of students	Picturing Polygons Number of Students
4	3	6
3	17	31
2	17	7
1	10	3

As a result of the direct vocabulary instruction used in the Picturing Polygons unit, the number of students that met or exceeded standards almost doubled. During the Mathematical Thinking unit, only 20 students met or exceeded standards, while 39 students met or exceeded standards in the Picturing Polygons unit. There was also a dramatic decrease in the number of students who were working towards meeting standards or not meeting standards. In the Mathematical Thinking unit, 17 students were working towards meeting standards, while only 7 students were at that level in the Picturing Polygons unit. The lowest score of a 1 show very limited understanding of the content covered. During the Mathematical Thinking Unit 10 out of 47 students received that score, while in the Picturing Polygons unit, only three out of 47 students received a score of a 1.

The implementation of direct vocabulary instruction had a profound effect on the success of students in the area of math. By implementing the six characteristics of direct vocabulary instruction, students were more actively engaged, were able to make connections with prior knowledge, and as a result, student success rates soared.

Discussion and Conclusion

By implementing effective direct vocabulary instruction into an already existing math unit on geometry, student success rates of meeting standards or exceeding standards nearly doubled. Students were actively engaged throughout this entire unit, and were excited when math instruction began. All of the participants in this research were able to make connections with their learning, and were able to participate and share in the learning experiences. Six characteristics of effective vocabulary instruction were implemented throughout the Picturing Polygons unit, and each lesson and activity helped students connect the new knowledge with their prior knowledge and relate complex vocabulary to their everyday lives.

Mathematics is one of the most difficult content areas because of the vast number of concepts and vocabulary words. Vicki Schell (1982) supported this idea and goes on to claim that math content has more concepts per single word, line and paragraph when compared to other content area subjects. As an educator, one must find a way to make math instruction more personal and meaningful for students in order to ensure success. One way of accomplishing this goal is by enhancing and increasing a student's vocabulary in math through direct vocabulary instruction.

Robert Marzano (2004) suggested that there are six common characteristics of effective vocabulary instruction. The first characteristic states that students should be allowed to describe words, not just define words using a dictionary. Margaret McKeown (1993) supported Marzano's claim stating that

dictionary definitions are often confusing for children, and the definitions are either too vague or broad to be fully comprehended. When implementing the Picturing Polygons unit, students were allowed to describe the polygons they were working with instead of defining the polygon using a dictionary. This activity helped students to comprehend and understand the new vocabulary in ways they hadn't before. For example, one student's description of a triangle was a shape that has three sides and three angles. When comparing this description to the dictionary definition of a triangle, a plane figure bound by three sides and having three angles, it is clear that the description is in more kid-friendly terms. By allowing students to describe the polygons in their own words, students completed the activity with a much more concrete understanding of what characteristics the polygons had, and were much more comfortable discussing and using the terms in their mathematical language.

The second characteristic of direct vocabulary instruction suggests that students should be allowed to represent their words in both linguistic and nonlinguistic ways. One way of doing this is to incorporate graphic organizers into the learning. Pamela Dunston (1992) supports this idea stating that graphic organizers help the brain organize information based on the nonlinguistic representations. Multiple graphic organizers were used throughout this unit, but the most beneficial to students was the Frayer Model. Students were allowed the freedom to represent their learning in both linguistic and nonlinguistic ways on this graphic organizer, and as a result, students had a much more solid understanding of the concepts being covered.

The third characteristic is to provide students with multiple and varied exposures to the new content being covered. Marzano (2004) explained the importance of multiple and varied exposures of new information claiming that they are necessary in order to have the new information be processed into permanent memory. The very nature of this unit, along with the implementation of the six vocabulary instruction characteristics provided students with a multitude of opportunities to work with and explore the new vocabulary. Each day, students were introduced to new terms, or were reviewing and working with terms they had previously been introduced to.

