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ABSTRACT

Autonomous Learning Behavior (ALB) as mediators between internal and external influences and performance on high level cognitive tasks was proposed as a possible explanation for gender-related differences in mathematics. This study developed a measure of ALB by drawing on teachers' working knowledge and the literature on problem solving, including self-regulatory and metacognitive strategies. The Math Assessment Project Questionnaire was used to assess students' awareness of their behaviors in a mathematics class and a non-routine word problem solving was used to measure the ALB. Students' confidence and achievement were also collected as data. No gender differences were found on the math achievement measures, the ALB questionnaire, or the confidence measure on two-tailed t-tests. However, the inclusion of the interaction term between gender and confidence showed a significant rise in the multiple R. The results of correlation analyses revealed significant correlations between the ALB score and the standardized test score, and confidence in math learning and gender. (YP)

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New Perspectives on Problem-Solving: Autonomous Math Learning Behavior and Math Achievement

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Presented at the annual convention of the American Educational Research Association, April 1990

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INTRODUCTION

Gender Differences in High Level Math Achievement

Popular discourse would have us believe that the gender gap has decreased in most areas that once plagued education. However, in the area of mathematics study, research has repeatedly found that males are far more likely than females to participate in and excel at the highest levels of math study (e.g., de Wolf, 1981; Wise, 1985; Chipman and Thomas, 1985). This persistent gender difference has been the focus of much research over the last 15 years.

While some researchers have implied innate differences between the sexes in mathematical ability (Benbow and Stanley, 1980; 1983), many more have found a variety of sociocultural variables to be related both to mathematics achievement and enrollment in advanced mathematics courses (e.g., Sherman, 1981; Armstrong, 1985). While these variables appear to exert a powerful influence on both math persistence and achievement, they are not readily amenable to interventions that produce behavioral changes. Thus, it has become necessary to investigate those variables upon which the educational community may have some influence.

Autonomous Learning Behavior

Autonomous learning behavior (ALB) was first proposed by Fennema and Peterson (1985) as a possible explanation for gender-related differences in mathematics. The behaviors that characterize ALB are viewed as mediators between internal and external influences and performance on high level cognitive tasks and are hypothesized to be the result of external and societal factors. Their conceptual model continues to hold promise as a vehicle through which researchers can begin to understand, clarify and effect change in the area of females' math enrollment and achievement. Several researchers have conducted studies examining classroom process and teacher-student interaction in an effort to identify ALB in the classroom. The present research attempted to develop a measure of ALB by drawing on teachers' working knowledge and the literature on problem-solving, including self-regulatory and metacognitive strategies. Moreover, student self-reports on this measure were obtained and related to their scores on a standardized math achievement test.

Attitudes Toward Math

There is a long history of research on the relationship between gender and attitudes toward mathematics. Carey (1958) found attitudes toward math to be strongly related to performance and found that females both performed less well in math and exhibited poorer attitudes toward the subject. Since Carey's research, many studies have found attitudes towa . math to be positively related to math achievement (e.g., Hilton & Berglund, 1974; Boswell, 1985; Ethington & Wolfle, 1988).

Various manifestations of interest have been measured and gender differences favoring males are still found on a variety of math attitude measures. The attitude of interest for the present study was Confidence in Learning Math, since recent research has found this to be an important variable in females' math achievement (e.g., Lantz, 1985; Lester & Garofalo, 1987).

METHOD

ALB Questionnaire

The questionnaire intended to measure ALB evolved through several phases of construction, and was adapted from the Math Assessment Project Questionnaire (MAPQ) (Tittle & Hecht, 1988). The MAPQ was designed to assess students' awareness of their behaviors in math class and when solving a non-routine word problem. The items included in their measure were gleaned from the research on metacognitive and self-regulatory strategies in the problem-solving literature and the work of Leinhardt and Putnam (1986) on strategies used during math lessons.

