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The Effect Gender Has on Mathematics Achievement

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THE EFFECT GENDER HAS ON MATHEMATICS ACHIEVEMENT

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CHAPTER I

STATEMENT OF THE PROBLEM

For the past several decades educational researchers have explored the topic of gender and mathematics achievement. Educators have been inundated with a wealth of data and analyses on the subject. Yet still, inconsistencies exist as to the nature and extent of the relationship between gender and mathematics achievement. Thus, the purpose of this study is to determine what effect gender has on mathematics achievement at Graham Middle School.

SIGNIFICANCE OF THE STUDY

In 1983, the National Commission on Excellence in Education began examining the quality of education in the United States. The U.S. Department of Education's National Commission on Excellence in Education published the report, *A Nation At Risk,* in 1983. This document is often cited as the origin of current reform efforts. The report stated its conclusions in brief but dramatic terms:

> Our Nation is at risk. Our once unchallenged preeminence in commerce, industry, science, and technological innovation is being overtaken by competitors throughout the world. This report is concerned with only one of the many causes and dimensions of the problem, but it is the one that undergirds American prosperity, security, and civility. We report to the American people that while we can take justifiable pride in what our schools and colleges have historically accomplished and contributed to the United States and the well-being of its people, the educational foundations of our society are presently being eroded by a rising tide of mediocrity that threatens our very future as a Nation and a people.

> What was unimaginable a generation ago has begun to occur--others are matching and surpassing our educational attainments. (p. 5)

Since this report, the field of education has been revolutionized. Teachers, administrators, and students have been scrutinized extensively. To assess aptitude of our educators and students, achievement tests have been designed and implemented into various grade levels. With so much riding on achievement scores, educators must utilize effective classroom instruction to maximize test results. Consequently, many factors, including gender, must be addressed to determine their impact on learning so as to maximize achievement in the classroom.

Previous studies have shown a link between gender and mathematics achievement. Gender related differences in mathematics achievement are visible as early as late childhood (Ethington and Wolfe, 1984). If research studies show gender differences do exist, teachers must reexamine their approach to teaching mathematics. Some schools have already capitulated. The state of California has taken the lead in bringing single-sex education to the public school realm. The state spent $3 million on twelve single-sex schools in 1997. A lot of other schools in California and around the country are considering the change as well. Lori Eibling, whose seventh grade daughter enrolled last year in an all-girls school in Lincoln, California, said that she wants the thirteen year old to continue there next fall (Reinhard, 1998).

> 'She's been happier in school this year,' Mrs. Eibling said last week. 'There seems to be more camaraderie between the kids, and they seem to be more focused. She's in a co-ed after school math and science club, and she still complains about the boys making fun of the girls. (p. 8)

Despite some positive reviews on single-sex schooling, the latest report from the American Association of University Women stated that single-sex education is not necessarily better than coeducation. What matters is small classes and schools, unbiased teaching, and a focused curriculum (Reinhard, 1998, p. 8).

While controversy abounds surrounding gender and achievement, one thing is for certain. Schools are making attempts to better meet the needs of their students and enhance performance by exploring the issue of gender and achievement. Perhaps this study will produce evidence that educators may utilize to enhance the teaching profession.

QUESTIONS TO BE INVESTIGATED

1. What effect does gender have on mathematics achievement?
2. How do boys and girls differ in ability to apply mathematical concepts and skills to problem-solving situations?

DEFINITION OF TERMS

- Computation: the act, process, or method of computing mathematical concepts.
- Gender: male or female.
- Mathematics Achievement: data gathered from classroom assessments and standardized test scores
- Mathematics: "the science of numbers and their operations, interrelations, combinations, generalizations, and abstractions and of space configurations and their structure, measurement, transformations, and generalizations" ("mathematics," 709)

- Problem solving: to find a solution to a mathematics question

- SAT: Scholastic Aptitude Test

RESEARCH PROCEDURES AND METHODOLOGY

The effects of gender on mathematics achievement were researched through two eighth grade math classes at Graham Middle School. Fifty students participated in the study. One class was an integrated mathematics course, the other a pre-algebra course. The students completed three classroom assessments. The mean scores of the males and females were compared and analyzed through the use of a t-test to determine the effect of gender and mathematics achievement. Additionally, questions which involved higher level thinking, such as problem solving, were examined to determine if gender differences existed.

