

THE USE OF ATTITUDINAL VARIABLES TO REDUCE POTENTIAL
PREDICTION BIAS OF ACT MATHEMATICS TEST SCORES FOR
NON TRADITIONAL-AGE STUDENTS

by

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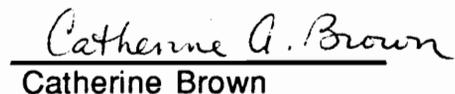
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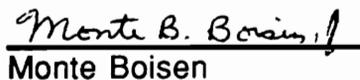
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(ABSTRACT)

The primary purpose of this study was to examine the extent to which age-related bias exists when ACT Mathematics test scores are used as the sole predictor of future academic performance in entry-level college mathematics courses. A secondary purpose was to investigate the extent to which academic and attitudinal variables, in conjunction with ACT Math scores, a) lessen or eliminate the age-related bias, and b) enhance the prediction of course grades and posttest scores in freshman level mathematics courses.

ACT Mathematics test scores were used to predict course grades and posttest scores of students enrolled in Developmental Math and General Math classes at Bluefield State College, WV, or one of its community college components. Course grades of Developmental Math students and posttest scores of General Math students were found to be underpredicted for nontraditional-age students and over-predicted for traditional-age students. No differences were found in predictions of posttest scores for Developmental Math students or in predictions of course grades for General Math students. When attitudinal and other academic

variables were introduced to the regression equation, there was less evidence of prediction bias and a significant increase in the amount of variance explained in the criterion measures.

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CHAPTER I

INTRODUCTION

General college aptitude and achievement tests, such as The American College Testing Program (ACT) and the College Board Scholastic Aptitude Test (SAT), have long been used for admission decisions by selective colleges and universities. Although these tests have many critics (Nairn, 1980), colleges and universities continue to use them as an assessment tool since numerous studies show them to be valid predictors of success in college when success is defined by freshman grade-point-average (GPA). With the adoption of the Carnegie Commission on Higher Education's recommendation for an "open door" admission policy (Brubacher & Rudy, 1976), community colleges and other non-selective colleges are no longer requiring these test scores for admission. However, many of these colleges require students to submit scores from such tests for placement decisions (Abraham, 1986).

The number of colleges using general college aptitude and achievement tests, whether ACT, SAT, or locally-developed tests, to make course placement decisions has increased over the past ten years and this trend is expected to continue. This is especially true in the area of mathematics with its carefully delineated, hierarchical course content. In fact, Rounds & Anderson (1984) found that test scores are most often used to make placement decisions in entry-level mathematics or English courses. In studies

of the nation's two-year institutions, Woods (1985) and McNabb (1990) found that between 82 to 90 percent of these institutions use assessment test scores to place students in entry-level mathematics courses.

Colleges which use test scores to make course placement decisions typically establish a predetermined cut-score. Students scoring below the prescribed cut-score are either encouraged or required to take a developmental or remedial course before enrolling in a credit-level course. Research has shown that the determination of these cut-scores should be made at each institution individually (Hector, 1984; Schmitz & delMas, 1991) since what constitutes successful performance at one institution may not be adequate in another. Thus, each institution is faced with the difficult problem of determining a cut-score that is consistent with its standards and curriculum.

Course placement systems also use test scores and other variables, such as high-school grade point average (HSGPA) or class rank, as independent variables within a regression equation constructed to predict academic performance in college courses. In these systems students are placed within a sequence of courses on the basis of their predicted performance. While there is a broad base of empirical evidence to support the use of test scores such as ACT and SAT for selection decisions, there is little evidence to support their use in placement decisions (Bridgeman, 1982). Consequently, when admission test scores are used for placement

purposes, one must assume that: a) previously acquired skills and knowledge, which are presumably measured by the test, are related to academic success in a given course; and b) that the course grade is a reliable and valid measure of skills and knowledge acquired in the course (Noble & Sawyer, 1987). Furthermore, according to Noble & Sawyer, the degree to which these assumptions are true affects the prediction accuracy of the prediction equation, that is, how well the predicted grades match the actual earned grades. The validity of placement decisions made by these systems depend on the validity of the prediction equations themselves. Test scores which are used for placement decisions ought to be free of prediction bias. If a bias is present in the prediction model, then a bias will be present in the course placement decision.

A test score used in a prediction model is free of bias if it predicts future performance equally well for all students who take the test (House, 1989). Prediction bias exists when differences occur across varying groups of students as to how well test scores make predictions of academic performance (Reynolds, 1982). For example, concern has risen over the use of prediction equations based on test data from high-school students to predict college performance of students who are several years away from high school. Achievement tests, such as the ACT, use only data from high school seniors to determine percentile ranks and corresponding scores for their tests (ACT, 1990).

Several studies have investigated bias when prediction equations derived from the test scores of one group of students are used to predict the performance of a totally different group of students. In a study conducted by ACT to determine if the prediction equations used for traditional groups of college freshmen predicted equally well for nontraditional groups of students, Sawyer (1985) found that the performance of younger students tends to be overpredicted while that of older students tends to be underpredicted. Casserly (1982) and Fincher (1983), in reviewing research on the accuracy of SAT scores as predictors of freshman GPA, also found that older students generally achieved a higher GPA than test scores predicted. Clark (1984) and House (1989) found similar results in a study regarding the use of the Graduate Record Examination (GRE) to predict first year graduate GPA. The findings of a study using only the ACT Mathematics test score as a predictor of mathematics course grade (Refsland, 1990) indicate that older students also tend to earn higher grades in their mathematics courses than predicted by their tests scores.

Furthermore, there is considerable evidence to suggest that older students do not score as well as younger students on the mathematical subtests of these standardized tests, as compared to their verbal scores which remain as high, or higher, than verbal scores of younger students (Clark, 1984; Fincher, 1983; and Sawyer, 1987). Separate studies by Fincher (1983) and Casserly (1982) suggest that one reason for this difference is that mathematical

knowledge is much more nearly "school bound" than English or verbal skills. Thus, mathematics course placement decisions based on ACT or SAT scores, which have a possible age-related bias, are a particular concern to colleges with large enrollments of nontraditional-age students.

Lower test scores for older students would not be cause for concern if they also earned lower course grades. The studies previously cited, however, suggest this is not the case. This raises questions about what other factors may play a role in prediction success. Sagaria (1989) found that older students generally outperform younger students because of their sense of purpose and their persistence. Studies by Gough & Lanning (1986), Levitz (1982), Sawyer (1986), and Sedlacek (1984) show that the addition of affective variables, such as perseverance and motivation, to the prediction equation more effectively predicted academic performance of nontraditional-age students than when just a SAT or ACT test score was used. Zeidner (1985) further suggested that prediction equations which incorporate factors such as length of time away from the classroom and the maturity of the older students are needed to improve placement procedures for older students. Reyes (1984) demonstrated that affective variables, such as a positive self-concept and confidence, are positively correlated with mathematics test scores, whereas math anxiety and test anxiety are negatively correlated. If such attitudinal variables and other non-cognitive measures are used along with the test scores,

colleges might have a better, and less biased, basis for predicting student performance in entry-level courses.

Statement of The Problem

The State College System of West Virginia has recently adopted a state-wide placement policy which requires that students attending two- or four-year, state-supported colleges be placed within the freshman mathematics sequence solely on the basis of their scores on one of three possible standardized, mathematics tests. According to this policy, students must meet one of the following criteria to be placed in a credit-level mathematics course:

- a) a minimum score of 18 on the mathematics section of the American College Testing Program's Enhanced ACT Assessment Test (Enhanced ACT);
- b) a minimum score of 380 on the quantitative portion of the College Board's Scholastic Aptitude Test (SAT), or
- c) minimum scaled scores of 38 and 31 on the numerical test and elementary algebra test, respectively, of the American College Testing Program's Assessment of Skills for Successful Entry and Transfer (ASSET).

These minimum scores will be raised to 19, 390, and 39/32, respectively, at the beginning of the 1992 fall semester. Students failing to meet one of these score requirements must successfully complete a non-credit, pass/fail developmental or pre-college level mathematics course before enrolling in a credit-level mathematics course. These minimum score requirements apply to all students regardless of age or previously demonstrated academic success.

The test score most often used to make mathematics course placement decisions in West Virginia colleges is the ACT Mathematics test score. According to ACT, the mathematics subtest is specifically designed to assess knowledge gained in high-school mathematics classes of graduating high-school seniors planning to enter college the following fall (ACT Handbook, 1991). When the ACT Mathematics subtest is taken by nontraditional-age students, no adjustments are made to the test, or to the way it is scored (ACT Handbook, 1991) and no consideration is made for the length of time away from the high-school mathematics classroom. Consequently, a test designed to assess mathematical knowledge gained by high-school students over a period of four years actively spent in an academic environment is used to assess the mathematical knowledge of adults who may have been away from this kind of learning and testing environment for several years. Since many West Virginia state colleges have a large enrollment of nontraditional-age students, any systematic misplacements result in a waste of resources for both the system and the students. Consequently, it is important to determine whether these test scores are valid predictors of academic performance and if not, what other variables might be used to enhance the predictions.

Purpose of Study

The main purpose of this study is to examine the extent to which an age-related bias is evident when scores from the ACT Mathematics test are used to predict grades earned in entry-level

mathematics courses across several campuses of a non-selective college in West Virginia. A secondary purpose of the study is to investigate the extent to which the use of academic and attitudinal variables used in conjunction with the ACT Math score, a) lessen or eliminate potential age-related bias, and b) enhance the prediction of grades in freshmen-level mathematics courses.

This study will not be concerned with evaluating placement decisions based on test scores. Rather, the focus of this study is on the prediction of grades earned in the entry level mathematics courses in which the students were placed and on the extent, and control, of age-related bias associated with the test scores in this context.

Study Objectives

In order to determine the most effective basis for predicting success in entry-level mathematics for nontraditional-age students, this study will examine the validity of test scores, attitudinal variables, demographic variables, and combinations of these variables when they are used as predictors of academic achievement. This study will:

1. Examine the extent of the age-related prediction bias of the ACT Mathematics score when used as the sole predictor of success in entry-level mathematics courses.
2. Investigate the relationship of selected attitudinal and demographic variables to the academic performance of nontraditional-age students in entry-level math courses.

These variables, along with the ACT Math score, will be incorporated within the prediction equation to:

- a) reduce the potential for prediction bias in the ACT Mathematics score,
- b) enhance the prediction of academic performance of nontraditional-age college students in entry-level mathematics courses.

CHAPTER II

REVIEW OF RELATED RESEARCH

This study focuses on the validity of ACT Mathematics test scores as predictors of academic performance in entry-level college mathematics courses. It will examine the effectiveness of standardized test scores in general, and ACT mathematics scores in particular, as predictors of course grades and posttest scores for two levels of college mathematics courses, Developmental Math and General Math. Accuracy of single test scores as predictors of success will be evaluated for two distinct groups of college students: traditional-age students (24 years old or younger) and nontraditional-age students (25 years old or older). This study will also investigate other academic and attitudinal variables which, when included with test scores in the prediction equation, may increase prediction accuracy.

Introduction

Course placement is a set of procedures designed to match a student's prior preparations with the appropriate college course within a sequence of courses. Course placement policies are designed to enroll students in courses which best meet their needs and for which they are adequately prepared. Placement systems assist in the identification of students with inadequate academic preparation for college-level work and their placement in developmental or remedial courses to correct deficiencies. The advent of open admissions policies corresponded with an increase in

the number of underprepared students. Many non-selective colleges have responded to the increased number of underprepared students by instituting procedures to assist them in making course placement decisions. Colleges that have faulty placement systems or no placement system at all risk having students who are either bored or in academic jeopardy (Lewenthal, 1981).