The fourth characteristic stated that by teaching parts of words, such as root word and affixes, students would have a better understanding of the terms they are learning. In a study done by Thomas White, Joanne Sowell and Alice Yanagihara (1989) findings proved that by teaching root words and affixes, student comprehension of new vocabulary terms increased drastically. Findings were very similar in the Picturing Polygons unit. Students were taught the prefixes of the names of polygons and were asked to relate this new information to other objects that have the same prefixes. Students were shocked and amazed to discover the connections they were making by relating this new knowledge to objects they encounter in everyday life. By teaching the students the prefixes in this lesson, they were able to examine and construct meaning from both familiar and unfamiliar words.

The fifth characteristic that was implemented in this unit was allotting time after each lesson for student discussion. By allowing students the opportunity to

discuss the terms they encountered and worked with, students were able to again describe the terms in their own words, and were continuing to be actively engaged with the words. Stahl and Vancil (1986) supported the theory that students need to be given time to discuss new findings and learning. Although discussion occurs naturally throughout instruction, students need to be allotted time each lesson to discuss their findings with their peers. This unit allowed students to discuss everyday, simply because of the groupings that were needed. Students were always working with at least one partner per activity. On top of the discussion that occurred throughout each activity, students were again given time at the end of each lesson to discuss as a whole class. This activity helped students process their new learning again, both by explaining themselves, and also by listening to other students' explanations, thus increasing the probability that this information will be stored in permanent memory.

The final characteristic that was implemented was the opportunity for students to play with words. The games that were implemented in this unit allowed students the opportunity to use what they have learned. Martin Covington (1992) supported the theory that games can be an effective way to teach vocabulary instruction, because they provide a challenge to the students while sparking some curiosity. The games that were played throughout this unit kept the students engaged and motivated, and allowed students to see a clear connection between the task at hand, and the information that they had previously learned.

The amount of active participation among students in this unit was surprising. Students were very eager and motivated to begin their math class everyday. The students really enjoyed the activities and were able to explain why they were learning this information. Students took ownership with their work, and were proud to see their accomplishments.

One thing that may have helped with student engagement is the number of hands-on activities that occurred throughout this unit. Students were using some sort of manipulative in most activities. While most students took advantage of these manipulatives, others did not, and were equally as engaged as those who did.

Throughout this unit, students were given multiple assessments, which allowed for adjustments in the lessons needed. Homework assignments were also modified to ensure content vocabulary review throughout the unit. One downfall of the math program implemented at this school is that students rarely get the opportunity to review prior learning throughout units. Once a concept has been talked about and explored, most of the time students would not see that concept mentioned again until the end of the unit assessment.

While reviewing the lessons, activities, observations and data collected from this unit, many reassuring and reaffirming results occurred. Student success nearly doubles, but just as important, students engagement, ownership, and pride in work increased. The only aspect that would be changed in the future would be the increase in implementation of these direct vocabulary instruction characteristics.

As a result of the increase in student success, a few further questions have arisen, which could be studied for further research. If student success increased with the implementation of direct vocabulary instruction during this geometry unit, would student success continue to rise if these same characteristics were implemented with other units? This geometry unit was very heavily weighted on the New York State Grade 5 Math test in March, as was the unit on fractions, decimals and percentages, Name That Portion. Would students benefit from the implementation of direct vocabulary instruction on the Name That Portion unit? When scores are compared on the geometry questions from the 2006 Grade 5 Math test to the 2007 Grade 5 Math test, will there be considerable differences? And lastly, would students benefit from direct vocabulary instruction in all content areas, not just in mathematics?

Resources

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Roser, N., & Juel, C. (1982). Effects of vocabulary instruction on reading comprehension. *New Inquiries in Reading Research.* As referenced by Robert Marzano (2004).

Schell, V.J. (1982). Learning partners: Reading and mathematics. *Reading Teacher, 35,* 544-548.