The first phase involved obtaining teacher-generated characteristics of ALB. An open-ended questionnaire was administered to 10 seventh- and eighth- grade math certified teachers in four different suburban New Jersey school districts. These teachers were asked to think of a student whom they considered to be a good problem-solver and an autonomous math learner and list specific characteristics and behaviors they had seen exhibited by this student.

Thirteen of the characteristics identified by teachers in the first phase did, in fact, reflect those identified in the math metacognition and self-regulation literature and were represented in the original MAPQ. However, 24 behaviors and characteristics generated by the pilot teachers were not included in the MAPQ. These 24 items, the 13 items identified in phase I and already included in the MAPQ, and an additional 20 items selected from the MAPQ, were integrated into a questionnaire.

Twenty-five math teachers, representing three private and five public schools, participated in phase II of the study. These teachers were presented with the items discussed above and were instructed to indicate for each item whether the behavior was characteristic of an autonomous math learner by checking "no," "maybe," or "yes" next to each item.

In the final phase of instrument development, the student ALB self-report questionnaire was constructed. Teacher-generated items to which 30% or more of the teachers checked "no" were eliminated from the measure, while all items selected from the MAPQ were included, for a total of 51 items (see Appendix). These 51 items were divided among four sections describing different stages of problem-solving- "before," "during," and "after" solving a non-routine problem, and a "classroom strategies" section. In accord with the procedure followed by Tittle and Hecht, a non-routine word problem preceded the presentation of the ALB items. The problem read:

> Eight pennies are arranged in a row on a table. Every other coin is replaced with a nickel. Then, every third coin is replaced with a dime. Finally, every fourth coin is replaced with a quarter. What is the total value of the coins on the table?

This problem gave the students a specific stimulus on which to reflect when responding to items regarding strategies/behaviors used before, during, and after solving a non-routine problem.

An example of an item from the "before" section read:

> I tried to put the problem into my own words.

Students indicated whether or not they had engaged in this behavior by checking "no," "maybe," or "yes."

An example of an item from the "during" section read:

> I drew a picture or diagram to help me understand the problem.

An example of an item from the "after" section read:

> I thought about a different way to solve the problem.

An example of an item from the "math classroom" section read:

> I usually ask questions of the "what if" and "why" type.

Scoring for responses to individual items was as follows. For items that were positively weighted , NO = 1, MAYBE = 2, YES = 3. For items negatively weighted, NO = 3, MAYBE = 2, YES = 1. An example of a negatively weighted item read:

> I would have liked the teacher to check each step as I worked it.

Other Measures

In addition to the questionnaire, students also completed the Confidence in Learning Math Scale, a subscale of the Fennema-Sherman Mathematics' Attitudes Scales (Fennema & Sherman, 1976). Scores on the math section of the Iowa Test of Basic Skills were obtained from the cooperating school and used as the standardized math test score.

It was expected that males would exhibit significantly higher ALB and Confidence scores than would females and that ALB would predict achievement on the standardized test significantly more than would either gender or confidence. Further, the interaction of ALB and Confidence was expected to predict the standardized math test score greater than would any other interaction term.

<u>Subjects</u>

One hundred twenty-two eighth-grade students-- 70 females and 52 males-- were used as subjects. The subjects represented all levels of math achievement, with students tracked in specific math classes according to this achievement.

RESULTS

The results reported herein are those of particular interest to the topic of this symposium. For a more detailed discussion of the study and results, see Caporrimo (1990).

Preliminary analyses were conducted to examine the relationship of standardized math achievement, ALB, and Confidence in learning math, to gender. Two-tailed <u>T</u>-tests were performed to assess the relationship between these variables using all sub-tests, as well as the overall math score, on the Iowa Test of Basic Skills and scores on the ALB Student Self-Report and Confidence in Learning Math questionnaires. No gender differences were found on the math achievement measures, the ALB questionnaire or the Confidence measure.

