others using toys which involve numerical, spatial, and mechanical relationships. As their daughters advance to higher levels of mathematics, Keinberg and Stenmark recommended that parents encourage and support their daughters. Allow the girls to talk about the problems they are having and listen attentively. Together, attempt to reach a solution, find others with whom to study, or talk to someone who also struggled with mathematics but were rewarded for perseverance. Statements, such as 'I was never good at math either' or 'I can't do that either' should be avoided. When children are studying, it is not helpful to give them correct answers, but to try to talk through the problem by reviewing the facts given and the questions asked, and by attempting to find a logical way to solve the problem. Most of all, parents need to be a role model for their children. If parents are willing to give up, even if the topic is not related to mathematics, children will develop similar attitudes, which will be reflected in their school work.

Teachers also need to be able to overcome this negative socialization. Jean Skolnick, Carol Langbort, and Lucille Day (1982), in their book, *How to Encourage Girls in Math and Science*, identified four strategies for teachers to focus on in attempting to overcome the negative socialization of students: a) building confidence, b) using
manipulative materials, c) using different social arrangements, and d) being aware of gender-role bias. Skolnick, Langbort, and Day (1982) believed that confidence is strongly linked to problem-solving skills. Students who are excellent problem solvers are students who strongly believe they are capable. Unfortunately, girls tend to be socialized early in life to believe they cannot do certain problems. Thus they tend to give up easily, are more discouraged, and do not get the same practice at problems as do boys. To help build confidence, Skolnick, Langbort, and Day suggested different approaches for teaching. First, they suggested that teachers present and evaluate topics at many different levels. This way the students will have the opportunity to successful at their own level. Secondly, they suggested that teachers give problems or activities which can be approached in different ways and may have more than one right answer. This is valuable since not all students will think about a problem in the same way; thus one approach is not necessarily better than another nor is the approach considered right or wrong. Problems with more than one correct answer will allow the students who only find one answer to still feel successful, while the higher level students can be challenged to find all possible answers. Students should also be encouraged to guess and test ideas, which is also an important part of problem solving. Girls
are often afraid of guessing because they are afraid of being wrong. Students need to be taught the importance of creating hypotheses and testing them, and if their guess is wrong, they must understand how to learn from mistakes. Finally, students need to estimate. If students realizes they are close to an answer, their confidence will increase and they will have a stronger desire to find the exact answer.

Using manipulative materials is another strategy suggested by Skolnick, Langbort, and Day (1982). The manipulatives used do not have to be expensive models ordered out of catalogue, instead they can include easy to find materials such as playing cards, clay, mirrors, rocks, or sugar cubes. Because of socialization, girls learn to interact through verbal means while boys learn through hands-on experiences. When children start school, girls are expected to understand and express mathematics verbally or by writing, without ever experiencing it through some concrete means. Thus it is important, at both the elementary and secondary level, to present concrete forms in order for the girls to fully understand the abstract concepts.

Using different social arrangements is the third strategy recommended by Skolnick, Langbort, and Day (1982). Social arrangements can be independent, cooperative (single-gender and mixed-gender groups)
and in the form of game playing. Students, especially girls, gain confidence from independent work because they are allowed to work at their own rate and to create their own ideas. Cooperative work allows the students to share ideas and to interact with others. Beginning with single gender groups allow the girls to share with other girls who may also have low confidence in mathematics. There may also be certain mathematical topics with which girls are not familiar and this allows them to work with others at their own level. Mixed-gender groups are more successful at later stages in activities. Girls will have had a chance to gain self-confidence before they begin working with boys. When girls and boys work together cooperatively, they will be able to learn from each other and to consider each other equal partners. Game playing helps the students to learn strategies. They learn to anticipate and to examine all possibilities and consequences. These techniques are not only valuable for problem solving, but for logical thinking as well.

The final strategy presented by Skolnick, Langbort, and Day (1982) is being aware of gender-role bias. Students learn what is expected of them from observing role models. Usually the role model observed is the same gender as the student. Through content relevance and the modeling of new options, it is believed that girls will see new opportunities available to
them which they never knew existed. Content relevance involves relating the mathematics which is being taught to different careers the students may not have been aware of or relating the mathematics to real life problems which may be solved by people in different careers. The modeling of new options presents problems in which women are portrayed in nontraditional jobs and men are portrayed in nurturing roles.

Skolnick, Langbort, and Day (1982) presented many specific activities to be used in the classroom in their book. The activities are divided up into four categories: spatial visualization, problem solving, logical reasoning, and scientific investigation. These activities are gender neutral so they are appropriate for the whole classroom. They provide alternate ways of presenting material which include more concrete explanations for those who have trouble grasping the abstract.