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Appendix A

Frayer Model

Must Have.	Can't have.
• at least 3 sides	• gaps in lines
• at leas 3 vertices	• curve lines
• straight lines	• crisscrossing lines
• closed lines to	• 2 sides 2 vertices
make closed shape	• extended lines
•	

Examples | Palygons | **Non examples**

Appendix B

Angle Sort

Appendix C

Sides Sort

| Scalene | Isosceles | Equilateral |

Appendix D

Parallel Lines Sort

Name _____

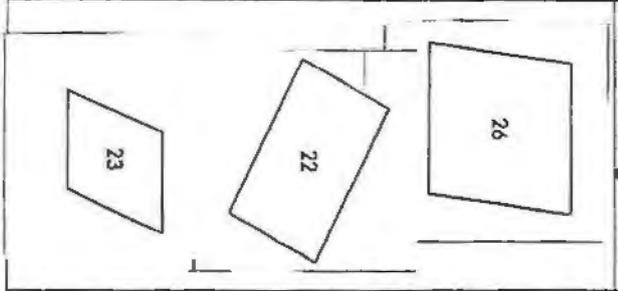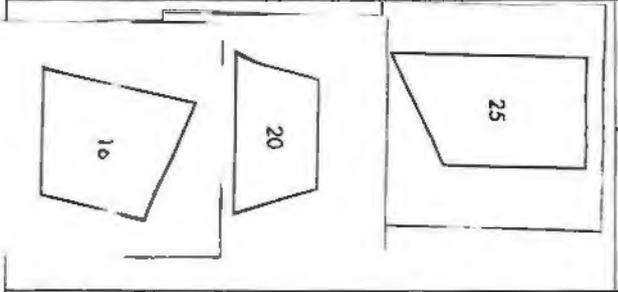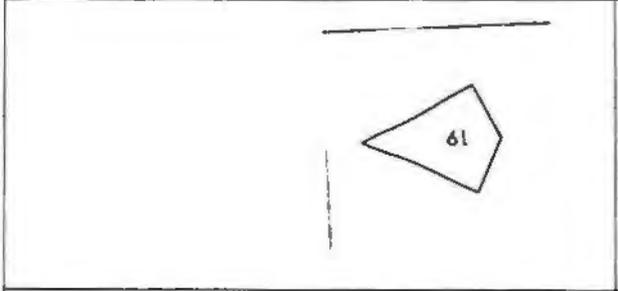| No Parallel Lines	One Pair of Parallel Lines	Two Pairs of Parallel Lines
14	16	13
17	20	18
19	25	21
15		
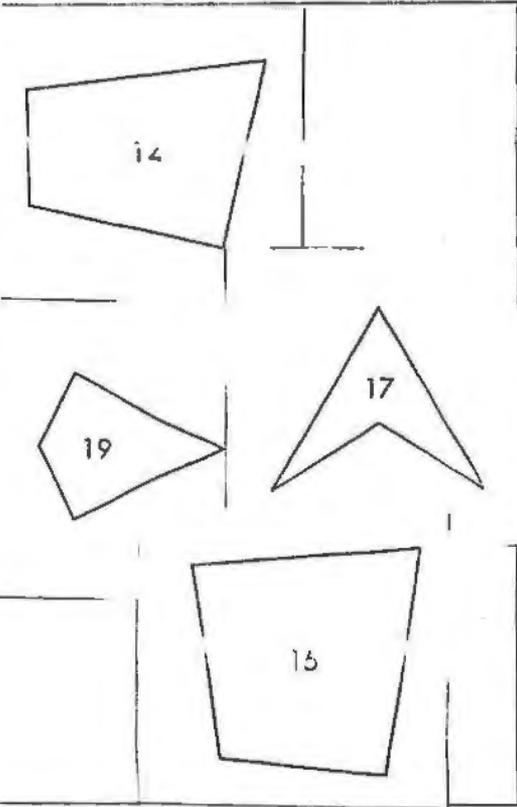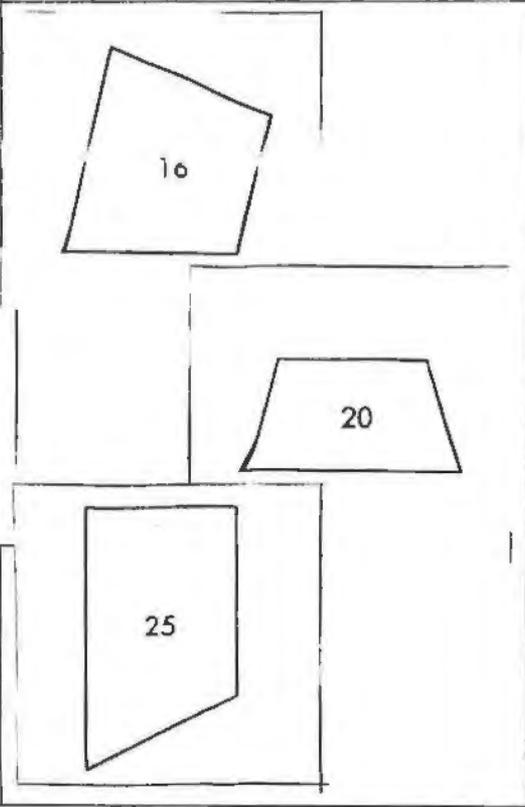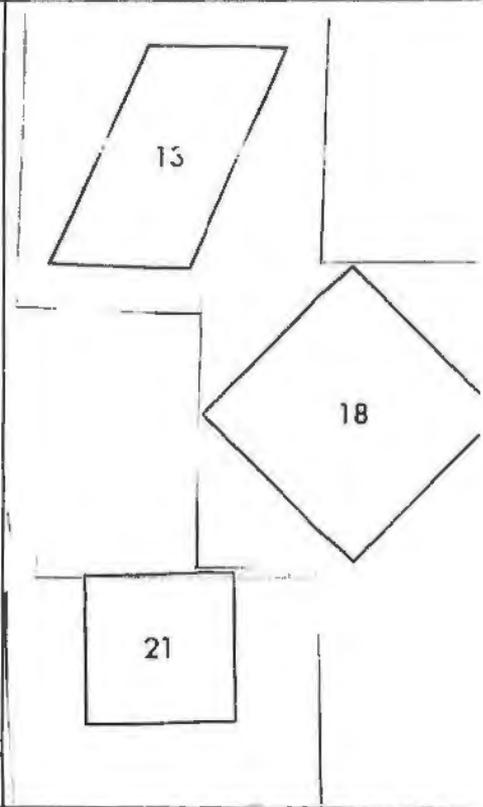
Appendix E

