Mathematics Anxiety and Learning Style of the Navajo Middle School Student

Oakley D. Hadfield
Jeanette V. Martin
Sharon Wooden

College of Education
New Mexico State University
Las Cruces, New Mexico 88003

Mathematics achievement in the Native American student population is significantly lower than that of the national norm (Bradley, 1984; National Research Council [NRC], 1989. An example is the state of New Mexico, where achievement of the Navajo in mathematics falls below other ethnic groups by the high school level, including Hispanics and Blacks (Bradley, 1984). This fact is at the forefront of concern regarding American Indian education because career opportunities have come to be more and more dependent on mathematical preparation in one's education (NRC, 1989). This situation is seen as one that will only increase in the ensuing years due to the technological foundations of an increasing portion of the newly created careers (James & Kurtz, 1985; NRC, 1989). Those who elect themselves out of mathematics courses due to either lack of interest or poor performance will be severely limited in future college majors and career choices (Burton, 1984; Sells, 1973; Steen, 1987).

This so called filtering of students out of technological careers has particular significance to Native Americans because they are already the most underrepresented of all minorities in the technological areas (Lawrenz & McCreath, 1988; South Dakota Indian Association, 1981). A very small percentage of mathematics and engineering positions are held by Native Americans due to their poor participation in corresponding college major areas. For example, only 18 bachelor's degrees and 7 master's degrees were awarded in mathematics to Native Americans in the entire US in 1984 (Grant & Snyder, 1984).

This situation has a particular impact on the southwestern US, where the largest Indian Reservation is located. The Navajo Reservation, with its population of almost 200,000, has a significant influence on the economy of surrounding communities. The size of the combined populations of Navajo, Pueblo, and Zuni tribes of New Mexico makes their educational and related socioeconomic status a noticeable ingredient in the state economy (Page, 1985; Pottinger, 1985).

Many diverse reasons have been suggested for the poor achievement and participation of Native Americans in mathematics. Most are culturally related. Due to the existence of over 400 tribes, each with its own unique culture, it is difficult to pinpoint specific cultural variables that could be related to mathematics achievement (Keshena, 1980). Among those suggested by previous research is noncompetitiveness, with more importance placed upon cooperation and harmony with the environment (Hynd & Garcia, 1979). Reliance on nonverbal and nonlinear communication has been noted by Connelly (1985).

The Native American student's lack of time specificity may make it difficult for him or her to perform well simply for future benefits of grades, college majors, jobs, etc. (Cundick, 1970). Teachers, counselors, and administrators have also been known to convey the impression that only basic skills in mathematical areas are necessary for Native American students (Green, Brown, & Long, 1978). Smith (1982) goes so far as to say that poor participation by Native Americans in the sciences is due primarily to the poor quality of mathematics and science instruction in Native American classrooms.

One prevalent variable which is negatively correlated with both mathematics achievement and mathematics participation is mathematics anxiety (Betz, 1978; Dew, Galassi, & Galassi, 1983; Frary & Ling, 1983; Shanklin, 1978). Mathematics anxiety is an emotional avoidance reaction to situations requiring numerical or mathematical conceptual tasks. It is not necessarily related to general intelligence, often affecting persons who are highly successful in other areas (Morris, 1981).

Another variable often explored in relation to mathematics achievement is learning style. Examples of learning style and cognitive style that are correlated with mathematics achievement include spatial visualization skills, field independence, and visual learning preferences. Field independent persons generally score significantly higher on total mathematics concepts and on problem-solving tests (Roberge & Flexer, 1983). An ability to visualize objects in space is also often correlated with mathematics achievement (Doody, 1980; Shrock, 1979). It appears that information on the learning styles of one of the larger Native American tribes such as the Navajo would be useful. The identification of a possible relationship between learning style and either mathematics achievement or mathematics anxiety could be pertinent to the design of instructional strategies to improve these deficiencies. The purpose of this study was to investigate the prevalence of mathematics anxiety in the Navajo middle school student. It also sought to explore possible relationships between learning styles and both mathematics anxiety and achievement.

Methods

Subjects and Procedures

The entire enrollment of a middle school in the southwestern United States was tested for both learning styles and mathematics anxiety. The school was located on the Navajo Reservation, with an ethnic representation of 98% Navajo. *Comprehensive Test of Basic Skills* (CTBS) (1982) achievement scores on the mathematics subtest (mathematics total) were collected from the school district files. Subjects who were not of Navajo lineage were dropped from the study, along with those that did not have scores available on all three instruments, resulting in a total sample of 358.