The typical student enrolling for the first time at community colleges and other non-selective colleges is no longer the traditional-age white male who has just graduated from high school. Today's new community college students may be several years away from high school graduation or they may have earned a General Equivalency Diploma (GED) in lieu of a high school diploma. Many of the new students are women, members of a minority, or students with special needs. Each year the numbers of these nontraditional groups of students add to the diversity of the community college student population. Colleges are challenged to find ways of placing these students in appropriate courses.

Colleges may choose from several placement system. Lewenthal (1981) identifies the four most commonly used models as a) self-assessment, b) advisement, c) mandatory placement, and d) modified mandatory placement. The advisement model recommends courses, but does not require the student to abide by the recommendation. The modified mandatory placement makes the final course decision for the student, after input from the student and several other sources. The mandatory placement option uses no

input from the student, other than a test score, and the student is required to abide by the course assignment made by the placement procedure.

Placement Procedures Using Test Scores

Mandatory placement models generally base decisions either on test scores alone or test scores in combinations with other information about the student. Mandatory placement models employ many different tests and may use test scores in many different ways to place students in courses. Generally, tests used for placement purposes can be classified as: a) tests produced by commercial companies to be administered nationally, or b) tests that are created by the faculty members of the individual colleges. Abraham (1986) documented the great variety of tests that are used for making mathematics course placement decisions in a large-scale survey of public institutions of higher education for the Southern Regional Educational Board (SREB). Nearly one-fourth of the 489 institutions responding to a SREB survey indicated that they designed their own placement tests. Only 15 percent (71 institutions) reported using ACT tests for placement purposes. The majority of institutions used an assortment of other tests. Abraham did not report ways in which scores were used for placement, other than cut-scores. He noted that since cut-scores ranged from 8 to 21 (corresponding percentile scores were 14% to 61%), great variation existed in placement criteria among colleges. The tests from which these cut-scores were derived were not named.

Rounds & Anderson (1986) conducted a survey of all 106 California community colleges to assess how test scores were used in the state of California for making admissions and placement decisions. Their study was motivated out of concern that the legislature was going to require mandatory placement decisions in state-supported institutions of higher education. Sixty-seven of the 99 responding community colleges indicated that they used some form of mathematics assessment for making placement decisions. Forty-two of the institutions (62.7% of users, 42.1% of total) recommended using test scores to make placement decisions. Only 25 of the colleges surveyed (37.3% of users, 25.3% of total) actually required test scores for placement. Rounds & Anderson, like Abraham (1986), found a variety of tests being used as placement instruments. They also found locally developed tests to be the most commonly used tests(27%). When commercial tests were used for assessment, the two tests most often mentioned were the ACT and the SAT. None of the responding colleges, however, required scores from either one of these tests as placement criteria.

Two nation-wide studies on the use of test scores for admission and placement purposes were conducted for ACT by McNabb (1990) and Woods (1985). Both of these studies, like the Abraham study, concluded that test scores are used extensively for placement purposes. Eighty-two percent of the 567 accredited two- and four- year institutions responding to the McNabb survey reported using test scores for placing students in freshmen mathematics

courses. ACT scores were reportedly used by 38 percent of the sample, in conjunction with other data sources (e.g., high-school over-all GPA, high school rank), to make placement decisions. Only three percent of the responding institutions reported using the ACT mathematics test score alone to make placement decisions, a decrease from the 34 percent that had reported using just the ACT mathematics test score in a similar study conducted by ACT earlier (McNabb, 1984). This decrease in use of a single test score as a predictor of success in a college course would seem to be evidence that a single variable is no longer considered an adequate basis for making placement decisions. Neither the report nor the survey instrument provided information as to how test scores were used to make the decisions.

Woods (1985) conducted the second of the two large-scale ACT studies in conjunction with the Association of American Community and Junior Colleges (AACJC). The Woods study investigated the increased use of test scores by two-year colleges. A questionnaire was distributed to 1,303 institutions from the AACJC master mailing list. Data derived from the questionnaire were used to examine the extent to which institutions used test scores for admissions and placement decisions. Another purpose of the study was to determine whether the test scores were used for mandatory or advisory placement. Over 90 percent of the 683 responding institutions indicated that tests scores were used for placement in some manner. Forty percent of the institutions reported using

advisory placement models at the time of the survey, although many of these institutions indicated that their use of test scores for placement purposes was likely to become more mandatory and more prescriptive in the future. Institutions also indicated that their use of test scores for placement decisions is likely to continue to increase. Woods did not identify the particular tests used for admissions or placement purposes. She did indicate that respondents, for the most part, were satisfied with the tests they were using.

Predictive Validity of Mathematics Test Scores

Despite the increased use of test scores as a placement tool, relatively few studies have addressed the predictive accuracy of specific standardized test scores, such as the ACT Math score, when used to predict academic performance in specific college courses. Some attention has been given to the accuracy of multiple-variable prediction equations in predicting grades in specific courses. Few studies, however, have addressed the predictive accuracy of single-variable prediction equations.

Two studies conducted for ACT (Sawyer, 1985; and Sawyer & Maxey, 1981) investigated the validity of an eight-variable multiple regression equation for predicting grades for freshmen mathematics courses. Independent variables in the regression equation were the four ACT subtest scores (English, mathematics, social sciences, and natural sciences), and self-reported high school grades in each of these four subject areas. The authors examined the ability of these

eight variables to predict college course grades in mathematics and freshman GPA. Data were collected from a random sample of 205 college participating in the ACT predictive research services for the years 1974-75, 1976-77, and 1979-80. Across the three study years, the median multiple correlation associated with predicting mathematics course grades was 0.52, somewhat lower than the 0.59 median multiple R obtained for freshman GPA.

Noble and Sawyer (1987) also assessed the validity of ACT subtests scores for predicting grades in specific courses by examining records of students enrolled in freshmen mathematics courses at 210 colleges participating in ACT's predictive research service for the years between 1980 and 1984. Noble & Sawyer used the same eight-variable prediction model (4 ACT subtest scores and 4 self-reported high school grades) used by Sawyer (1985) and Sawyer and Maxey (1981). They evaluated the accuracy of the multiple regression equation in predicting grades in mathematics courses by examining the median multiple correlation coefficients between the regression equations and grades in various course grades. The researchers reported median multiple correlation coefficients ranging 0.47 to 0.53 between the four ACT subtest scores, high school grades and mathematics course grades. When only the four ACT subtest scores were used, the median multiple correlations for test scores and mathematics course grades dropped from a range of 0.47 to 0.53 to a range of 0.36 to 0.39. Comparing the prediction results across subject areas, the authors noted that

prediction accuracy, as measured by median multiple R, was fairly constant across all courses in English, mathematics, and social studies course groups (0.46 to 0.56). The mathematics test score was found to be the least valid of the four scores for predicting specific course grades. Since the larger number of predictors resulted in higher mean multiple correlation coefficients, the authors recommended, as did Sawyer (1985) and Sawyer & Maxey (1981), that the full eight-variable prediction model be used as the predictor of course grades in order to maximize the accuracy of placement decisions.

A study in which only ACT subtest scores were used in the regression equation for predicting grades in specific college courses is reported in the current ACT Assessment Program Technical Manual (1988). The report contains data for a three-year period from 1982 to 1985 from 191,101 students attending 260 colleges. All the colleges were participants in the ACT predictive research services. The multiple coefficient representing the correlation between the actual and the predicted grades for mathematics was found to be 0.40, the lowest for the four subject matter courses. Using only the ACT mathematics test score to predict the mathematics course grade yielded an even lower correlation of 0.38 between the ACT mathematics subtest score and course grade. When correlations between each of the ACT subtests scores and the corresponding four subject areas were compared, mathematics course grades were found to be the least reliably predicted grades.

Findings of the study indicated that high-school grades tend to be better predictors of college freshmen mathematics course grades than ACT test scores. These results, added to those of previously cited ACT studies, present a strong argument against making placement decision using only one ACT subtest score as the predictor of success. This argument is especially strong when the ACT Math score is used as the predictor of success, since the math subtest score proved the poorest predictor of the four subtest scores.

One of the first studies to suggest that the age of the student population played a role in the validity of the ACT scores as predictors of academic success was conducted by Schade (1977). He examined the validity of the ACT composite score and the four ACT subtest scores as predictors of academic success in specific courses, and as predictors of overall GPA. Scores were examined for 21 percent of the freshman class (N = 110) at Crowder College, Missouri, for whom ACT scores and first semester grades were available. Schade found the ACT Composite score to have the highest correlation with GPA ($r = .465$) and the ACT Mathematics score to have the lowest correlation ($r = .353$). Shade hypothesized that the marginal predictive ability of the test scores, may be because the tests themselves may not be properly formulated for typical Crowder College students, the majority of whom were 25 years old or older. Shade recommended that Crowder College continue to use

the ACT Composite score as an advising tool, but stated that it was not a good predictor of specific course performance.

Test Scores Differences between Older and Younger Students

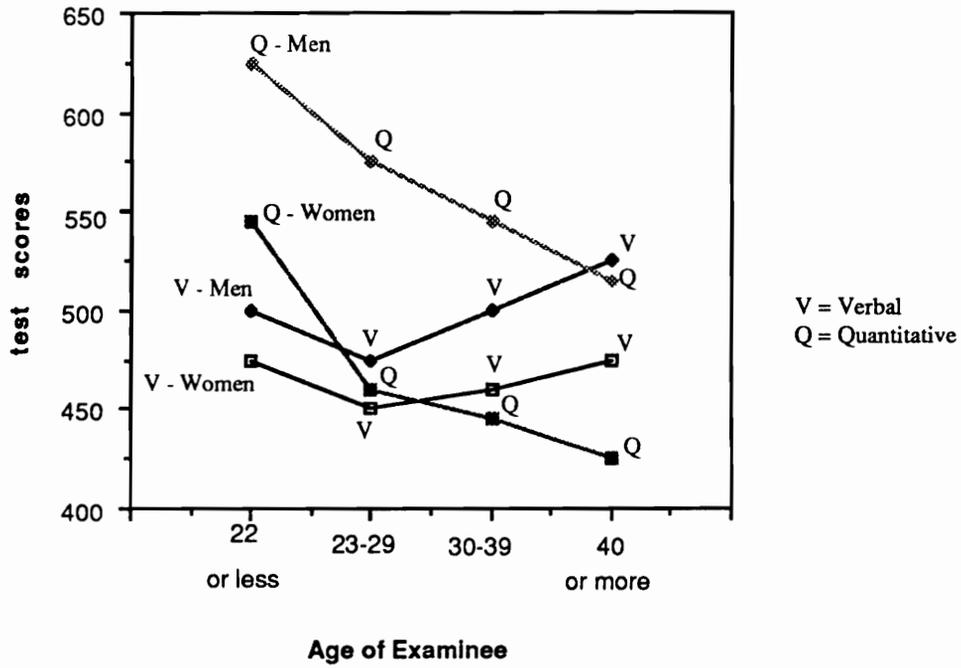
A fundamental concern in making placement decisions based on a prediction of success made by a single test score is whether the test score predicts equally well for all groups of students. This concern is particularly important with respect to nontraditional-age students. Several researchers have indicated that when older students make lower scores than younger student on aptitude or achievement tests, it cannot be concluded that the older students will also make lower grades than the younger students.