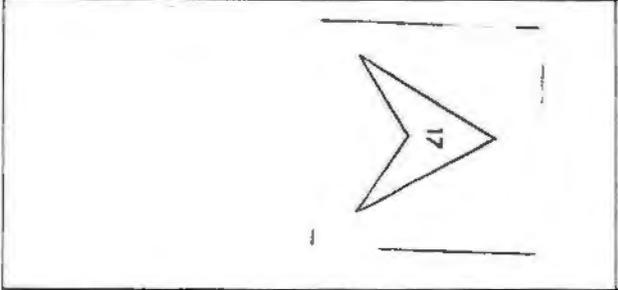Regular vs. Irregular Polygons Sort

Regular Polygons

Directions: Look at your Power Polygons and determine if they are regular or irregular polygons. You may use a ruler and protractor for help. Once you have determine what type of polygon each is, trace and label it with the letter in the correct column.

Regular Polygons	Irregular Polygons

B

G

D

H

E

C
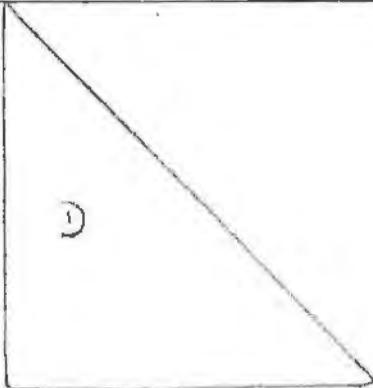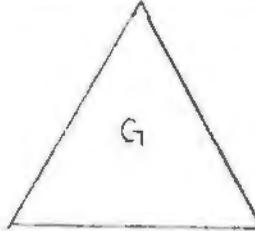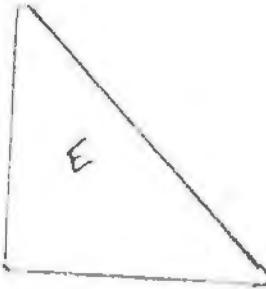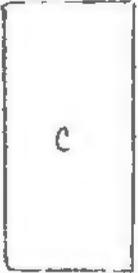
Appendix F