Similar activities can be found in the *Math for Girls Handbook* (Downie, Slesnick, & Stenmark, 1981). In 1973, it was observed that females were coming to college with insufficient mathematical background. Through extensive research, this handbook was published to help girls learn mathematics through hands-on experience. The activities were designed to decrease students' fear for math and increase their problem solving skills. Although the activities are appropriate for males
and females, all pronouns in the book are either "she" or "her". The term "students", however, is used in place of "girls".

Conclusion

Researchers are still searching for an answer to the gender difference question. Meanwhile, statistics show girls are lacking in the mathematical field. Whether or not researchers ever agree on a solution to the gender question, alterations need to be made in mathematical education. Genetic differences are impossible for parents and teachers to alter. Therefore, parents and teachers are challenged to alter socialization. Being aware of the gender difference problem and being aware of the changes which can be made through socialization will be a start towards encouraging girls to believe they are capable and that they can succeed.
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Gender Differences in Mathematical Ability:

An Empirical Look

In their review of the literature on gender differences, Maccoby and Jacklin (1974) concluded that one of the four primary gender differences is that boys excel in mathematical ability. They believed that all gender differences, including the gender difference in mathematical ability, are the result of a) genetic factors, b) shaping of boy-like behavior and girl-like behavior by parents and other socialization agents, and c) children's spontaneous learning of behavior appropriate for their own gender through imitation. Maccoby and Jacklin reported that there was little difference between male and female mathematical ability until adolescence; however, the age at which gender differences appeared depended on the measure used in testing. Mathematics is not a unitary factor; the solving of mathematical word problems is related to verbal ability while other mathematical concepts, such as geometry, are related to visual-spatial ability. Because mathematics is not a unitary factor, it is difficult to determine the factor which causes the gender difference. Maccoby and Jacklin were not able to give a definite reason for the mathematical gender difference but did cite a number of theories and hypotheses.

Maccoby and Jacklin (1974) determined that a gender difference in
mathematical ability did exist, however, the extent and reasons for this gender difference could not be determined. Following the publishing of their findings, research continued to debate the genetic versus the socialization theories of mathematical gender differences. Although new discoveries have been made, old theories disproved, and new theories created, the research is still inconclusive.

Vandenberg (1968; c.f. Maccoby and Jacklin, 1974) stated that visual spatial ability was linked to heredity. Visual-spatial ability was believed to be linked to the X-chromosome causing visual-spatial ability to be expressed at a higher rate in males than in females in a ratio of two-to-one (see Maccoby & Jacklin, 1974, for a review). There is little support for mathematics being genetically related, however, there are many theories for the relationship between visual-spatial ability and heredity. Since mathematics is related to visual-spatial ability, it is believed that mathematics is indirectly genetically linked. The exact genetic basis for visual-spatial ability is unknown, however, there is support for an X-linked trait, hormones, or hemispheric specialization. It is still unknown if these traits are independent or dependent, and if dependent, to what extent they rely on one another (Thomas & Kail, 1991; Hier & Crowley, 1982; Geschwing & Galaburda, 1987; c.f. Halpern, 1982). Camilla Benbow
has been a leader in the search for a genetic reason for the mathematical gender difference. Benbow (1990) believed it to be important for girls to realize that genetically they may not be as intelligent as boys so that they may accept and adjust to the situation. Many feel that it is dangerous to state such opinions from controversial research (Kolata, 1980).

Other researchers think that boys have been socialized over time to have a greater interest in mathematics than have girls. This socialization begins in the home by the parents when the children are young with simple things such as toys. Boys are given mathematical and science related toys such as erector sets and microscopes, while girls are given dolls and eventually parents will have a greater desire for their sons to go to college than for their daughters. Parents tend to discourage inappropriate gender behavior in boys more than in girls by allowing girls to act as tomboys but considering it wrong for boys to act feminine (Lansky, 1967).

The socialization theory is favored more than the genetic theory. Support for the socialization theory is summarized in six hypotheses stated by Halpern (1992):

1. Females maintain more negative attitudes toward mathematics.

2. Females perceive mathematics to be less important for career goals than males do.
3. Females have less confidence in their ability to learn mathematics.

4. Mathematics is a male-stereotyped cognitive domain.

5. Females receive less encouragement and support for studying advanced mathematics.

6. Females take fewer mathematics courses than males; therefore, they score lower on tests of mathematical reasoning ability.

The majority of researchers believe in a combination of genetics and socialization. Scarr (1987) discussed how genetics may influence our interest, while the environment limits our experiences. The question about reasons for gender differences in mathematics is still unanswered. Because it is possible to alter socialization, as opposed to genetics, society is encouraged to create an environment in which females are given the opportunities to be mathematically equal to males.