Nairn (1980) reported that standardized aptitude tests tend to penalize people who have not had recent practice in test-taking skills. He also reported that aptitude test scores tend to decline with age test-takers move from the test-oriented school world into the skill-oriented job world. He also attributed a decline in performance on aptitude test scores to the decline, with age, in the ability of test-takers to do well on timed multiple choice tests. Nairn concluded that aptitude tests produced by the Educational Testing Service (ETS) systemically discriminate on the basis of age and personality. He supported his conclusion by citing a 1969 ETS study of applicants to 26 business schools using the Admissions Test for Graduate Study in Business (ATGSB, now called the Graduate Management Admission test [GMAT]). Applicants between the ages of 19 and 21 were found to have a higher mean score than older

students, even though the older students were currently in the business world. Applicants in the age range 19-21 had a mean score of 563 on the test, while applicants in the age range 26-27 had a mean score of 524. The lowest mean score of 490 was made by applicants in the age range 35-57. The older students did not, however, make lower grades than the younger students as their test scores indicated they would. The ETS study supported the notion that older students tend to perform better in school than predicted on the basis of aptitude test scores. Nairn concluded that conventional methods of using a combination of ATGSB scores and undergraduate grades seemed to be less effective as a predictor of academic performance for older students than they are for younger students accustomed to taking tests.

An ETS study of the Graduate Record Examination (GRE) by Clark (1984) yielded similar information concerning differential test scores by older and younger students. Clark found that older students score as high as, or higher than, younger students on the verbal portion of the GRE (GRE-V) but lower than younger students on the GRE quantitative portion (GRE-Q). Clark's findings are consistent with those of a similar study conducted earlier by Hartle, Baratz, & Clark (1983). Both studies found that the size of the difference between the group means of GRE-Q scores of older and younger students tends to increase in direct relationship to the age of the groups. Figure 2.1 shows the differences in the 1980-81 mean GRE-V and GRE-Q scores by age as reported by Clark for both men and

Figure 2.1: Gre Scores by Age and Sex - 1980-1981



Source: Clark, 1984

women. Clark also reported the outcome of using GRE scores, verbal and quantitative, in a regression equation to predict first year GPA. As cited in the earlier ETS study of applicants to graduate schools of business, GPAs of older students were higher than they were predicted to be. The grade point averages of two age groups of students, 24 years old and younger and ages 25 to 29, were found to be over-predicted by 0.18 and 0.08 standard deviations, respectively. Students 30 years old and older were even more under-predicted. Results of the study showed they were under-predicted (0.21 standard deviations).

ETS studies by Casserly (1982) and Fincher (1983) also focused on the differences in the performance of older and younger students. Mean scores on the SAT were examined for differential predictions. Both Casserly and Fincher both found that older students scored as high or higher than the younger students on the SAT-Verbal (SAT-V) sections of the test, and that the reverse was true for the Sat-Mathematics (SAT-M) portion. Younger students scored higher on the SAT-M than the older students.

Only three of the 210 colleges Casserly (1982) originally surveyed actually participated in her study. Only two of the three colleges, designated "College B" and "College C", gave separate SAT verbal (SAT-V) and SAT mathematics (SAT-M) data. In both colleges, older students (21 years of age or older) scored higher on the SAT-V than their younger counterparts. On the other hand, younger students outperformed the older students on the SAT-M portion of

the test. These findings are supported by the findings of Clark (1984) in the ETS study of GRE-V and GRE-Q scores for older and younger students.

Casserly (1982) also investigated the relationship between SAT scores and freshman GPA. Different relationships between SAT scores, HSGPA, and GPA were found when data from colleges B and C were examined. College B had a significant relationship between SAT-V and GPA, while College C had a significant relationship between high school percentile rank and GPA. More important to the current investigation was the fact that SAT-M was not significantly related to GPA at either of the two colleges.

Fincher (1983), examining evidence from a study involving the SAT, concluded that while SAT-V and SAT-M scores correlated significantly with freshman GPA, the correlations did not match what is customarily found in traditional college-aged populations. SAT test data from 1,694 nontraditional-age students and 22,572 traditional-age students in the University System of Georgia were examined. Like Casserly (1982), Fincher found that older students (25 years of age or older) scored significantly higher than the younger students on the verbal part of the test and significantly lower on the quantitative part. Both verbal and mathematics scores were found significantly correlated with freshmen GPA for both younger and older students. Correlation coefficients between both SAT-V scores and GPA and between SAT-M and GPA were found to be higher for traditional-age students (SAT-V/GPA = 0.37, SAT-M/GPA

= 0.37) than for nontraditional-age students (SAT-V/GPA = 0.31, SAT-M/GPA = 0.26). High school grade-point-average, however, was found to be the strongest single predictor of success in college, followed by verbal and mathematical ability scores.

In a similar study of the effect of age on the validity of a scholastic aptitude test, Zeidner (1987) pooled data across age groups to use a single regression model for predicting GPA. The subjects of his study were students in a major University in Northern Israel. An analyses of covariance revealed that age interacted significantly with aptitude test scores in predicting GPA, $F(3,787) = 5.41$ ($p < .001$), implying significant differences in the regression slopes by age groups.

In its 1973 ACT Technical Report, the American College Testing Program acknowledged that its college admissions tests discriminate on the basis of age. After an evaluation of ACT test scores as predictors of success for younger and older students, ACT concluded that "there is clear evidence of bias against adults in the use of a single regression equation" (p. 264). The ACT examination for possible age-bias in test scores began after several colleges using the ACT predictive research services reported that older students obtained higher grades than predicted by the total group regression equations. Data drawn from five colleges (ACT Technical Report, 1973) were examined for relative accuracy of predicted GPA for both traditional- and nontraditional-age freshmen. Eight-variable multiple regression equations were constructed using the

four ACT subtest scores and four self-reported high school grades for both the total group and separately by age. Results were summarized for the two groups of freshmen: nontraditional-age students 21 years and older (N = 318), and traditional-age students under 21 (N = 4,180). The correlations between earned and predicted GPA were .37 for nontraditional-age and .50 for traditional-age freshmen. When separate group equations were used, the correlations between earned and predicted GPA were .47 for nontraditional-age and .58 for traditional-age freshmen. The report concluded that the use of separate group prediction equations led to a reduction in prediction bias for older students.

Sawyer (1985) further investigated the possibility that using a total group-regression equation to predict freshmen GPAs might result in systematic over- or under-prediction for different age groups. The same eight-variable total group equation used in other ACT studies was used to predict grade averages for 46,589 traditional-age students and 6,735 nontraditional-age students. Differences between predicted and actual GPA revealed a median underprediction of -.20 for older students and a median overprediction of .06 for younger students.

The validity of ACT test scores in predicting freshmen GPAs for both traditional-age freshmen (under 20 years of age) and nontraditional-age students (20 years years old or older) was also examined by Levitz (1981). A stratified sample of 223 institutions was selected from the 571 institutions that participated in ACT's

predictive research services in 1977-78 and one or more of the previous years 1973-75. Forty-eight of the participating institutions had an enrollment of more than 50 nontraditional-age freshmen. A total of 106,613 student records were examined for the study. Three age categories were used for the study: 17-19, 20-25, and 26 years old or older. The same total group, eight-variable multiple regression equation used in other ACT studies was used to predict freshmen GPA. Differences were found between the predictive validity of GPA for nontraditional- and traditional-age freshmen. The finding from Levitz's study most pertinent to this current investigation was that the cross-validated multiple correlation of ACT scores with GPA was only .30 for the 20 years old and older group, but an impressive .54 for the under 20 group. This finding suggests that the ACT scores are a less appropriate predictor of GPA for nontraditional-age students than for traditional-age students. Levitz concluded that there may be value in considering other variables for use in the prediction equation for nontraditional-age freshmen.

Refsland (1990) showed, in an analysis of a small sample (N = 87) of Greenbrier Community College Center students during the 1989 fall semester, that ACT Mathematics scores may not predict performance in mathematics courses equally well for traditional- and nontraditional-age students. ACT Math scores were used as the sole independent variable in the total-group regression equations used to predict math course grades for both traditional (24 years old

and under) and nontraditional-age students (25 years old and older). Actual course grades were compared with the predicted course grades and residuals (predicted grade minus the actual grade) computed. Results of the study showed that grades of nontraditional-age students tended to be higher than predicted and grades of traditional-age students tended to be lower than predicted.

In a similar study of the validity of the GRE in predicting graduate grade point averages (GGPA), House (1989) found that both GRE-V and GRE-Q scores were significantly correlated with GGPA and that no significant differences existed between the correlation coefficients for younger and older students. He then focused on the question of whether the GRE predicted GGPA equally well for students of all ages. The critical issue for his study was the existence of equality of prediction accuracy when test scores are used for selection purposes. His investigation centered on determining if there were systematic differences between groups in how well the test scores predicted later performance. GRE scores of 1,138 graduate students in education at a large midwestern public university during the 1985 fall semester were examined for possible differential validity in the GRE. A total-group regression equation comprised of GRE-V, GRE-Q, and GRE-total scores was used to predict the graduate grade point average (GGPA) of 260 students traditional-age (24 years old or younger), and 878 nontraditional-age students (25 years old or older). Significant differences ($p <$

.01) were found in the mean error of prediction between age groups: both GRE-Q and GRE-Total scores underpredicted the achievement of older students (-.013 and -.01) and overpredicted the achievement of younger students (.045 and .038). As the result of his study, House concluded that GRE scores do not predict graduate performance equally for students of all ages and that a prediction bias was present in GRE scores.

The current study uses the design of House's study with two notable differences. First, House investigated the extent of age bias in the prediction of graduate performance from GRE scores, whereas the current study investigated the extent of age bias in the prediction of mathematics course performance from ACT Math test scores. Second, this study expands the investigation beyond the House study to include an investigation of increasing prediction accuracy by including affective variables in the prediction equation. The study by Levity (1982) also served as a structural model for the current study. This study and the Levitz study share a concern with the validity of standardized test scores when used as predictors of success for nontraditional students. The two studies differ in that Levitz focuses on the use of test scores in making admission decisions and the focus of this study is on use of test scores in making placement decisions.

Attitudinal Variables as Predictors of Academic Performance

Research has shown that several personality, or affective, variables contribute to the academic success of nontraditional-age

college students. These variables, used in conjunction with standardized test scores, may help to reduce the potential for an age-related bias in tests scores used for prediction. Reyes (1984) reviewed current literature on the role of affective variables in mathematics education. Dowling's study (cited in Reyes, 1984) showed a correlation of .54 between confidence and total mathematics performance scores. Similarly, Crosswhite (1972, cited by Reyes, 1984), reported correlations ranging for 0.19 to 0.37 between confidence and mathematics achievement scores. A consistent, positive correlation between self-concept and mathematics achievement was supported by the literature.

Research by Stroup (cited in Gough and Lanning, 1986), later extended by Gough and Lanning (1986), clearly indicates that affective variables can be used in combination with test scores to predict both GPA and academic performance in single college courses. Gough and Lanning used the 18 scales of the California Psychological Inventory (CPI) in developing multiple-variable prediction equations. They identified six personality factors on the CPI which could enhance the predictive accuracy of standardized test scores: sense of well-being, responsibility, good impression, achievement via independence, intellectual efficiency, and psychological mindedness. Data were analyzed from three large, heterogeneous groups of psychology students from five institutions. The initial sample consisted of 13,457 male and 1,842 female students enrolled in Berkeley or one of four other, quite selective,

colleges from the 1950s through 1984. The study was cross-validated using 326 male and 570 female students from introductory psychology classes at Berkeley.

The studies by Gough and Lanning established three separate criterion variables: course grade, two-year GPA and four-year GPA, respectively. All grades were standardized to a mean of 50 and a standard deviation of 10. Analyses were conducted, separately by sex, to identify the best combination of the 18 scales of the CPI for predicting GPA. Significant correlations ($p < .01$) between the CPI scales and the standardized measures of academic performance were reported. Correlation between predicted scores and the criteria was .34 for males and .31 for females.