The results of Pearson correlation analyses revealed significant correlations between ALB score and standardized test score ($r = -.19$, $p < .04$) and Confidence in learning math and gender ($r = -.24$, $p < .01$). Thus, this measure of ALB was a significant, although negative, predictor of standardized math test score.

In the multiple regression analysis the addition of gender and confidence, individually, to the regression equation following ALB, did not significantly increase the multiple R. However, the inclusion of the interaction term Gender*Confidence resulted in a rise in the multiple R from .24 to .30, a significant increment of .06. The variables accounted for by these variables was only 9%, with the ALB measure explaining only 4% of the variance in the standardized math score. No other variables or interaction terms added significantly in this prediction.

The finding that the interaction of gender and confidence added significantly to the prediction of the standardized test score, was unexpected. Figure 1 depicts the regression line for females and males of the relationship between confidence in learning math and the standardized math test score when considering the average ALB score. For males, higher standardized scores are related to higher Confidence in learning math scores. For females, an small inverse relationship exists--the relationship between Confidence and the Iowa score is relatively weak. Regardless of the Confidence in math score, the

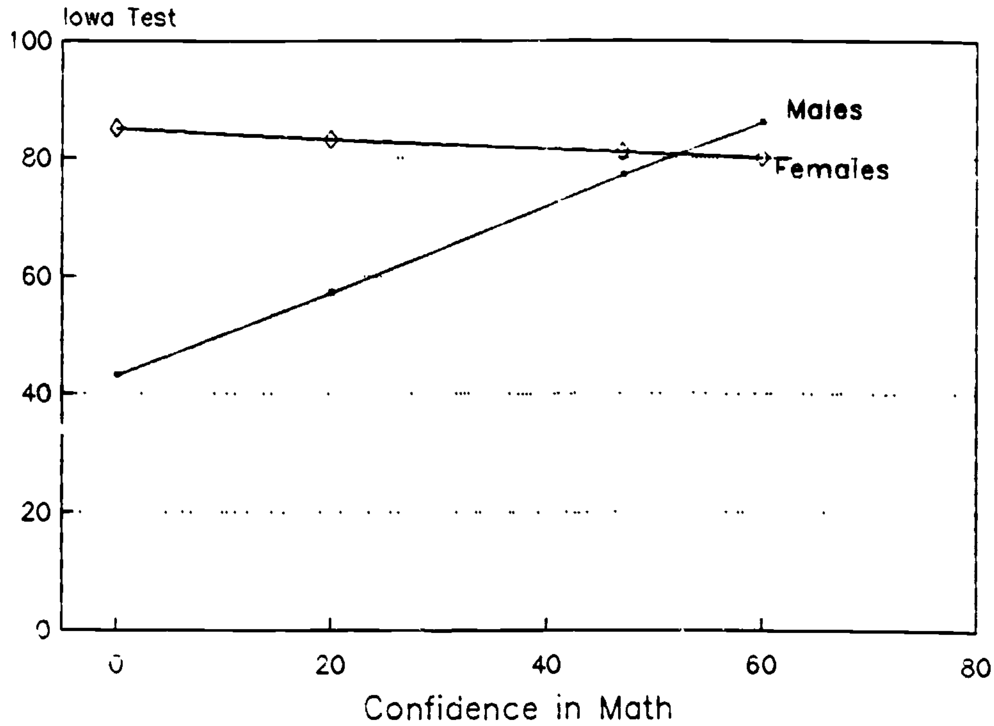

Figure 1
Regression lines for females and males of the relationship between confidence in learning math and standardized math test score when considering ALB

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standardized math score for females remains in the range of 80 - 85.

DISCUSSION

Results suggest that autonomous learning behavior must be more clearly conceptualized in order to design a better measure of this construct. Although this particular measure was ineffectual in clarifying the function of ALB and gender, it served to elucidate other issues regarding autonomous learning behavior, problem-solving strategies, and standardized math test scores.