ASSUMPTIONS

1. All students participating in the study will work to the best of their ability.
2. All students were taught the same curriculum.

LIMITATIONS

1. School absences may affect test results.
2. Only two mathematics classes at Graham Middle School were studied due to the extent of the mathematics schedule.
3. Mathematics classes at Graham Middle School are ability-grouped.

DELIMITATIONS

1. Only eighth grade students at Graham Middle School were studied.
2. Only three classroom assessments were given due to time constraints.

CHAPTER II

REVIEW OF LITERATURE

Gender differences in mathematics achievement have been the subject of extensive research over the years because mathematics achievement plays a vital role in the students' subsequent schooling, career choices, and professional development. However, the results of this research have been inconsistent.

Several authors have demonstrated that gender-related differences in mathematics achievement are visible as early as late childhood but are more visible in older students (Ethington and Wolfe, 1984; Fennema, 1984; Johnson, 1987; Martin and Hoover, 1987). When differences are discovered, they tend to favor boys, especially in more advanced abilities such as problem solving, applications of mathematics, and mathematics reasoning (Armstrong, 1981 & Marshall, 1984). In another study, Byrnes and Takahira (1993) used a cognitive process approach to explore gender differences on the mathematics subtest of the Scholastic Aptitude Test. Besides the Scholastic Aptitude Test, students were also given surveys to measure their prior knowledge of concepts and effective use of problem-solving strategies. Results showed that males performed better than females on the SAT-M; however, one's prior knowledge and use of strategies explained the majority of differences.

Gallagher and DeLisi (1994) found that boys' performance in mathematics was consistently higher only on problems that required "unconventional" problem solving. Gallagher (1996) suggested that, based on research findings, the reference to a global "gender gap in mathematics" is much less accurate than "gender differences in solving complex mathematics problems" (p. 463). Similarly, Becker and Forsyth (1990) presented further evidence about sex differences among high-ability students. In examining gender differences in a longitudinal study of scores on the Iowa Tests of Basic Skills and the Iowa Tests of Educational Development across 10 years (grades 3-12), they found that males performed significantly better at the upper percentiles (90^{th} and 75^{th}) in vocabulary and mathematics problem solving across all grade levels. Additionally, Chen, Fan, and Matsumoto (1997) found when high end math score distributions were examined, noteworthy gender differences favoring male students emerged. These differences became larger from the eighth to the twelfth grade and were more prominent at more extreme score ranges. Gender differences at the high end of math score distributions are likely to be one reason for the gender imbalance in the flow of new students into science and engineering careers (Chen, et al, 1997). Park & Reis (2001) concluded in 1996 that the population of girls taking the SAT averaged 46 points lower than boys on the math section. Also, the number of top-scoring males on the quantitative section of the SAT far exceeded the number of top-scoring females. Eight percent of males, (39,369) but only 3 percent of females (19,005) scored 700 or greater (Educational Testing Service, 1996).

In the Netherlands, the results of a large-scale national assessment study displayed marked gender differences in mathematics performance in a test based on topics from the arithmetic curriculum (Wijnstra, 1988). Differences in mathematics performance between boys and girls were found as early as fifth grade and increased in the higher grades. Differences in gender were most prominent in more complex tasks requiring problem solving. Additionally, Leder (1992) reported that at the beginning of secondary school, males frequently perform better on standardized measures of mathematics achievement. According to Leder, gender differences depend on the content and format of the assessment administered, the age level at which testing takes place, and the cognitive level of the test questions.

While many studies have concluded that there is a link between gender and mathematics achievement scores, other studies have challenged this general conclusion. For example, Galbraith (1986) studied 334 Australian junior high school students and found that girls outperformed boys in mathematics. The same conclusion was reached by Stockard and Wood (1984) for high school students in the United States.