When Gough and Lanning used SAT-V and SAT-M scores to predict the criterion GPA, the SAT-M score correlated only .30 with grades for males and .24 for females. Thus, they showed that the correlations of the cross-validated values for the CPI with the course grade, (.38 males and .36 females) were higher than the correlations of the SAT-M score (.34 males and .24 females) with the course grades. Gough and Lanning concluded that prediction accuracy can be improved by using a prediction equation that adds a combination of personality variables to aptitude test measures.

Reyes (1984) in a review of the literature showed that attitudinal variables which reflect the level of maturity and motivation found in nontraditional-age students contribute positively to prediction accuracy. She also found several factors

which contribute negatively to prediction accuracy, including test anxiety and math anxiety. Zeidner (1987) suggests that the level of performance of nontraditional-age students on standardized tests can be affected by factors such as recency of test taking experiences, test-wiseness, test attitudes, motivation and anxiety. Zeidner also noted that occupational training and experiences accumulated through the course of day-to-day living can affect performance.

Several other instruments, in addition to the CPI cited above, have been used to research the use of attitudinal variables as predictors of future academic success. Tracey and Sedlacek (1984) used questionnaires of their own design to conduct extensive research on personality, or noncognitive, variables associated with the college performance of several subgroups of student. Sedlacek (1984) identified eight affective variables thought to be important determinants of academic success for all students. He used these variables in conjunction with variables traditionally used as predictors of success, ACT, HSGPA, etc, to predict college performance. These eight affective variables are collectively referred to as noncognitive variables. His research suggests these affective variables are especially important predictors for some subgroups of students, including nontraditional-age students. Evidence of the relationship of these noncognitive variables to academic success has been established by several studies conducted by Sedlacek (Sedlacek, 1989; Sedlacek & Gaston, 1989; Tracey &

Sedlacek, 1984). Tracey and Sedlacek (1984, 1985) assessed the validity of each of these dimensions with respect to grades in college and they found strong support for using them as variables in predicting college grades.

Tracey and Sedlacek (1984) identified the first of the noncognitive variables as self-concept: one's self-image, strength of character, determination, and independence. The second noncognitive dimension, realistic self-appraisal, is defined as the ability to recognize, accept, and to work to overcome, any deficiencies in academic background. Third, preference for long range over short term goals refers to the ability to respond to deferred gratification. The availability of a strong support person, successful leadership experience, and demonstrated community service are, respectively, the fourth, fifth, and sixth noncognitive dimension. The seventh variable is knowledge acquired in a field, referring to any unusual or culturally-related ways in which knowledge has been obtained outside the classroom. The eighth variable is an understanding of racism (Bandalos and Sedlacek, 1989).

Tracey and Sedlacek (1980) developed a questionnaire to measure the eight affective, or noncognitive, variables. Initially named the Non-Cognitive Questionnaire (NCQ) it was revised in 1984 and renamed the Revised-NonCognitive Questionnaire (R-NCQ). The R-NCQ was used as the foundation for the questionnaire developed for this study. The R-NCQ was designed to study the prediction of

success in college as defined by freshmen GPA, while the current study is limited to a study of the prediction of mathematics course grades. All items in the R-NCQ which investigated attitudes about racism were rewritten to investigate attitudes about the study of mathematics.

Summary

Total group equations using scores from mathematical tests, designed and constructed for a younger student population, have the potential for an age-related bias when used as a predictor of academic performance of older students. Research indicates that while the performance of nontraditional-age students on the verbal portion of nationally administered test equals, or surpasses, that of the traditional-age students, the performance of nontraditional-age students on the mathematical portion of the same tests is below that of the traditional-age students. It is hoped that prediction accuracy of standardized test scores can be enhanced, and the mean error of prediction reduced, by including personality variables in the multiple regression equations.

CHAPTER III

DESIGN AND PROCEDURES

This study has two major objectives. The first objective is to determine the extent to which ACT Mathematics test scores, when used to predict success in entry-level college mathematics courses, are biased against nontraditional-age students. The second objective has two components: a) to investigate characteristics of nontraditional-age students which are related to achievement in college-level mathematics courses and b) to determine the extent to which academic and attitudinal characteristics can be used in conjunction with the ACT Mathematics score to reduce the potential age-related bias associated with the use of the scores from the ACT Mathematics test.

Method

Sample:

Data for this study was obtained from students enrolled in Developmental or General Math courses on the main campus of Bluefield State College (BSC) in Bluefield, West Virginia or one of its three community college components: Greenbrier Community College Center (GCCC) in Lewisburg, WV, the BSC on-campus community college, or the off-campus branch in Welch, WV. The sample for this study includes only those students who completed a Developmental or General Math class taught by one of eight

cooperating instructors during the fall semesters of the 1990-91 or 1991-92 school years.

Developmental Math is a pass/fail, non-credit, remedial, mathematics course. This study requires a four-level grade for each student, so instructors were asked to keep grade records as they would for a credit-level course. General Math is the lowest for-credit mathematics course available at BSC. It is a one-semester, survey course which covers a variety of topics, i.e. algebra, geometry, logic, statistics, etc.

Students included in the sample were classified according to two age groups: a) traditional-age students, 17 through 24 years old, and b) nontraditional-age students, 25 years old or older. These age categories were chosen in order to be consistent with earlier research of this type (House, 1989). Age was determined to be the self-reported age on the questionnaire completed during the first week of the 1990-91 and 1991-92 fall semesters. Individuals younger than age 17 were excluded from the sample, as accelerated academic achievement and college attendance suggests a need for a separate study (Levitz, 1982). Students who had previously been enrolled in a college mathematics course were also excluded from the sample.

Data Collection

During the 1990 and 1991 fall semesters the following data were collected for each student enrolled in either a Developmental Math class or a General Math class:

1. Academic data including, ACT Composite score, ACT Math score, and high school grade point average (HSGPA).
2. Affective measures related to success in college obtained from the questionnaire administered to all students during the first week of their regularly scheduled mathematics classes for the 1990 and 1991 Fall semesters.
3. Two measures of success in mathematics for each student were obtained from the instructors. The first measure was the instructor-assigned course grade. The second measure was the score on a brief posttest administered as part of the regularly scheduled course final examination.

All Development and General Math students were asked to complete an attitudinal questionnaire, using their social security numbers for identification, during the first week of classes. The questionnaire was a modification of the Revised-NonCognitive Questionnaire (R-NCQ) developed by Sedlacek and Tracey (1984) as described in Chapter II. Changes were made to several items in order to focus attention on attitudes toward mathematics rather than towards college courses in general. The questionnaire contained 49 Likert-type statements assessing the noncognitive dimensions described by Sedlacek, plus 12 demographic questions dealing with age, sex, academic goals, size of high school and home town, and location of home (rural, urban or city). Students were asked to respond to the noncognitive, or attitudinal statements, using a 5-point Likert type format using a scale from 1 to 5, 1 being strongly agree and 5 being strongly disagree. A copy of the

questionnaire is found in Appendix A. Reverse-coded items are noted with an asterisk.

Two measures of achievement were used for each student, the course grade given by their instructor at the end of the semester and the student's score on a short posttest given at the end of each course. The posttest for Developmental Math students consisted of twenty multiple-choice questions which were given at the beginning of the final exam. The posttest for General Math students, given during the same time period, consisted of thirteen multiple-choice questions. All instructors involved in teaching one of the courses had input into the construction of the posttest and were involved in determining the final questions to be used. Copies of both posttests are found in Appendix B.

Analyses:

A computer file was created by merging all three sources of data into a single record for each student. Out-of-range values were identified by generating a frequency distribution for each variable. All data associated with students in each of the two courses were treated as separate cohorts, a distinction made necessary since the two measures of success differ across courses.

Means were computed for the academic measures, ACT Math, ACT Composite, and HSGPA by course and by age group. Means were also computed by course and by age group for course grades and posttest scores. Data from the questionnaire were analyzed for reliability using Cronbach's Alpha and were subjected to a principal

component analyses to see whether the items fit the original dimensions. A five-factor solution accounting for 33 percent of the variance was subjected to a varimax rotation. Items from the questionnaire which did not have a strong loading (< 0.40) on a particular factor or which didn't have a strong loading on any of the five factors were not used in the composite factors.

The first objective of this study, to determine the extent to which predictions of success in entry-level college mathematics courses using only ACT mathematics test scores are biased against nontraditional students, was accomplished by using only scores from the ACT Mathematics test to predict course grades and posttest scores, separately by course. Course grades were standardized within each class to means of 50 and standard deviations of 10 to allow for differences in grading standards of individual instructors. Posttest scores were also converted to standard t -scores within courses to transform the distributions to have means of 50 and standard deviations of 10. Residual scores for each criterion were computed by subtracting the observed score from the predicted score. Mean errors of prediction (mean residual scores) were computed and compared by age. A t -test was used to determine whether the mean residual scores differed significantly ($p < .05$) between traditional and nontraditional students within each course. The mean residual score for nontraditional-age students was hypothesized to be positive, indicating that ACT Mathematics scores under-predicted their academic performance in mathematics

courses. The mean residual score of the traditional-age students was hypothesized to be negative, showing an over-prediction of academic performance.

The second objective of this study, the investigation of characteristics of nontraditional-age college students related to their achievement in college-level mathematics courses and the extent to which using academic and attitudinal variables in conjunction with ACT mathematics scores might reduce the potential for age-related bias, was accomplished by using two procedures. First, correlations were computed between the academic data, the composite data from the questionnaires, and the two criteria of course grades and posttest scores. Secondly, multiple regression was used to determine which academic and attitudinal composite variables could be used in conjunction with the ACT Math score to enhance the prediction of the same two criteria, course grades and posttest scores. Regressions were done separately by course. Residual scores were again computed and a t -test used to determine whether the mean residual scores differed significantly between traditional- and nontraditional-age students within each cohort. If the second research hypothesis is supported the mean residual scores of the traditional- and nontraditional-age students will not differ significantly. Such a finding would indicate that attitudinal predictors of success can be effectively used to reduce the potential age-related bias associated with using only the

ACT Math scores as the predictor of success in entry-level college mathematics.

Limitations of the Study

While the most favored research method for this type of study would be an experimental study design, such a design is not feasible. Placing students in mathematics courses without regard to their background experiences in mathematics would not be practical, nor would random assignment of students to classes. Random assignment of students and faculty would be further affected by scheduling constraints. Five additional limitations associated with this study include:

1. Potentially confounding variables, such as pedagogical practices and grading standards, are uncontrolled.
2. Generalizability of results is limited since the study was conducted for only one four-year college and its three community college components.
3. Fifteen percent of the students in the sample had GED certificates rather than high school diplomas and so did not have a high school GPA. For analyses purposes, these students were assigned an average GPA equal to the average GPA of all students in their course.
4. Data from all students in the mathematics courses sampled could not be used since some students submitted quantitative test scores from the SAT or ASSET tests for course placement rather than ACT Mathematics scores.
5. Cooperation received from faculty and students at the three campuses varied.

CHAPTER IV

RESULTS

This study analyzed records from a total of 615 students enrolled in either a Developmental or General Math course at Bluefield State College (BSC) or one of its community college components. Over one-half (54%) of these students were enrolled in Developmental Math. Nontraditional-age students constituted the minority in both courses (30% in Developmental and 37% in General Math classes.)