Instruments

The National Association of Secondary School Principals Learning Style Task Force developed, tested, and refined the *Learning Style Profile* (LSP) (Keefe & Monk, 1986) in a series of very thorough phases carried out over a 4-year period (Keefe, 1987). The instrument is designed as a first level diagnostic tool for classroom teachers to use in personalization of instruction to better match the learning styles, strengths, and weaknesses of their students through the use of individual student profile sheets. It is suggested that other more specific tests be used to investigate to greater depth any areas that may be suggested by the LSP. The instrument consists of 126 test items that make up 23 independent scales. These scales represent the four higher order factors of cognitive skills, perceptual responses, study preferences, and instructional preferences. The focus of this study includes scales only from the cognitive skills and perceptual responses areas.

Available norms on the LSP were drawn from a large number of studies. Internal consistency (alpha) and test-retest reliability (10-day) data range from 0.37 to 0.82 with an average of about 0.61 (Thomson, 1986). Concurrent validity studies yielded positive correlations of the appropriate subscales of the LSP with the *Group Embedded Figures Test* (Witkin, Oltman, Raskin, & Karp, 1971), the *Edmund Learning Style Identification Exercise* (Reinert, 1980), and the *Learning Styles Inventory* (Dunn, Dunn, & Price, 1974).

The *Mathematics Anxiety Rating Scale for Adolescents* (MARS-A) is a 98-item Likert scale questionnaire designed specifically for adolescents to estimate their proneness to debilitating degrees of anxiety in numerical situations, including classroom, testing, and everyday functions such as balancing one's checkbook (Suinn, 1982). Total scores range from 98 to 490, with the higher scores representing the most mathematics anxiety. National norms for the middle school student range from 195 to 210. Content validity has been confirmed through item analysis to include two areas: (a) numerical anxiety and (b) mathematics test anxiety. It should be noted that both of these factors have been shown to be distinct from general anxiety and general test anxiety (Suinn & Edwards, 1982).

The CTBS mathematics subtest is made up of concepts, computation, and application questions. It is a widely accepted norm-referenced, objectives-based test in basic skill with well documented reliability and validity (CTBS Technical Manual, 1984). The standardized total score for this entire section was used because it was judged to give the most inclusive picture of overall mathematics achievement. All scores obtained were results of testing one year or less prior to the study.

Data Analysis

Initially, two separate stepwise multiple regression analyses were performed in order to find the variables that best predicted mathematics anxiety and mathematics achievement. All 23 scales on the LSP were entered as predictor variables, with mathematics anxiety and mathematics achievement as the criterion variables. Both SL entry and SL stay were set at 0.15 for the stepwise technique. These procedures were performed on the total sample and then also by sex and by grade level. Eight subscales surfaced in at least one of the series of regressions. These variables included all six of those in the cognitive skills area, along with two in the perceptual responses area. These eight predictor variables are as follows:

1. Analytical skill--ability to identify simple figures hidden in a complex field.
2. Spatial skill--ability to identify geometric shapes and rotate objects in the imagination.
3. Discrimination skills--ability to identify the important elements of a task.
4. Categorizing skill--ability to use reasonable versus vague criteria for classifying information.
5. Sequential processing skill--ability to process information sequentially and verbally.
6. Memory skills--ability to retain distinct versus vague images in repeated tasks.
7. Persistence orientation--willingness to work at a task until completion.
8. Verbal-Spatial Preference--preference for verbal versus nonverbal activities.

Two standard design multiple regression procedures were next performed with these eight predictor variables in order to find which would be most influential in predicting mathematics anxiety and/or mathematics achievement. Both regressions were performed on the total sample of subjects, as well as by sex and grade level. Correlation tables were then developed to enhance the overall view of results and interrelationships of all variables. In addition, a one-way analysis of variance (ANOVA) was performed by grade level with mathematics anxiety as the dependent variable.

Results

Standardized beta values were used in the tables in order to make comparisons across subscales. As can be seen in Table 1, there were only three subscales on the Learning Style Profile instrument that were related to mathematics anxiety at the $p <$ .05 level of significance or better and could, therefore, be considered predictors. They were spatial skills, discriminatory skills, and persistence orientation. A comparison of the standardized coefficients in the total sample reveals that persistence orientation had the strongest relationship to mathematics anxiety, with spatial and discriminatory skills following in that order. Analytical and sequential skills were significant in the sixth-grade subgroup only. Verbal-spatial preference was significant in the male subgroup only.