Quadrilateral Sort

Name _____

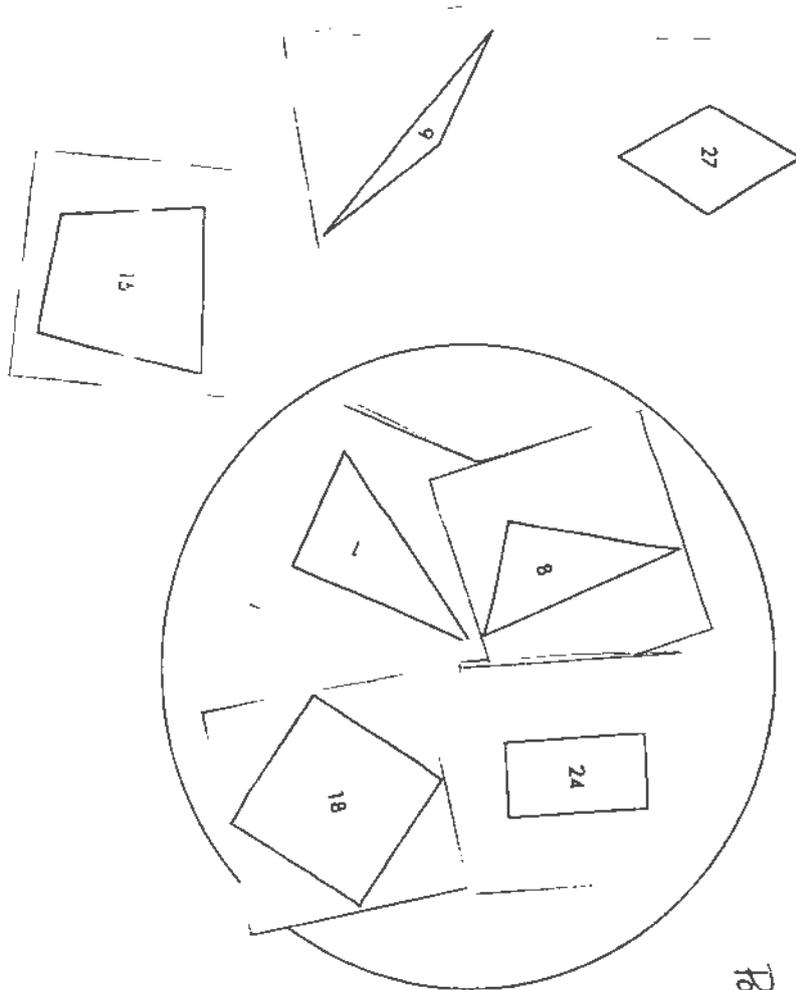| Parallelogram	Trapezoid	Kite	Chevron
26 22 23	25 20 10	19	17

Appendix G

Polygon Chart

Types Of Polygons

Fill in the second column of the chart with the name(s) of the polygon for each number of sides. Fill in the third column with related words or objects that use the same prefix.

# of Sides	Name of Polygon	Related Words or Objects
3	Triangle	Tripod, Trycicle, Triops
4	Quadrilateral	quadruped, quadroplet
5	Pentagon	Pentameter, Pentathalon
6	Hexagon	hexameter, hexahedron
7	Septagon	september, Septuplets septagenorian
8	Octagon	October, octupus octet Octogonal Octogenarian
9	Nonagon	nonagenarian, November
10	Decagon	December, Decathalon, decimal
11	Hendecagon	Hendecasyllabic
12	Dodecagon	Dozen dodecahedron dodecasyllabic

Appendix H

Guess My Rule

Guess My Rule

Polygons with right angles