The descriptive statistics for all the academic variables used in the analyses are reported by age groups in two tables: Table 4.1 for Developmental Math, and Table 4.2 for General Math students. Independent sample *t*-tests were used to test mean differences in

Table 4.1
Descriptive Statistics and Age Differences in ACT Mathematics Test Scores, High-School Grade-Point-Averages (HSGPA), Course Grades and Posttest Scores by Age Groups for Developmental Math

Variable	24 & Under			25 & Over		
	N	Mean	SD	N	Mean	SD
Mean ACT-Math	236	13.39	3.93	69	12.72	3.87
Mean ACT-Comp	254	16.16	3.86	78	15.68	3.86
Mean HSGPA **	256	2.77	0.56	79	2.33	.52
Mean Course Grade *	246	2.31	1.30	79	2.68	1.21
Mean Posttest Sc	216	14.56	3.15	67	15.43	4.51

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

the academic variables for each age group and in each course. Differences found to be significant are signified by an asterisk placed next to the variable names. As shown in the Tables 4.1 and 4.2, significant differences ($p < .01$) were found in the HSGPA means of traditional-age and nontraditional-age students in both Development Math ($M = 2.77$ versus $M = 2.33$) and General Math ($M = 2.94$ versus $M = 2.70$.)

Table 4.2
Descriptive Statistics and Age Differences in ACT Mathematics Test Scores, High-School Grade-Point-Average (HSGPA), Course Grades and Posttest Scores by Age Groups for General Math

Variable	24 & Under			25 & Over		
	N	Mean	SD	N	Mean	SD
Mean ACT-Math	176	14.80	5.56	70	13.87	4.79
Mean ACT- Comp	191	17.99	4.16	80	18.31	4.24
Mean HSGPA **	197	2.94	0.64	83	2.70	0.66
Mean Course Grade	197	2.48	1.19	83	2.53	1.13
Mean Posttest Sc*	166	8.96	2.68	66	8.12	2.64

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

In Developmental Math, the mean course grade for nontraditional-age students ($M = 2.68$) was significantly higher ($p < .05$) than the mean course grade of traditional-age students ($M = 2.31$). In General Math, however, no differences were found in the mean course grades of traditional- and nontraditional-age students. The reverse was true for posttest scores. Significant differences ($p < .05$) were found in the posttest scores of General Math students for nontraditional-age students ($M = 8.12$) and traditional-age

students ($M=8.96$), but not in the posttest scores of Developmental Math students.

First Objective of Study

The primary objective of this study was to examine the extent of age differences in prediction of course grades and posttest scores when ACT Math scores were used as the sole predictor of success in entry-level mathematics courses. Two methods of analyses were used for this investigation. First, Pearson product-moment correlation coefficients were computed for all students in Developmental Math and in General Math to determine the strength of the relationship between course grades and ACT Math scores. Prediction accuracy increases with higher correlation between two variables (Ary, Jacobs, & Razavieh, 1985). Second, regression equations were used to predict course grades and posttest scores. Residuals were computed and mean residuals compared by age.

Correlation coefficients of course grades with posttest scores, ACT Math scores with course grades, and ACT Math scores with posttest scores for both Development Math and General Math students are presented in Table 4.3. As can be seen from the Table 4.3, ACT Math was not significantly correlated with Developmental Math course grades or posttest scores for traditional-age students. ACT Math scores, however, were significantly correlated ($p < .05$) with the Developmental Math grade of nontraditional-age students and with course grades of the total group. ACT Math scores were not significantly correlated with Developmental Math posttest scores

for either age group or the total group. Course grades were highly correlated ($p < .01$) with posttest scores for both Developmental Math and General Math.

Table 4.3
Correlation Coefficients of Course Grades with Posttest Scores, ACT Math Scores with Course Grades, and ACT Math Scores With Posttest Scores By Age For Developmental Math

	24 & Under	25 & Over	Total Group
Course Grade/Posttest	.66 *** N=216	.32 ** N=67	.55 *** N=283
ACT-M/Course Grade	.11 N=236	.26 * N=69	.14 * N=305
ACT-M/Posttest Score	.13 N=200	-.04 N=57	.08 N=257

* $p < .05$. ** $p < .01$. *** $p < .001$.

Correlations between ACT Math scores and course grades or ACT Math scores with posttest scores found in Developmental Math were not generally found in General Math. As shown in Table 4.4, ACT Math scores were significantly correlated ($p < .01$) with General Math course grades and posttest scores for both traditional-age students and the total groups. ACT Math scores, however, were not correlated with either course grades or posttest scores of the nontraditional-age students. Since significant correlations ($p < .01$) were found for both traditional-age students and the total groups, and not for nontraditional-age students, it is possible that the significance found for the total group may be carried by the younger students.

Table 4.4
Correlation Coefficients of Course Grades with Posttest scores,
ACT Math Scores With Course Grades, and ACT Math Scores
with Posttest Scores By Age Group For General Math

	24 & Under	25 & Over	Total Group
Course Grade/Posttest	.40*** N=166	.59*** N=66	.44*** N=232
ACT-M/Course Grade	.40** N=176	.16 N=70	.33** N=246
ACT-M/Posttest Score	.25* N=146	.12 N=56	.20** N=202

* $p < .05$. ** $p < .01$. *** $p < .001$.

The second method of analysis was to compare mean error predictions by age for each criterion variable. Total-group regression equations were used to compute predicted course grades and predicted posttest scores, using only ACT Math scores, for each student in Developmental Math. The single-variable regression equations associated with the prediction of Developmental course grades and posttest scores are as follows:

$$\text{Predicted Course Grade} = 1.774 + 0.045 (\text{ACT Math score})$$

$$\text{Predicted Posttest Score} = 13.879 + 0.069 (\text{ACT Math score})$$

The correlation coefficient r between predicted Developmental Math course grades and ACT Math scores was found to be .14. The r -value between the predicted Developmental Math posttest scores and ACT Math scores was .08. Total-group regression equations, using only ACT Math scores, were also used to compute predicted course grades and predicted posttest scores for each student in General Math.

Single-variable equations associated with the prediction of General Math course grades and posttest scores are as follows:

$$\text{Predicted Course Grade} = 1.423 + 0.074 (\text{ACT Math score})$$

$$\text{Predicted Posttest Score} = 7.164 + 0.106 (\text{ACT Math score})$$

The correlation coefficient r between predicted General Math grades and ACT Math scores was computed to be .33. The r -value between the predicted General Math posttest scores and ACT Math score was .19. The value of r -square for the total group regression equation for predicting Developmental Math grades was .02. Such a low r -square indicates that while the ACT Math score is statistically significant in predicting course grades, its significance has little practical value. The Developmental Math total group regression equation for predicting posttest scores had an even lower r -square value of .01. In General Math, the total group regression equation for predicting course grades had a r -square value of .11 and the total group regression equation for predicting General Math posttest scores has a r -square of .03.

To examine the extent of differences in prediction of mathematics course grades and posttest scores, residuals and mean errors of prediction were computed by age group and by course. Age groups within each course were compared on the mean error of prediction. To find the mean error of prediction, residual scores were computed for each individual student, one for course grade and one for posttest score, and mean errors computed. To test for systemic error in the prediction of course grade and of posttest

score from ACT-Mathematics test scores (Reynolds,1982) an ANOVA was used to compare the mean errors of each age group for each course. The mean errors of prediction are reported by age group and by course in Table 4.5.

It can be seen from Table 4.5 that there were significant differences ($p < .05$) between age groups in the error of prediction in Developmental Math course grades. Grades of nontraditional-age students were underpredicted by .268 grade units and the traditional-age students were over-predicted by .079 grade units. Differences in mean error of prediction were not found for Developmental Math posttest scores, General Math course grades or General Math posttest scores.

Table 4.5
Mean Error of Prediction for Single-Variable Regression Equations
for Predicting Course Grades and Posttest Scores by Age & by Course

Mean Error	24 & Under	25 & Over	F-Value	df
Developmental Math				
Mean Error ACT Math Course Grade	.079 N=235	-.268 N=69	3.99*	304
Mean Error ACT Math Posttest score	.136 N=200	-.476 N=57	1.82	257
General Math				
Mean Error ACT Math Course Grade	-.023 N=176	.057 N=70	.26	246
Mean Error ACT Math-General Math Posttest score	-.158 N=146	.411 N=56	1.82	202

* $p < .05$

This finding of differential prediction is supported in research by Casserly (1982), Clark (1984), Fincher (1983), Hartle, 1983, and Zeidner, 1987). Their studies indicated that age-related differences such as these can occur whenever tests designed to assess knowledge of traditional-age students are used to assess knowledge of nontraditional-age students. Research conducted for ACT using data from their predictive research services also support these findings (Noble & Sawyer, 1987; Sawyer, 1986).

Second Objective of Study

The literature review by Reyes (1984) showed the strong role attitudinal variables play in academic success. Sagaria (1989) attributed much of the success of older students to their increased motivation and persistence. To examine the role of attitudinal variables in this study, the second objective of the study was: a) to investigate attitudinal characteristics common to nontraditional-age students which are related to their performance in college mathematics courses and b) to investigate the extent to which other academic and noncognitive variables could be used in conjunction with the ACT Math score to more accurately predict performance of nontraditional age students. Questionnaire data were analyzed to identify attitudinal characteristics of nontraditional-age students which contribute to their success in college math. The questionnaire was a modification of a questionnaire use successfully by Tracy & Sedlacek (1984) with several different nontraditional groups of students. Research by Gough & Lanning

(1986) also found that attitudinal variables were good predictors of success in an academic environment.

A factor analysis was conducted on data from the 49 Likert-type statements on the questionnaire completed by students in all Developmental Math and General Math classes to identify clusters of variables and to explore the nature of the factors (Crocker & Algina, 1986). A five factor solution accounting for 33 percent of the variance was subjected to a varimax rotation. The five identified attitudinal factors are: attitudes towards the study of mathematics, leadership, self-confidence, planning for the future, and age-related anxieties. These five composite factors will be referred to collectively as attitudinal variables. Table 4.6 shows the reliability coefficients, which ranged from .63 to .84, for each of the attitudinal factors. Also shown is the number of cases contained in each of the composite factors, the loading and number of items on which each of the factors is based. In a study concerned with prediction of math course grades, it is not surprising to find that the attitudinal factor with the highest reliability coefficient was the factor concerned with attitude towards the study of mathematics.

Table 4.6
Cronbach Alpha Reliability Coefficients for Composite Scales

Scale	n of cases	n of items	loading	r_{xx}
Self-Confidence	519	10		.71
Enjoy working with others			.60	
Want chance to prove myself academically			.56	
Comfortable interacting with people of different ages			.48	
Will take advantage of free tutoring			.48	
Act on things about which I feel strongly			.47	
Often make lists of things to do			.46	
Usually mark important dates on my calendar			.46	
Try to find new opportunities to learn new things			.45	
More comfortable in new place after making friends			.42	
Expect to have little contact with people significantly older or younger than I am			-.43	
Math Attitude	521	6		.84
Difficulty in making a B in math class			.64	
Enjoyment in the study of mathematics			.64	
Strength of math skills			.63	
Background suitable for college work			.54	
Easily discouraged when working math problems			-.55	
Expectations of difficulty in math class			-.73	
Leadership	521	5		.69
Looked to as a leader			.72	
High school or community leader in past			.68	
Friends expect me to make decisions			.60	
Looked up to by others			.41	
Not good at getting a long with others			-.44	
Planning for the Future	518	5		.75
Already talked to someone about career goals			.76	
Already explored areas of interest			.74	
Already know something about intended major field			.60	
Know what I want to be doing 10 years from now			.59	
Have studied about my major field on my own			.59	
Age-related Anxieties	518	5		.63
Friends and family support my attending college			.61	
Expect difficulties in math because of years out of school			.60	
Expect difficulties in math because of my age			.59	
Feel anxious about taking math			.47	
Family has always wanted me to go to college			-.55	

A correlation matrix was generated to determine the correlation coefficients between each of the academic variables (ACT Composite, ACT Math, and HSGPA), the five attitudinal variables (Math Attitudes, Leadership, Self-Confidence, Future Plans, and Age-related Anxieties), and the two criteria variables (course grades and posttest scores). Correlations and descriptive statistics for each of the variables are shown by course and by age in Tables 4.7 - 4.12. These tables show that ACT Composite was significantly correlated ($p < .01$) with course grade and posttest score for all students in both classes. Additionally, math attitudes and HSGPA were both significantly correlated ($p < .05$) with course grades and posttest scores for both traditional- and nontraditional-age students in both courses.