There are also studies that have found no gender differences in mathematics achievement. Swafford (1980) investigated the performance of males and females with comparable math backgrounds in first-year algebra classes in high schools across the U.S. and found no significant gender-related differences. In Australia, Leder (1980) used the data from testing for a high school certificate from the state of Victoria and discovered no significant differences between the genders in mathematics performance. In Papua New Guinea, Kaeley (1988) studied gender and mathematics learning of post-secondary students. He evaluated the mathematics performance of the students with no significant differences in their math background (through assessment in the form of assignments, tests, and the final examination) and found no significant differences in the achievement of male and female students.

The majority of studies on gender and mathematics have focused on non-classroom measures of mathematics performance, typically standardized tests. Most of the studies that have used classroom grades have found either female superiority or no differences in mathematics performance of male and female students for grades seven and higher (Kimball, 1989). Kianian (1996) examined gender and math performances at the Metropolitan State College of Denver and the Community College of Denver by using semester grades. The subjects of his experiment were the 479 students in his 24 general math classes taught over the period 1987-1990. The results of the experiment showed no significant gender differences in mathematics achievement.

Due to the inconsistent results of research, educators have been unable to draw a general conclusion to the effects of gender and math achievement. Consequently, some researchers have begun to study sociological variables related to gender and mathematics achievement to determine whether a correlation exists.

Since early in this century, researchers have been interested in discovering and isolating specific skills and talents which might relate to mathematics achievement. Aiken (1971) indicated that verbal skill correlated well with mathematics achievement. Spatial skills have also been found to be related to mathematics achievement (Tartre, 1990). Although spatial and verbal skills are not the only cognitive factors which correlate significantly with mathematics achievement, they have been cited consistently as skills which might help explain the gender-related differences often found in mathematics achievement.

Affective variables have also been examined to determine how they relate to mathematics achievement. For example, several studies have found that confidence in one's ability to learn mathematics is positively correlated with mathematics achievement (Koehler & Meyer, 1990). Since girls have tended to be less confident in their ability to learn mathematics than boys are (Koehler & Meyer, 1990), it is reasonable to assume that confidence is related to gender and math achievement. Negative self-perceptions and feelings that one is different make students at-risk for underachievement (Ablard, 1997). However, Jacobs, Lanaz, Osgood, Eccles, and Wigfield (2002) found that self-concept of ability in math decline for both genders between first and twelfth grade with no real difference between girls and boys trajectory over time. Once again, inconsistencies permeate throughout the research.

Fennema and Tartre (1995) studied the relationship of selected cognitive and affective variables to mathematics achievement for a random sample of 60 students as they progressed through sixth, eighth, tenth, and twelfth grades. No consistent significant gender difference between means was found for spatial skills, verbal skill, or mathematics achievement. Confidence, verbal skill, and spatial visualization were each consistently positively correlated with mathematics achievement for both boys and girls. No gender difference was found for these correlations. However, spatial skills alone were found to be consistent significant predictors of mathematics achievement for females each year of the study, but not for males. Verbal skill was a consistent significant predictor of mathematics achievement for males, but not for females. This study debunks the myth that male superiority in spatial visualization skill has contributed to gender differences found in mathematics achievement.

Researchers have also investigated male and female students' attitudes toward mathematics, social stereotyping of mathematics as a male domain, and other negative social experiences for female students' mathematics achievement. Fennema and Tartre (1995) found that males stereotyped mathematics as a male domain to a greater degree than the females did for each year of a six-year study. Sax (1994) also found that male students have more positive attitudes toward mathematics and participate more actively in math-related courses.

Another affective variable, mathematics anxiety, has been well researched and documented. Eccles and Jacobs (1986) suggested that gender differences in mathematics anxiety are attributable to gender differences in mathematics achievement. On the basis of a review of a number of studies concerning gender differences in mathematics anxiety, Hunt (1985) concluded that there are noticeable differences between males and females in mathematics anxiety and that researchers need to examine the reason females are more anxious about mathematics than their male counterparts. In her study of 36 mathematics students at Urbana University, Bumbalough (2000) concluded that females revealed far more mathematics anxiety than the males, however, females earned better class grades, but males scored better on standardized mathematics subtests.