Table 2 reveals that spatial, categorical, and sequential skills were the best predictors of mathematics achievement in the total sample, with analytical and memory skills showing significance in one subgroup each, female and sixth grade respectively.

The Pearson correlation coefficients indicated that no two cognitive subscales on the LSP instrument were related above r = .300, which lends validity to the multiple regression approach to this study. Three factors were found to be significantly correlated with mathematics achievement. They were mathematics anxiety (r = -.228, p = .001), spatial visualization ability (r = .321, p = .0001), and sequential ability (r = .349, p = .0001). The ANOVA for comparison of mathematics anxiety between grade levels showed no significance. Comparisons were not made between the male-female subgroups for mathematics anxiety or mathematics achievement because the means were so close in value that significant differences were not suspected (m_{male} = 246.97, m_{female} = 245.67).

Perhaps the most significant finding in the study was the mean MARS-A value of the total sample (M = 246.22, SD = 62.31, N = 358), which is considerably higher than the 195-210 predicted by national norms (Suinn & Edwards, 1982).

Conclusions and Discussion

The spatial skills relationship to mathematics anxiety in the

Table 1

LSP Subscale Factors Related to Mathematics Anxiety (Standardized Beta Coefficients)

Independent Variables	Total Sample (N=358)	Males (n=152)	Females (n=206)	6th (n=120)	7th (n=109)	8th (n=129)
Analytical	.033	.107	-.039	.240*	-.077	-.033
Spatial	-.140*	-.097	-.161*	-.156	-.195	-.108
Discriminatory	-.110*	-.083	-.142	-.174	-.074	-.098
Categorical	-.010	.014	-.018	.048	.012	-.013
Sequential	-.083	-.103	-.055	-.237*	.029	.038
Memory	.043	.056	.042	-.058	.008	.144
Persistence	-.246***	-.292**	-.231**	-.123	-.281**	-.338*
Verbal	.107	.264	-.008	.119	.082	.078
R^2	.103	.124	.127	.213	.128	.094

*$p < .05$ **$p < .01$ ***$p < .0001$

Table 2

LSP Subscale Factors Related to Mathematics Achievement (Standardized Beta Coefficients)

Independent Variables	Total Sample (N=358)	Males (n=152)	Females (n=206)	6th (n=120)	7th (n=109)	8th (n=129)
Analytical	.047	-.044	.132*	-0.58	.036	.096
Spatial	.214***	.136	.277***	.248**	.300**	.328***
Discriminatory	.056	.104	.016	-.061	-.078	.113
Categorical	.146**	.140	.172**	-.075	.063	.284***
Sequential	.256***	.292***	.234***	.130	.170	.067
Memory	-.083	-.054	-.107	.301**	.038	-.026
Persistence	.059	.117	.026	.165	.154	.097
Verbal	-.030	-.157	.055	-.076	.019	-.088
R^2	.207	.207	.256	.253	.190	.297

*$p < .05$ **$p < .01$ ***$p < .0001$

total sample was not surprising in light of previous studies (Fennema & Sherman, 1978; Hadfield & Maddux, 1988). The results here, however, indicate that persistence orientation is a far better predictor for four of the five subgroups as well as for the total sample. This sheds a new light on mathematics anxiety, indicating that it is perhaps even more of an attitudinal orientation than previously thought, at least for the Navajo student. The absence of significance at the sixth-grade level perhaps indicates that they have not yet been allowed to become discouraged and give up when an analytical task requires persistence. More concentration on sticking with a task until completion, no matter how challenging, should be stressed by middle school teachers. Challenging assignments, including word problems and puzzles, rather than just drill, should be incorporated into the curriculum to build confidence. Confidence has been shown to be a key factor in prevention and reduction of mathematics anxiety (House, 1989), and perhaps increased confidence will lead to more persistence.

It is noteworthy that spatial ability is significant in only one subgroup, that of females. Males have been shown to have better spatial ability in general, and this is often purported as the reason for their slight edge in mathematics achievement across the board (Bank, 1982; Berenbaum, 1977). Ethington (1984) also found the effects of spatial ability on mathematics achievement to be greater among women. Another conclusion that could be drawn from these results is that males appear to have more general confidence in their mathematical ability (and thus less mathematics anxiety), regardless of their cognitive orientation, while females (due to environmental influences) only build confidence if they have above average spatial skills.