To explore the possibility of increasing prediction accuracy for all students, multiple-regression equations were generated separately for each course using a three-step block entry regression. The results of these regressions are shown in Tables 4.13 through 4.16. Correlation are given between predicted course grades, predicted posttest scores and the seven variables in the multiple-regression equation. Also shown are beta weights of each variable in the equations, as well as Multiple R values for each of the equations.

The second step of the block entry regression was the addition of the variable HSGPA to the original independent variable, ACT Math scores. The correlation coefficient r for the two-variable

Table 4.7. Correlation Matrix of Academic and Attitudinal Variable
For all Students in Developmental Math

Variables	N	Act Math	Act Comp.	HS GPA	Math Att.	Leader- ship	Self- Conf.	Fut. Plans	Age-rel. Anx.	Post Test	Course Grade
Act Math	305	1.00	.55***	.06	.01	.07	-.02	-.12*	-.08	.08	.14*
Act Composite	332	1.00	1.00	.19***	-.11	.06	-.01	-.04	-.02	.26***	.22***
HSGPA Math	335	1.00	1.00	1.00	.16**	.12*	.09	-.01	-.24***	.15*	.33***
Attitude	318	1.00	1.00	1.00	1.00	.14*	.12*	.09	.15**	.11*	.22***
Leadership Self	318	1.00	1.00	1.00	1.00	1.00	.28***	.17**	-.15**	-.03	.03
Confidence	317	1.00	1.00	1.00	1.00	1.00	1.00	.42***	-.11*	-.01	.07
Future Plans	318	1.00	1.00	1.00	1.00	1.00	1.00	1.00	.06	.02	.05
Age-related Post	318	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	.13	.04
Test	283	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	.56***
Course	225	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00

Table 4.8. Correlation Matrix of Academic and Attitudinal Variables For Traditional-age Students in Developmental Math

Variables	N	Act Math	Act Comp.	HS GPA	Math Att.	Leadership	Self-Conf.	Fut. Plans	Age-rel. Anx.	Post Test	Course Grade
Act Math	236	1.00	.55**	.09	.00	.00	-.04	-.15*	-.11	-.13	.11
Act Composite	254	1.00	1.00	.21**	-.14*	.03	-.03	-.10	-.08	.27***	.19**
HSGPA Math	256			1.00	.16*	.06	.12	.08	-.23***	.22***	.42***
Attitude	241				1.00	.11	.16**	.18**	.11	-.25**	.29***
Leadership Self	241					1.00	.36***	.23**	-.06	-.03	.00
Confidence	241						1.00	.46***	-.28**	.11	.10
Future Plans	241							1.00	-.15*	.05	.04
Age-related Post	241								1.00	-.03	.10
Test	216									1.00	.66***
Course	256										1.00

Table 4.9. Correlation Matrix of Academic and Attitudinal Variables For Nontraditional-age Students in Developmental Math

Variables	N	Act Math	Act Comp.	HS GPA	Math Att.	Leadership	Self-Conf.	Fut. Plans	Age-rel. Anx.	Post Test	Course Grade
Act Math	69	1.00	.54**	-.04	.04	.23	.07	.04	.10	-.04	.26*
Act Composite	78	1.00	1.00	.12	.00	.14	-.06	.19	.22	.27*	.37**
HSGPA	79	1.00	1.00	1.00	.09	-.12	.00	.16	-.10	.22	.12
Math Attitude	77	1.00	1.00	1.00	1.00	.12	.06	.01	-.47**	-.17	.09
Leadership	77	1.00	1.00	1.00	1.00	1.00	.10	.04	.06**	-.04	.22
Self Confidence	76	1.00	1.00	1.00	1.00	1.00	1.00	.29*	-.22*	.28*	-.05
Future Plans	77	1.00	1.00	1.00	1.00	1.00	1.00	1.00	-.13	-.10	.06
Age-related Post Test	77	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	.29*	.20
Course	67	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	.31**
Course	79	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00

Table 4.10. Correlation Matrix of Academic and Attitudinal Variables
For All Students in General Math

Variables	N	Act Math	Act Comp.	HS GPA	Math Att.	Leader- ship	Self- Conf.	Fut. Plans	Age-rel. Anx.	Post Test	Course Grade
Act Math	246	1.00	.64**	.22**	.37**	.04	.01	-.01	-.22**	.20**	.33***
Act Composite	271	1.00	1.00	.20***	.33**	.13*	.02	.07	-.13*	.25**	.37***
HSGPA Math	280			1.00	.18**	-.03	-.10	-.03	-.18**	.28***	.40***
Attitude	263				1.00	.14*	.09	.01	-.39***	.22**	.40***
Leadership Self	263					1.00	.18**	.27***	-.12	-.02	.08
Confidence Future Plans	262						1.00	.35***	.09	-.03	.03
	263							1.00	-.01	-.15	.03
Age-related Post Test	263								1.00	-.20**	-.21**
	232									1.00	.44***
Course	280										1.00

Table 4.11. Correlation Matrix of Academic and Attitudinal Variables For Traditional-age Students in General Math

Variables	N	Act Math	Act Comp.	HS GPA	Math Att.	Leadership	Self-Conf.	Fut. Plans	Age-rel. Anx.	Post Test	Course Grade
Act Math	176	1.00	.67**	.24**	.40**	.09	.02	-.01	-.27**	.21*	.40***
Act Composite	191	1.00	1.00	.20**	.34**	.16*	-.02	.08	-.18*	.25**	.40***
HSGPA Math	197	1.00	1.00	1.00	.18*	-.04	-.08	-.07	-.15*	.27***	.43***
Attitude	183	1.00	1.00	1.00	1.00	.15*	.01	.05	-.48**	-.24**	.40**
Leadership Self	183	1.00	1.00	1.00	1.00	1.00	.21	.32**	-.09	-.04	.08
Confidence Future	182	1.00	1.00	1.00	1.00	1.00	1.00	1.00	-.27***	-.12	.04
Plans	183	1.00	1.00	1.00	1.00	1.00	1.00	1.00	-.12	-.11	.03
Age-related Post	183	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	-.20*	-.21**
Test	166	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	.40**
Course	197	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00

Table 4.12. Correlation Matrix of Academic and Attitudinal Variables
For Nontraditional-age Students in General Math

Variables	N	Act Math	Act Comp.	HS GPA	Math Att.	Leader- ship	Self- Conf.	Fut. Plans	Age-rel. Anx.	Post Test	Course Grade
Act Math	70	1.00	.54**	.07	.28*	.01	.10	.06	-.11	.12	.16
Act Composite	80	1.00	1.00	.22*	.30*	.11	-.10	.03	-.14	.25*	.29**
HSGPA Math	83	1.00	1.00	1.00	.18	.17	-.10	.02	-.21	.27*	.32**
Attitude	80	1.00	1.00	1.00	1.00	.13	.16	.07	-.52**	.17	.36**
Leadership Self	80	1.00	1.00	1.00	1.00	1.00	.23*	.38**	-.09	.00	.03
Confidence Future	80	1.00	1.00	1.00	1.00	1.00	1.00	.46***	.02	-.09	.07
Plans	80	1.00	1.00	1.00	1.00	1.00	1.00	1.00	-.13	-.20	-.02
Age-related Post	80	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	.00	-.20
Test	66	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	.59***
Course	83	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00

regression equation for predicting Developmental Math grades was .36, up from an r -value of .14 with just ACT Math alone. The r -value for the two-variable equation for predicting Developmental Math posttest scores rose from .08 to .22. In General Math, the addition of HSGPA to the regression equation did not bring about as large a change in the r -value as it did for Developmental Math. When predicting General Math course grades, the r -value for the two-variable equation rose from .33 to .45. When predicting General Math posttest scores, the r -value went from .19 to .34. Except in the prediction of Developmental Math posttest scores, both ACT Math and HSGPA were significant at the .05 level.

The five attitudinal variables were added to the prediction equation in the third step of the block entry regression. Beta weights for the attitudinal variables and multiple R values for the regression equations are shown in Table 4.13 - 4.16.

Table 4.13
Block Entry Regression Results for Predicting Course Grades
for All Students in Developmental Math

Variable	r_{xy}	Step 1		Step 2		Step 3	
		R	Beta	R	Beta	R	Beta
ACT Math	.14*		.15		.15		.15
HSGPA	.33***				.31		.31
Math Att	.22***						.19
Leadership	.03						-.06
Self-Conf	.07						.02
Future Plans	.05						.06
Age-rel Anx	.04						.13
Multiple R		.14		.36		.42	

* $p < .05$. *** $p < .001$.

As can be seen from Table 4.13, the multiple R for the Developmental Math multiple-regression equation for predicting course grades was .42. The resulting R-square indicates that 18 percent of the variance in Developmental Math grades is accounted for by the multiple-regression equation, a great improvement over the 2 percent of the variance in course grades that was accounted for by the single-variable equation with only the ACT Math score as the predictor of course grades.

Table 4.14
Block Entry Regression Results for Predicting Posttest Scores
for All Students in Developmental Math

Variable	r_{xy}	Step 1		Step 2		Step 3	
		R	Beta	R	Beta	R	Beta
ACT Math	.08		.08		.08		.08
HSGPA	.15*				.23		.23
Math Att	.11						.11
Leadership	-.03						-.06
Self-Conf	-.01						.01
Future Plans	.02						.02
Age-rel Anx	.13						.16
Multiple R		.08		.22		.30	

* $p < .05$.

As can be seen from Tables 4.15 and 4.16, the increase in the number of variables used to predict General Math course grades and posttest scores also brought about a considerable increase in the multiple R value of the regression equations. The additional of attitudinal factors to the multiple-regression equations increased the multiple R of the the prediction equation for course grades from .33 to .49 and from .19 to .34 for posttest scores.

Table 4.15
Block Entry Regression Results for Predicting Course Grades
for All Students in General Math

Variable	r_{xy}	Step 1		Step 2		Step 3	
		R	Beta	R	Beta	R	Beta
ACT Math	.33***		.11	.11		.11	
HSGPA	.40***			.31		.31	
Math Att	.40***					.29	
Leadership	.08					.02	
Self-Conf	.03					.04	
Future Plans	.03					.01	
Age-rel Anx	-.21**					.05	
Multiple R		.33		.45		.49	

** $p < .01$. *** $p < .001$.

Tables 4.13 - 4.16 show that two variables, HSGPA and Math Attitudes, contributed significantly to the prediction of both course grades and posttest scores for both Developmental Math and General Math. This finding agrees with Fincher (1983) who found HSGPA was the strongest predictor of GPA and with Casserly (1982) who found HSGPA was a significant predictor of GPA in one of the two colleges studied. The attitudinal variable, Age-related anxieties, significantly contributed ($p < .05$) to the prediction of both course grades and posttest scores for General Math, but not for either criteria of Developmental Math. ACT Math scores were significant, except in the prediction of Developmental Math posttest scores.