The effect of educational variables such as teachers and classroom instruction have also been studied. Fennema and Leder (1990) suggested that it is relatively easy to identify differential teacher interactions with girls and boys; in particular, teachers interact with boys more than with girls, praise and scold boys more than girls, and call on boys more than girls. However, the impact of this differential treatment is unclear and difficult to ascertain. The data that resulted from the studies do not support the premise that differential treatment of boys and girls causes gender differences in mathematics. Elizabeth Fennema, a leader in this area of research, wrote the following:

> Identifying behaviors in classrooms that influence gender differences in learning and patterns in how students elect to study mathematics has been difficult. Factors that many believed to be self-evident have not been shown to be particularly

> important. Consider sexist behaviors, such as those indicating that mathematics is more important for boys than for girls. No one would deny that such behaviors exist. However, Peterson and I (Peterson & Fennema, 1985; Fennema & Peterson, 1986) did not find major examples of overall sexist behaviors on the part of teachers, but rather small differences in teacher behavior, which, when combined with the organization of instruction, made up a pattern of classroom organization that appeared to favor males. We also found patterns of teacher behavior and classroom organization that influenced boys and girls differently. For example, competitive activities encouraged boys' learning and had a negative influence on girls' learning, while the opposite was true with cooperative learning. Since competitive activities were much more prevalent than cooperative activities, it appeared that classrooms we studied were more often favorable to boys' learning than to girls' learning. (Fennema, Research, Mathematics, and Gender section, para. 9)

Taking research a step further, Hopp (1994) studied the dynamics of cooperative small groups that influences the learning of mathematics, particularly the learning of complex mathematics like problem solving. She found that boys and girls engage in different mental activities during cooperative problem solving, and the impact of working in cooperative groups on their learning may be quite different depending on what mental activity is engaged in during the cooperative activity. Just working in small groups does not insure that girls will learn mathematics. It depends upon what goes on as the groups engage in cooperative activity. Thus, while research conducted from a cognitive science perspective is still in its infancy as far as gender and mathematics are concerned, such studies can provide knowledge that will help us understand the underlying mechanisms that have resulted in gender differences in mathematics.

While many researchers have revealed gender differences in mathematics achievement, others have found no significant differences. Obvious inconsistencies in the results of research studies have created difficulty in understanding the effects of gender and math achievement. Perhaps related variables such as anxiety, attitude, and teacher instruction are the key link between gender and achievement scores. It is apparent further studies are necessary to resolve the issue.

CHAPTER III

SUBJECTS

At the time of the study, Graham Local School District was a rural school district with a student population of approximately 2100 students. Graham Middle School contained sixth through eighth grades with less than one percent of the student body being of racial minority. The subjects in this study were 50 eighth grade students, 18 girls and 32 boys, ages fourteen and fifteen. Due to schedule availability, only two mathematics classes were involved in the study. One was a pre-algebra course that contained students who tested at a higher ability level. The second was an integrated mathematics course. These students were tested at a lower ability level the previous year.

INSTRUMENTATION

Students were instructed through a variety of instructional methods, including direct instruction, concept attainment, and cooperative learning. At the end of each chapter of study a mathematical assessment was administered. Assessments consisted of approximately twenty-five questions, twenty questions involving basic computation, and five questions incorporating problem solving. According to the state of Ohio's academic content standards, competency in mathematics includes understanding of mathematical concepts, facility with mathematical skills, and application of concepts and skills to problem-solving situations. The first twenty questions were designed to test students' understanding and facility with mathematical computation skills. (See Appendix A and B). For example, students were given a proportion and asked to solve for the missing length. The proportion was already conceptualized for students to calculate. Only students' ability to facilitate the mathematical skill, which often involves basic computation, was tested. The last five questions were designed to test students' application of concepts and skills to problem-solving situations. For example, students were given a real world problem-solving situation and asked to apply the concept of proportionality to solve the problem. The instructor of the class determined all three tests to be equal in the degree of difficulty.

PROCEDURES

Each student completed three assessments. Results of test scores for males and females were evaluated and compared to determine whether gender differences in achievement existed for students participating in the study.