Hyde and his colleagues (Hyde, Fennema, & Lamon, 1990) believed that the actual gender differences are very small and in some cases do not exist, depending on how the mathematical categories are classified. They found females to be slightly superior in computation, males to be slightly superior in problem solving, and no gender difference relating to understanding of concepts. Miller and Crouch (1991) found that even
though males score higher on achievement tests, females actually have a higher GPA in mathematics classes than do males. The extent of the gender difference, or lack thereof, depends on the subjects and measurements used in testing.

The purposes of this study were to explore: a) gender differences in elementary grades versus high school grades, b) gender differences in high school English grades versus mathematics grades, c) gender differences in English achievement scores versus mathematical achievement scores. It was expected that there would be no gender difference in elementary grades while the females would score higher than males in high school. This was expected because few gender differences were found until adolescence (Maccoby & Jacklin, 1974), however, in high school girls were found to have a higher GPA than males (Miller & Crouch, 1991). On achievement tests, it was expected that males would score higher than females on the mathematical section while females would score higher than males on the English section. This was expected because of the belief that males are more superior in mathematics, while females are more superior in English (Maccoby & Jacklin, 1974).
Method

Subjects. The subjects in the experiment were 190 seniors at a public high school in a rural district of northwestern Indiana. The students came mostly from white, middle class families and had a mean age of 17.7 years (32 were 17 years old, 38 were 18 years old, 4 were 19 years old, and 1 was 20 years old). Approximately 39% of the students participated.

Procedure. The surveys (see Appendix A) were handed out in the English classes of the high school and were returned to the English teachers when completed. The survey was voluntary and the only identification information required was gender and age. The students were asked to record their English and mathematical grades for kindergarten through the twelfth grade and their SAT scores.

Results

The means of the mathematics and English grades for elementary and high school and SAT scores can be found in Table 1. The grades in Table 1 are on a four point grading scale.

There were no significant gender differences found in mathematical elementary grades, mathematical high school grades, mathematical SAT scores, or English SAT scores. Although no significant differences were
found in these categories, females did have a higher mean in the mathematical elementary grades. The males had a higher mean in the mathematical SAT and Verbal SAT. There was a significant difference in English elementary grades and English high school grades. Females ($M=3.45$) had significantly higher English elementary grades than males ($M=2.99$), $F=5.831$, $p<.05$. Females ($M=3.10$) also had significantly higher English high school grades than males ($M=2.36$), $F=14.63$, $p<.001$. 
Table 1

Means of grades and SAT scores by gender

<table>
<thead>
<tr>
<th>Variables</th>
<th>Males</th>
<th>Females</th>
<th>Significance of F</th>
</tr>
</thead>
<tbody>
<tr>
<td>Elementary</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Math</td>
<td>3.17</td>
<td>3.42</td>
<td>.179</td>
</tr>
<tr>
<td>English</td>
<td>2.99</td>
<td>3.45</td>
<td>.021</td>
</tr>
<tr>
<td>High School</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Math</td>
<td>2.87</td>
<td>2.88</td>
<td>.954</td>
</tr>
<tr>
<td>English</td>
<td>2.36</td>
<td>3.10</td>
<td>.001</td>
</tr>
<tr>
<td>SAT Scores</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Math</td>
<td>561</td>
<td>500</td>
<td>.195</td>
</tr>
<tr>
<td>Verbal</td>
<td>479</td>
<td>448</td>
<td>.267</td>
</tr>
</tbody>
</table>
Discussion

The purposes of this study were to explore: a) gender differences in elementary grades versus high school grades, b) gender differences in high school English grades versus high school mathematics grades, and c) gender differences in English achievement scores versus mathematical achievement scores. It was expected that there would be no gender differences in elementary grades, while females would have higher grades at the high school level in both mathematics and English. It was also expected that males would have a higher achievement score in mathematics, whereas females would have a higher score on the English achievement tests.

It was expected that there would be no gender differences in the elementary grades in either mathematics or English. However, there was a significant difference in the elementary English grades in favor of the females. Although Maccoby and Jacklin (1974) reported few gender differences until adolescence, they also reported that females have a greater verbal ability than males. Maccoby and Jacklin also reported that males have a greater mathematical ability than females, however, Hyde, Fennema, and Lamon (1990) found males to have a greater mathematical ability in problem solving only. They found no gender difference in
understanding of concepts and female superiority in computation.

Elementary mathematics places little emphasis on problem solving which may help to keep the gender differences balanced in the elementary school.

The expectation that females would have higher grades in high school was supported by the data, however, a significant difference was found in English grades only. Miller and Crouch (1991) found that females usually have higher GPAs than males. It is not surprising that a significant difference was found in English, since females also tend to have greater verbal abilities than males (Maccoby & Jacklin, 1974). One reason females tend to have higher GPAs in any subject at the high school level is that they are more responsible and more attentive to their grades. Although females are more responsible at the high school level, the mathematical classes are beginning to increase in difficulty. At adolescence, males begin to surpass females in mathematical ability (Maccoby & Jacklin, 1974) which may account for the close means for male and female mathematics grades.