Table 4.16
Block Entry Regression Results for Predicting Posttest Scores
for All Students in General Math

Variable	r_{xy}	Step 1		Step 2		Step 3	
		R	Beta	R	Beta	R	Beta
ACT Math	.19*		.08		.08		.08
HSGPA	.27***				.17		.17
Math Att	.24**						.13
Leadership	-.04						.03
Self-Conf	.04						.04
Future Plans	-.11						-.17
Age-rel Anx	-.20*						-.07
Multiple R		.19		.30		.34	

* $p < .05$. ** $p < .01$. *** $p < .001$.

Beta weights for each of the seven-variable multiple-regression equations show the relative predictive value of each of the variables. In the prediction of course grades and posttest scores for both Developmental Math and General Math, HSGPA and Math Attitudes had the strongest predictive values.: .31 and .19 for Developmental Math course grades, .23 and .11 for Developmental posttest scores, .31 and .29 for General Math course grades, and .17 and .13 for General Math posttest scores. It can be readily seen that beta weights were higher for multiple-regression equations predicting course grades and for multiple-regression equations predicting posttest scores.

Multiple regression equations were evaluated for age-related prediction bias by computing the mean error of prediction by age for each course. As reported in Table 4.17, the age-related bias found in the prediction of Developmental Math scores using only the ACT Math score is still present, even with the addition of HSGPA to the

prediction equation. Older students were underpredicted by .366 grade units and younger students were over predicted by .107 grade units. Differences in the mean errors of prediction for the two age groups were significant at the .05 level.

Table 4.17
Mean Error of Prediction for Multiple-Regression Equations
Using ACT Math Scores and HSGPA by Course & By Age

Mean Error	24 & Under	25 & Over	F-Value	df
Developmental Math				
Mean Error ACT Math/HSGPA				
Course Grade	.107 N=235	-.366 N=69	8.48 *	304
Mean Error ACT Math/HSGPA				
Posttest score	.205 N=200	-.719 N=57	3.20	257
General Math				
Mean Error ACT Math/HSGPA				
Course Grade	-.040 N=176	.100 N=70	.89	246
Mean Error ACT Math/HSGPA				
Posttest score	-.112 N=146	.293 N=56	.98	202

* $p < .05$

The mean error of prediction for the seven-variable regression equation was also computed by age for General Math. As shown in Table 4.18, no differences were found in the prediction of either course grades or posttest scores for the two age groups. The additional of the five attitudinal variables to the equations with

Table 4.18
 Mean Error of Prediction for Multiple-Regression Equations by Age
 For Developmental Math For ACT Math Scores, HSGPA, & Attitudinal Factors

Mean Error	24 & Under	25 & Over	F-Value
Developmental Math			
Mean Error ACT Math/HSGPA/Attitudinal Factors			
Course Grade	.054 N=223	-.179 N=67	2.15
Mean Error ACT Math/HSGPA/Attitudinal Factors			
Posttest score.	.038 N=196	-.132 N=56	0.11
General Math			
Mean Error ACT Math/HSGPA/Attitudinal Factors			
Course Grade	.016 N=163	-.038 N=68	0.14
Mean Error ACT Math/HSGPA/Attitudinal Factors			
Posttest score	.050 N=142	-.126 N=56	0.19

independent variables, ACT Math and HSGPA, effectively eliminated the age-related bias found when ACT Math scores alone predicted Developmental Math course grades, and when both ACT Math scores and HSGPA were used in the prediction equation. Each of the multiple-regression equations predicted course grades or posttest scores equally well for both traditional- and nontraditional-age students.

CHAPTER V

DISCUSSION

The Board of Directors of The State College System of West Virginia recently adopted a new policy on course placement for freshman-level mathematics courses based entirely on student scores on standardized achievement and aptitude tests. This policy mandates that all students attending West Virginia's state-supported, 2- and 4-year colleges, must be placed in entry-level mathematics courses on the basis of their scores on one of three standardized aptitude and achievement tests. All colleges in the state public system, regardless of the size or mission of the institution, are required to use the same cut-score. Additionally, the cut-scores are identical for all students enrolling in an entry-level mathematics course, without regard to the student's past academic performance or length of time the student has been away from the academic classroom. In order to accurately predict student performance in entry-level mathematics courses, the test scores used for prediction must be free of bias. This study grew out of a concern for evaluating a possible age-related prediction bias in ACT Mathematics test scores when used as the sole predictor of success in college-level mathematics courses.

Recent research has shown that standardized tests designed to assess the mathematical knowledge of high school students have an age-related bias when used with nontraditional-age students (Casserly, 1982; Fincher, 1983; and Sawyer, 1986). The results of the current study did not entirely confirm or deny these earlier findings; results were mixed as to the presence of an age-related prediction bias in the ACT Math score. Prediction bias was found when ACT

Math scores alone were used to predict course grades for Developmental Math, the mathematics course of main concern in this study. The same bias was not found when ACT Math scores alone were used to predict course grades for General Math. No bias was found for posttest scores in either Developmental or General Math courses. This inclusive evidence of the existence of an age-related bias may be a factor of the size of the data set and the small number of instructors involved. More extensive investigations are needed using a much larger sample size for both students and instructors.

Single-variable regression equations with only ACT Math scores as the independent variable had very low r -square values when predicting either criterion variable for Developmental Math. Values of r -square for the single-variable regression equations of .02 for course grades and .01 for posttest scores indicate that only a small amount of variance in course grades or posttest scores is accounted for by ACT Math scores. Such small r -square values shows that the ACT Math score alone has little practical value as a predictor of academic performance in Developmental Math.

The second approach used to evaluate the performance of ACT Math scores as predictors of academic performance in mathematics examined the slopes of the regression equations. Regression equations were graphed along with additional plots of points representing the relationship between ACT Math scores and the two criteria variables, course grades and posttest scores. Figures 5.1 and 5.2, respectively, are graphs of the regression equations for predicting Developmental Math course grade and posttest score using just the ACT Math score. Graphs of the regression equations for predicting General Math course grades and posttest scores using the ACT Math score alone are shown in

Figures 5.3 and 5.4, respectively. In each case, the points representing the relationship between the ACT Math score and course grade, or ACT Math and posttest score, are scattered all over the quadrant. Points scattered in this fashion clearly show that the ACT Math score is not a good predictor of performance in entry-level college mathematics.

Three variables were identified by this study as good predictors of course grade and posttest scores in Developmental and General Math. ACT Math scores were not one of these variables. With the exception of nontraditional-age students in Developmental Math, the ACT Composite score, HSGPA, and the attitudinal factor defined as attitudes towards mathematics, were all significantly related to both course grades and posttest scores, for both Developmental Math and General Math courses, and for both age groups. Another attitudinal variable, age-related anxieties, was significantly related for both age groups in General Math.

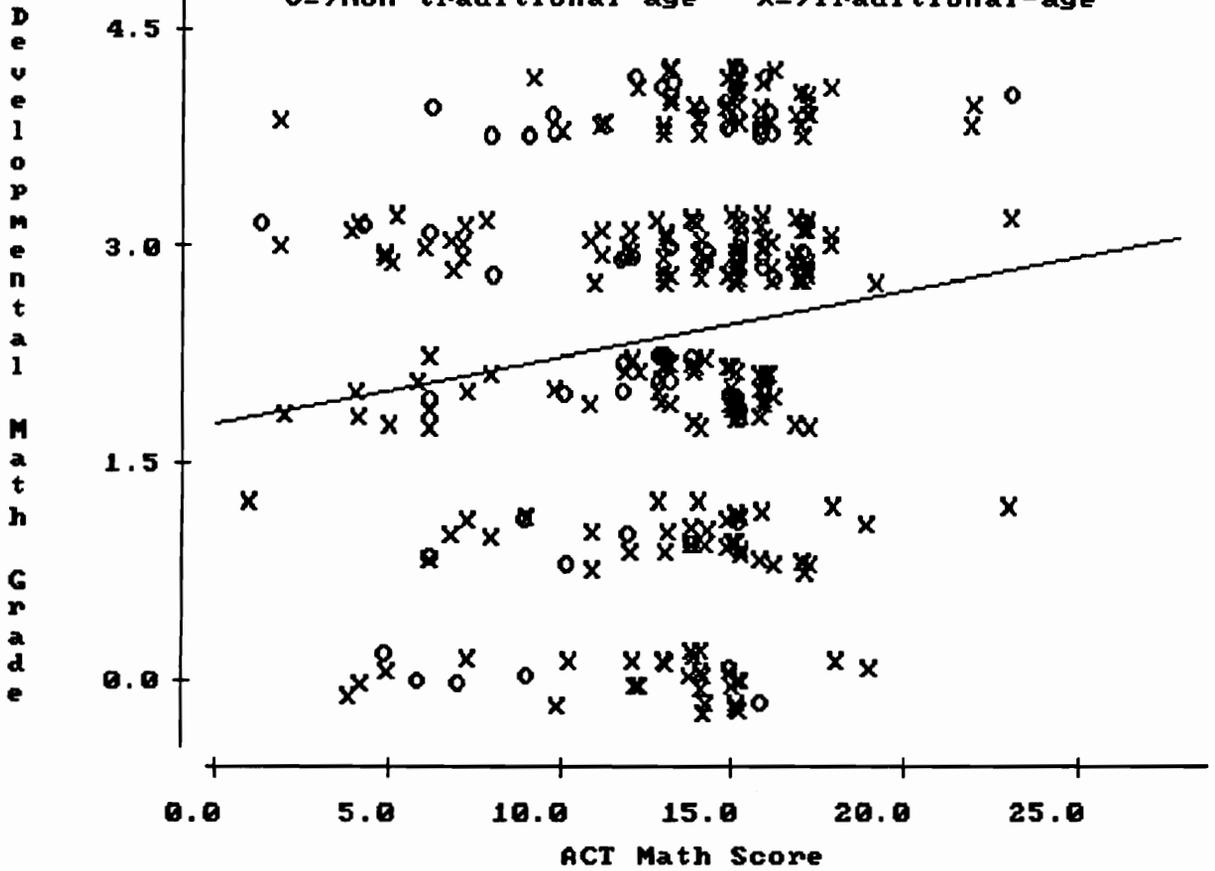
Results of the regression analyses suggest that the addition of HSGPA and the attitudinal variable, math attitudes, to the regression equation, in combination with the ACT Math score, enhances the prediction of academic performance in mathematics classes for nontraditional-age students. Research by Gough & Lanning (1986), Levitz (1982), Sedlacek (1985), Zeidner (1987) supports the use of academic and attitudinal variables to predict academic performance of nontraditional-age students.