Assessments were also designed to test students understanding of basic concepts and to test their ability to apply concepts and skills to problem-solving situations as explained in the "Instrumentation" section. The assessment was divided into two parts to determine student achievement on each distinct ability. A percentage was calculated based on the student's performance on each section. For example, student A correctly answered 18/20 questions on the first section (compuatation). Therefore, student A's percentage on the first section was 90%. Student A correctly answered 3/5 questions on the second section (problem solving), which would translate to 60%. Once assessments were completed, mean scores of males and females on each section were compared by using an independent t-test.

CHAPTER IV

ANALYSIS OF THE DATA

Eighth grade students at Graham Middle School received daily instruction in mathematics through a variety of instructional methods. At the end of each chapter, assessments were administered to measure student mastery of learning outcomes. The mean scores for boys and girls were calculated to determine the effect of gender on mathematics achievement. To assist in the analysis of the assessments, a separate non-independent t-test was used for data. The non-independent t-test allows evaluation of the data to determine if a significant difference occurs between the two genders. The data was collected and is displayed in Table 1.

Assessments were also designed to measure students problem-solving skills. Mean scores of boys and girls for problem solving were calculated to determine how boys and girls differ in ability to apply mathematical concepts and skills to problem solving situations. Once again, a non-independent t-test was applied to the data. The results can be seen in Table 2.

Table 1: Mean Test Scores

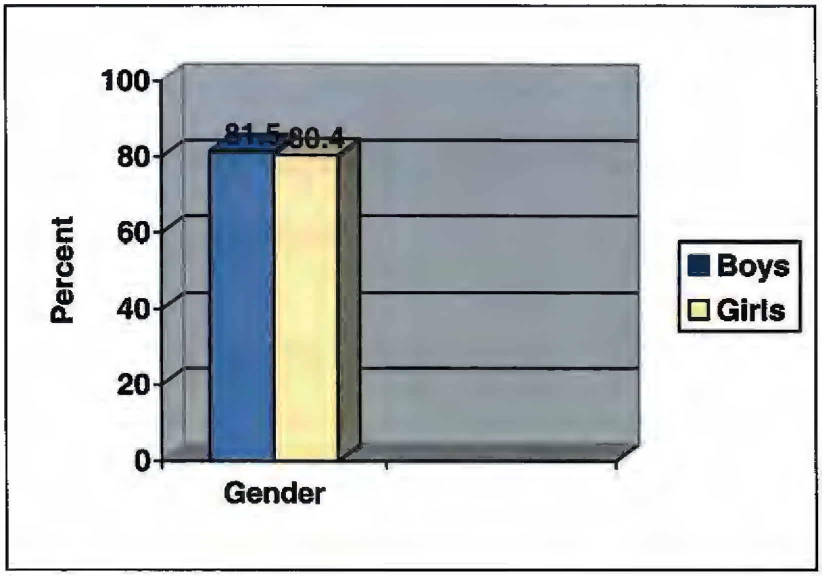
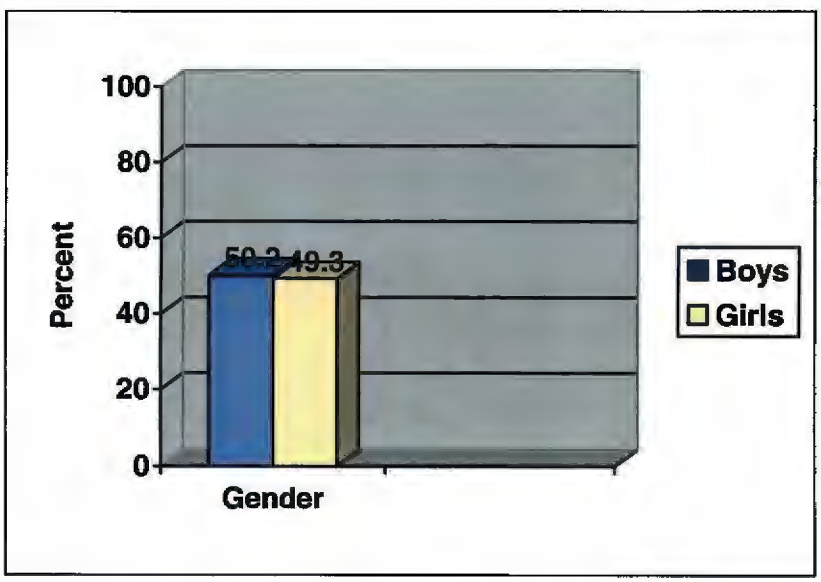