The relationships of categorical and sequential skills to mathematics achievement are not surprising. They are both basic cognitive skills that one would expect to be necessary for the solution of mathematical problems. It is noteworthy, however, that analytical skill was not significant except in the female group. Females also were one of two subgroups that showed significance for categorical skills. The summation of this and the previously noted isolation of spatial skills relationship to mathematics anxiety in females could support the conclusion that many of the cognitive skill areas must be above average for females to exhibit both achievement ability and confidence in mathematics in our society. Perhaps the environment does not entirely hinder those females with above average abilities, but for those with standard abilities, obstacles are more prohibitive to success.

The male group appears to be less influenced by any of the cognitive variables in development of mathematics anxiety and only by sequential ability in development of mathematics achievement. They are more influenced by the affective perceptual domains in development of mathematics anxiety (persistence and verbal orientation). There is also the possibility that the lack of a significant relationship between analytical ability and mathematics achievement simply indicates a weakness in the validity of the analytical scale on the instrument.

An unrelated but interesting speculation is that sixth-grade students are perhaps being tested over mathematics that requires more memorization of steps than higher-order thinking, since theirs is the only subgroup whose achievement scores are related to memory skills. Then at the eighth-grade level, where achievement is shown in Table 2 to be related to categorization skills, the cognitive skills appear to come into play.

The previously noted negative correlation between mathematics anxiety and mathematics achievement was expected, as revealed in several other research studies mentioned in the introductory section. It should also be noted that both spatial and sequential skills, as previously mentioned in the results section, appeared to be more highly correlated with mathematics achievement than mathematics anxiety. As the third highest correlation, however, mathematics anxiety is still a substantial ingredient in the mathematics achievement formula. It is also noteworthy that a much higher percentage of the variance of mathematics achievement (20.7%) than mathematics anxiety (10.3%) can be explained by the predictor variables according to Tables 1 and 2. This agrees with the hypothesis that mathematics anxiety is primarily an emotional rather than a cognitive factor, thus making it more difficult to predict through the use of cognitive subscale scores.

Perhaps in addition to the indication of lack of persistence orientation as a key factor in the development of mathematics anxiety, the most important aspect of this study is the magnitude of the MARS-A score mean of 246.22 for the entire Navajo sample. A recent study for a comparable group within 100 miles of this study, in a town of similar size but with predominantly Caucasian students, yielded a much lower mean MARS-A score ($M = 201.08$, $SD = 57.41$, $N = 481$) for high school students. This indicates an apparent disturbing gap between ethnic groups. There is, therefore, a crucial need for change in the reservation classroom in order to lessen anxiety toward mathematics and to increase student confidence.

The first step in approaching a solution is to make educators of Native Americans aware that such problems may exist. Perhaps inservices could be provided for reservation teachers in order to inform them of the potential for such extreme mathematics anxiety among Native American students. Teachers could then be provided with many of the latest techniques for prevention and reduction of mathematics anxiety. Many mathematics anxiety reduction programs have been implemented in various parts of the country with often favorable results (Bander, 1979; Bander, Russell, & Zamostny, 1982; Hendel, 1977). Techniques include the use of hands-on activities, attention to demonstrating relevance of mathematics to real life situations, introduction of an overview first and then provision of details (Navajos are taught to look at the big picture first), establishment of a nonthreatening tone by the instructor, relaxation techniques, study skills, step-by-step explanations, group work, etc. This study makes it apparent that some type of measures must be taken or the Native American reservation school students will fall even farther behind in mathematics and will consequently reduce their career options even more drastically.

The focus of this study was primarily upon a population of 200,000 Navajos, which on the surface may appear insignificant from a national standpoint; however, with the checkerboard of Native American reservations throughout this country that fall into the same depleted economic and unemployment patterns, it seems pertinent that these often at-risk groups be given adequate educational attention. With the importance of getting minorities involved in mathematics and science as expressed by the National Research Council (1989), it seems mandatory that the barriers to their participation requires investigation. The finding that the typical barrier of mathematics anxiety is related to lack of persistence rather than strictly cognitive ability among Native American students provides a substantial starting point for improvement of instruction.

It might be summarized that it is not what mathematical content is taught to this minority group but what mathematical attitudes are being perpetuated among students. This is not unlike the situation in the Black and Hispanic minorities. It therefore appears on the broad perspective that efforts toward improvement of mathematics education should not be limited to boosting content alone. A national effort of equal strength needs to be made to reduce mathematics anxiety and improve attitudes toward mathematics across all of the minority groups that are plagued with poor participation.

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