The final expectation was that males would have a higher mathematical achievement score whereas females would have a higher English achievement score. The results showed that males scored higher on the achievement tests in both mathematics and verbal, however, none
of the scores were significant. Because there were few subjects on which
to calculate the data for achievement tests, no significant difference was
found for the mathematical section. However, the mean score differed by
61 points in favor of the males. If there had been more subjects, there
may have been a significant difference in favor of the males. This
supports the research of Miller and Crouch (1991) which found that males
have higher mathematical achievement scores than females.

This research had its limitations. The number of participants who
agreed to participate were few in number. Because this was a
retrospective survey, of those students who did participate, few students
were able to provide complete surveys. It should also be noted, that even
though males and females responded evenly, females tended to be more
complete in their memory of grades. It can also not be certain that the
students were honest in their responses. To receive more accurate and
complete data, it would be helpful to have the students obtain a copy of
their transcripts or to receive this information from the school systems.
Another option, which is time consuming, is to follow the students from
kindergarten through the senior year of high school. The significant
differences observed or not observed in this sample may have been
different if more subjects had participated. The larger the sample, the
more accurate the results.

It is important to look at many different areas before creating a conclusion concerning gender differences in mathematics. Few researchers compare achievement scores to grades in their investigations. They tend to draw conclusions from one or the other. If more research were done in comparing achievement scores to grades it may be possible to see that grades depend more on social factors while achievement scores tend to be more genetically based. Researchers have also found that when different measures are used the degree of the gender difference is altered. To be more consistent, researchers should use more than one measure to determine gender differences, before drawing conclusions which may be invalid. Researchers should also consider the different parts of mathematical ability, instead of looking at mathematics in general. Males may be considered superior in mathematics in general, however if you separate mathematics into problem solving, computation, and understanding of concepts, males may not always be considered the superior ones.
References


APPENDIX A

Student Letter and Survey
Dear Seniors,

I am doing my Honors Thesis at Ball State University and would appreciate your help in collecting data. My thesis involves researching the development of achievement in mathematics and language. I would appreciate your cooperation in filling out this survey as completely and accurately as possible. Any item for which you do not have information or any item which is not applicable should be left blank. Your participation is strictly voluntary and the only identification I want is your gender and age. When you are finished with the survey, please return it to your English teacher.

Thank you,

Jenny Lou Coffer
DEVELOPMENT OF ACHIEVEMENT
Jenny Lou Coffer--Ball State University

Circle one: male female Age:__________________

PART I--MATH GRADES

Please fill in the math grades you received and the gender of the teacher for the following grades.

<table>
<thead>
<tr>
<th>grade</th>
<th>grading period</th>
<th></th>
<th>gender of math teacher</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>K</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
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<td></td>
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<tr>
<td>3</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>4</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>5</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>6</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>7</td>
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<td></td>
<td></td>
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<tr>
<td>8</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Please fill in your grades from high school under the appropriate math class. In the parentheses, state the year taken (9, 10, 11, or 12) and include the gender of the teacher.

<table>
<thead>
<tr>
<th>subject</th>
<th>grading period</th>
<th></th>
<th>gender of math teacher</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>(year)</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>basic math</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>pre-algebra</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>algebra I</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>geometry</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>algebra II</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>trigonometry</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
(Math grades continued)

analytic geo ( )

calculus ( )

other:

( )

( )

PART II--ENGLISH GRADES

Please fill in your English grades for the following classes and the gender of your English teacher for each class.

<table>
<thead>
<tr>
<th>grade</th>
<th>grading period</th>
<th>gender of English teacher</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1 2 3 4 final</td>
<td></td>
</tr>
<tr>
<td>K</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td></td>
<td></td>
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<tr>
<td>2</td>
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<tr>
<td>3</td>
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<td></td>
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</tr>
<tr>
<td>8</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Please fill in your English grades from high school under the appropriate English class. Include the gender of the English teacher for each class.

<table>
<thead>
<tr>
<th>subject</th>
<th>grading period</th>
<th>gender of English teacher</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1 2 3 4 final</td>
<td></td>
</tr>
<tr>
<td>Freshmen English</td>
<td></td>
<td></td>
</tr>
<tr>
<td>General</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Academic</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Gifted</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
(English grades continued)

Sophomore English
  General
  Academic
  Gifted

Junior English
  General
  Academic
  Gifted

Senior English
  General
  Academic
  Gifted

PART III--STANDARDIZED TESTS

Please fill in the scores for the test which you have taken and for which you have a record of scores.

ISTEP (Score(s) and date(s) taken):

SAT Scores: Verbal: ___________ Math: ___________

ACT Scores: English: ___________ Math: ___________
            Composite: ___________

Plans following graduation (include intended major if attending college):

___________________________________________________________________________

___________________________________________________________________________