Table 2: Mean Scores (Problem Solving)



As shown in Table 1, mean scores for boys and girls were very similar. The mean score for boys was 81.5 and the mean score for girls was 80.4. Based on calculations of the non-independent t-test, the research shows that there was no significant difference between math achievement of boys and girls. The result of the non-independent t-test was 0.25, showing no significant difference.

As shown in Table 2, mean scores for boys and girls during problem solving were also quite similar. The mean score for boys was 50.2 and the mean score for girls was 49.3. According to calculations of the non-independent t-test, the research shows that boys and girls are similar in their ability to apply mathematical concepts and skills to problem solving situations. The result of the non-independent t-test was 0.22, showing no significant difference.

CHAPTER V

SUMMARY OF FINDINGS

Fifty eighth graders at Graham Middle School were studied to determine the effect of gender on mathematics achievement and how boys and girls differ in their ability to problem solve.

The findings are conclusions based upon the data collected during the study. Given the results in Tables 1 and 2, no significant differences exist between boys and girls in mathematics achievement. Similarly, no significant gender differences in the ability to apply mathematical concepts and skills to problem solving were discovered.

During the study, differences were noted in mean scores of the two divergent sections of the assessments. Mean scores of students, both male and female, were lower on the section of the test that required problem solving compared to the section of the test that employed basic mathematics computation. The average percent of boys decreased from 81.5 to 50.2 percent when problem solving. The average percent of girls decreased from 80.4 to 49.3 percent when problem solving.

CONCLUSIONS

Based on the results of this study, the following conclusion can be made: No significant differences exist between boys and girls in mathematics achievement. Additionally, no significant gender differences exist in students ability to problem solve.

IMPLICATIONS

The field of education has changed dramatically over the last decade. Due to implementation of the No Child Left Behind Act, teachers and administrators are being held accountable for student achievement. With so much emphasis on achievement scores, educators must utilize effective classroom instruction to maximize test results. Understanding the relationship between gender and mathematics achievement would aid educators in their quest to improve student achievement.

Based on the findings of this study, there is no significant gender difference in mathematics achievement for eighth graders at Graham Middle School. Educators need to take this information into consideration when preparing lessons. However, because students performed poorly on problem solving, teachers will have to address this issue. Teachers will have to focus more time on improving problem solving skills and applications. Since the new achievement tests major impetus is problem solving, it is vital that teachers develop lessons and activities to increase students problem solving strategies.

Those teachers who realize the importance of problem solving skills should feel compelled to convey their cognizance to other teachers in their building and district.

They, too, could utilize this knowledge to prepare lessons that will enhance student performance.

RECOMMENDATIONS AND FUTURE RESEARCH

Research on the effect of gender and mathematics achievement should continue. While results from this study yield no significant difference between males and females on mathematics achievement, many other studies prove contradictory. Perhaps various cognitive and affective variables contribute to gender differences in mathematics achievement. Might test anxiety, spatial skills, or verbal skills impact mathematics achievement? Perhaps test anxiety, student attitudes, or educational variables such as teachers and classroom instruction impact mathematics achievement.

Because of the short time of this study, not all components of gender and mathematics achievement could be investigated. A large-scale study would be useful to determine if the results hold for larger groups and longer periods of time. Additionally, similar studies could be conducted at other grades. It would be interesting to note if gender differences in mathematics achievement apply to other subject areas.

An analysis of this study exposed the weakness of students of both genders with problem solving. Future research on this topic could provide valuable information educators could use to improve student performance and meet the needs of today's students.

Our children are the future. They deserve every opportunity to become successful. Using current knowledge about gender and learning mathematics is a positive step toward helping each child reach his or her maximum potential.

APPENDICES

APPENDIX A

Chapter 9 Test

Express each ratio or rate as a fraction in simplest form.