This was a first attempt at designing a measure of autonomous learning behavior. In designing the questionnaire, the investigator drew heavily on two sources: 1) the literature on problem-solving and 2) teachers' working knowledge.

The items in the first three sections of the questionnaire were based on research findings from the literature on self-regulation and metacognitive problem-solving strategies. Since the positively weighted items described successful problem-solving behaviors, it is apparent that researchers must recognize that students who are good problem-solvers are not necessarily autonomous math learners.

Teachers' working knowledge was used to generate items describing autonomous math learners. This allows researchers to wonder if teachers themselves are aware of the difference between students who are adept at solving problems and those who are truly autonomous learners. Teachers are able to observe behaviors in which students engage, yet must hypothesize on the relationship between these specific behaviors and math achievement. Thus, teachers were in agreement that following orderly procedures and being eager to get an answer, were indicators of ALB. Yet, these behaviors may not describe the essence of ALB or the cognitive processes in which these students engage that are related to their superior achievement. While initially it appeared that drawing on teachers' observations would serve to assist in operationally defining ALB, it may be impossible since teachers would have to rely on inferences drawn from possibly unrelated behaviors.

Another consideration is that the section on the "math classroom", with items drawing heavily on the work of Leinhardt and Putnam (1986) appears to best describe how researchers have thought about ALB. Items such as "when my math teacher makes a mistake, I say something about the error;" "I like to do new word problems by myself, even before the teacher explains them;" and "I usually ask questions of the "what if" and "why" type" appear to describe students who are willing to take personal responsibility for their learning. Thus, it may be important to expand on research conducted in the math classroom, specifically by interviewing students in an effort to discover cognitive processes and strategies used during the learning process rather than exploring strategy use during actual problem solving performance.

Another issue which merits exploration is the finding that the ALB measure used was negatively related to standardized math test score. Although there was a variety of item types, many from the first three sections fall into a broad category describing a meticulous problem-solver, a "careful worker." Given the time factor involved in the standardized testing context, it is likely that meticulous, step-by-step problem-solvers would not do as well as those who skip steps and take chances. Thus, skills that serve students well in the math classroom and are indeed endorsed by teachers, may be counter-productive in the standardized testing context. The skills that are seen as important in the math classroom and by problem-solving researchers may help students to better understand and enjoy the nature and process of problem-solving. Unfortunately, these skills appear not to be valued by those who construct and monitor procedures of standardized tests.

The finding that Confidence in learning math is related to standardized math test scores differently for females and males, warrants further discussion. It has been assumed that Confidence in learning math is important in that it may impact on student math achievement. Thus, one approach to increasing math achievement has been to attempt to increase students' confidence. These results indicate that a different explanation may be appropriate. For males in this sample, the higher the math achievment level, the higher the score on the Confidence in learning math measure. There is no way, however, of suggesting the causative relationship of these variable. For females, the

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relationship between Confidence level and achievement level suggests that confidence in learning math may not be an important variable. Past research conclusions have suggested methods to increase females' confidence in their ability to learn and perform well in math. However, one may also conclude that regardless of past achievement, females remain less confident than males in their ability to achieve highly in math.

SUMMARY

This research was a first attempt to design a measure of autonomous learning behavior. Although it appears that this particular measure did not capture the essence of ALB, it shed light on several important issues relating to ALB, problem-solving strategies, and standardized math achievement.

Recently I spoke with a university dean regarding the problem of standardized testing and its impact on students' self-concept, motivation and cognitive processes. He illustrated my point by explaining that as a student, he generally tested quite "average" on standardized tests although his classroom achievement was exemplary. When he stopped thinking too deeply, he asserted, he began to increase his standardized testing scores.

What a shame it would be if teachers had to train their students not to think. If learning not to think has become an important part of excelling on standardized tests, then there is an obligation to the minds of tomorrow to "re-think" standardized testing.

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