1. 16 girls: 28 students
2. 24 inches per yard
3. 48 to 16
4. 200 miles in 4 hours
5. Express $480 for 12 tickets as a unit rate.

Solve each proportion.

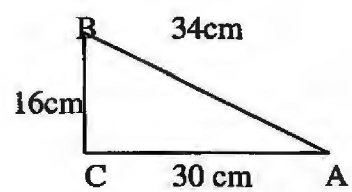
6. 18/24 = a/4
7. 8/1 = 24/b
8. 18/c = 3/100
9. d/7 = 5/6
10. Do 5/9 and 7/9 form a proportion?
11. Camille can type 3 pages in 20 minutes. How many minutes will it take to type 8 pages?

Find the actual distance if the scale on the map is 1 inch : 30 miles

12. 4 inches
13. ½ inch
14. 4 1/2 inches
15. Polygon ABCD has vertices A(-2,-2), B(-3,3), C(1,3), and D(3,-1). Find the vertices for a dilation with a scale factor of 1/3.

Complete each exercise, using the information in triangle ABC.

16. tan A
17. m < A
18. cos B
19. m <B
20. m<C



Problem Solving. Show all work!

21. There are 8 golfers in a golf tournament. The player with the highest score is eliminated at the end of each round of play. How many rounds will be played during the tournament?

22. Explain how you could use indirect measurement to find the height of a flagpole on a sunny day.

23. The Fort Couch Middle School Chess Club has eight members. Recently, each member agreed to play every other member exactly once. How many games will be played in all?

24. Many tourists travel to New York City during the holidays to see the decorated tree placed at Rockefeller Center near the skating rink. One year the tree was 63.2 feet tall. A guy wire was attached to the top of the tree and made a 72 degree angle with the ground. To the nearest foot, how long was the wire?

25. Mrs. Allen's science class is standing evenly spaced in a circle. If the sixth person is directly opposite the sixteenth person, how many people are in the circle?

APPENDIX B

Chapter 10 Test

State whether each number is divisible by 2, 3, 5, 6, or 10.

1. 1620
2. 852
3. 4236
4. Write the product of (5)(5)(5)(5)(5)(5)(5)(5) using exponents.

Evaluate.

5. five to the fourth power
6. $x^2 - 2y$ if $x = 5$ and $y = 7$

Factor each number or monomial completely.

7. 693
8. 308
9. $75x^2y$

Find the GCF for each set of numbers or monomials.

10. 56 and 84
11. 20, 60, and 180
12. $32a^2b$ and $36ab^2$

Write each fraction in simplest form.

13. –45/75
14. $72x^2y^2/80xy^3$

Find the LCM for each set of numbers or monomials.

15. 48 and 120
16. 15, 120, and 180
17. $32a^3b^2$ and $48a^3b^3$

Find each product.

18. $(-15x^3y)(3x^2y^2)(-2x)$
19. $a^3(b^2)(b^3)$
20. $32ab(ab^3)$

Problem Solving. Show all work!!

21. Jamal is cutting wooden patterns. Some patterns are 4 inches square and some are 6 inches square. How wide a piece of wood should he buy to avoid waste, if the length of wood comes 60 inches long?

22. Mary needs ½ yard of cloth to make some doll clothes. She has a piece of blue cloth which measures ⅔ of a yard and a red piece which measures ⅜ of a yard. Which piece is large enough to make the clothes?

23. The Carpet Experts cleaning team can clean carpet in a room that is 10 feet by 10 feet in 20 minutes. Draw a diagram to find how long it would take them to do a walk-in closet that is 5 feet by 5 feet.

24. The Graham High School Band and chorus have been invited to participate in the Thanksgiving parade. There are 210 band members and 40 choir members.
    a) Can the band march in a rectangular formation having 8 band member in each row? Why or why not? If not, draw a diagram of a rectangular formation that would be permissible.

    b) Twenty-six chorus members and 140 band members have not brought in their permission slips for the Thanksgiving trip. Explain how to tell whether a greater fractional part of the chorus or band has not brought in their slips. Find which part is greater.

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