An examination of correlations among variables revealed one unexpected result. When recording data, student questionnaires were coded by course and instructor as part of the identification process. When this code was added to an exploratory analysis, the results showed that instructors had no significant effects

Figure 5.1

Grade in Developmental Math Versus ACT Math Score

O=>Non-traditional-age X=>Traditional-age

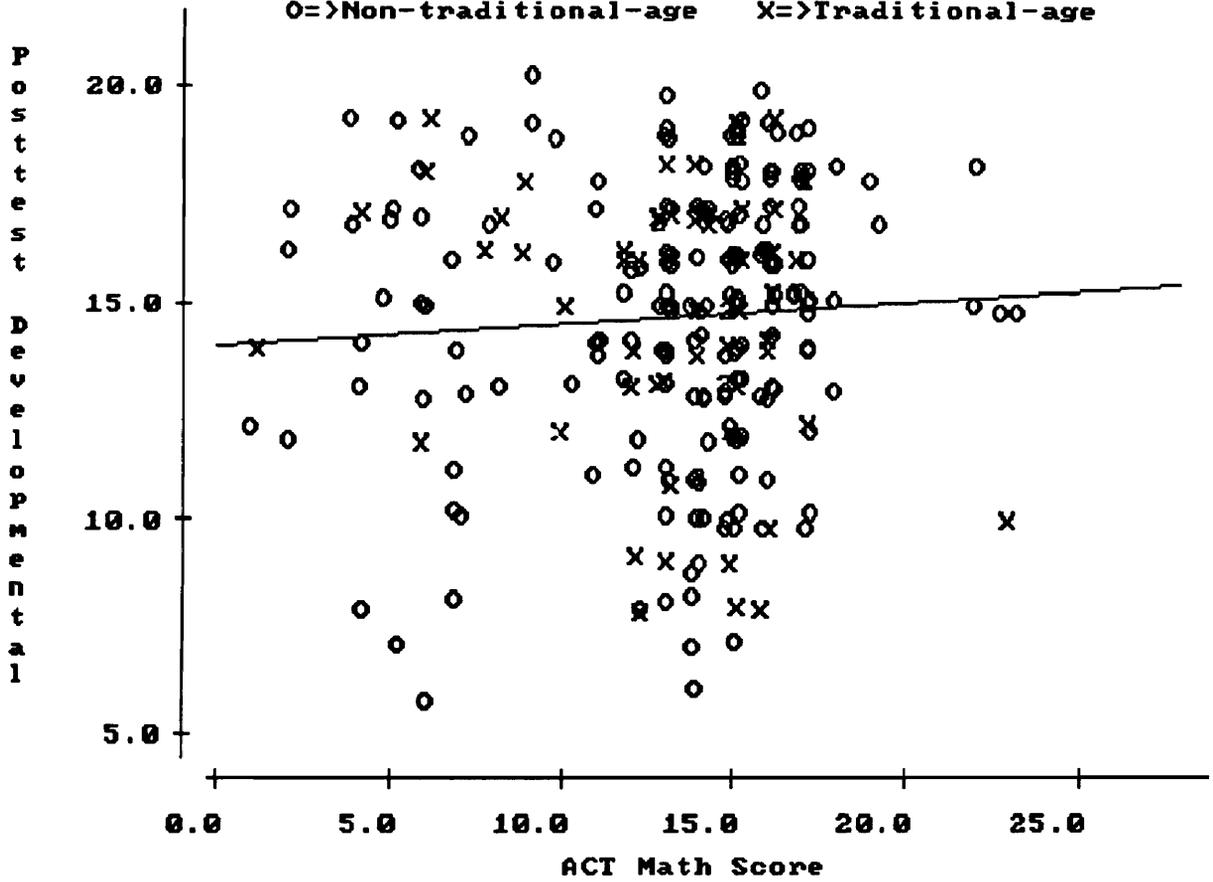


Data "fuzzed" to improve graphic resolution.

Figure 5.2

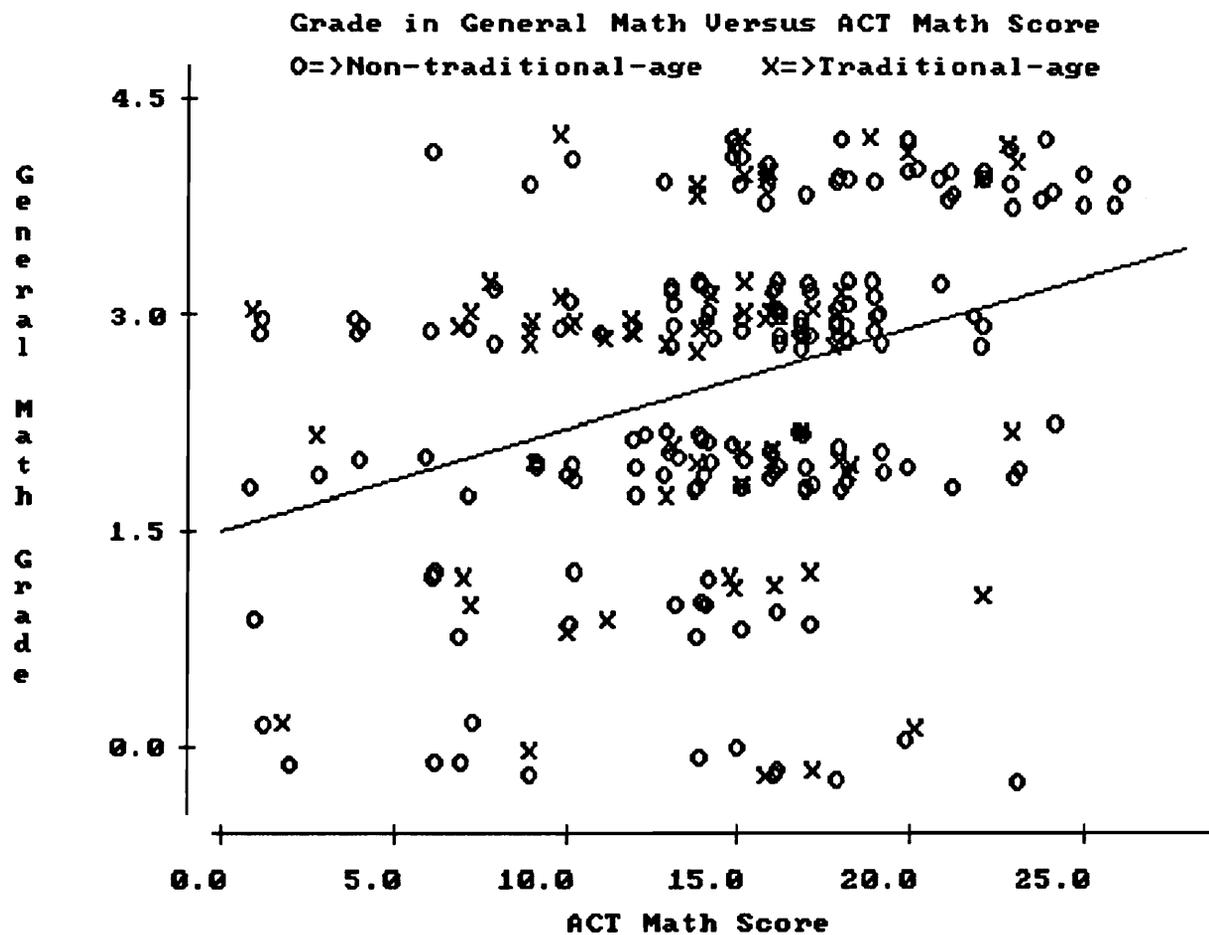
Posttest Score in Developmental Math Versus ACT Math

O=>Non-traditional-age X=>Traditional-age



Data "fuzzed" to improve graphic resolution.

Figure 5.3

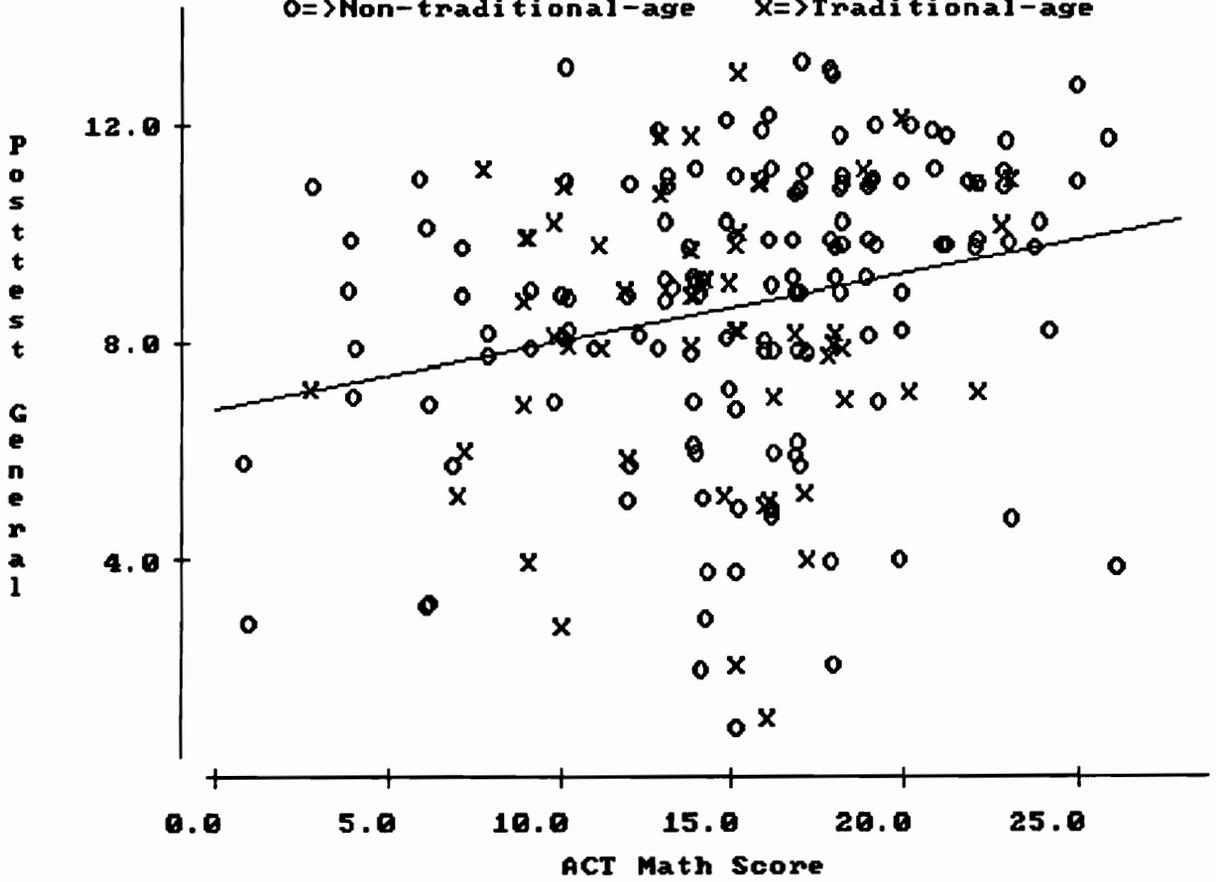


Data "fuzzed" to improve graphic resolution.

Figure 5.4

Posttest in General Math Versus ACT Math Score

O=>Non-traditional-age X=>Traditional-age



Data "fuzzed" to improve graphic resolution.

on course grades in either Developmental Math or General Math. Significant differences, however, were found between instructors, within courses, for posttest scores. Course instructors affected the outcome of this research in another, more subtle way. Some instructors were very conscientious about getting every student to complete the questionnaire, encouraging them to provide the requested information, and to identify their questionnaires and posttests with their social security numbers. Other instructors were less conscientious, and, as a result, some students do not have a complete set of data. Also, some students refused to give their social security numbers. When pressed to do so, they wrote a false number on the paper. Part of this lack of cooperation was the result of the investigator being on one campus and six of the other instructors being on a campus nearly one hundred miles away. Also contributing to this situation was the fact that the investigator was an unknown to the large majority of the students. Even with written assures that their social security numbers were purely for identification purposes, some students would not give their correct number. Problems also developed with the posttest. One instructor gave the posttest to only half of two courses for unknown reasons, and another one decided at the beginning of the final exam period not to give the posttest at all. These unexpected instances occurred even though the posttest had been previously prepared and delivered to the classrooms prior to the exam period. For the most part, however, excellent cooperation was received from almost every one involved and usable data were gathered from a large percentage of the student sample.

Further Discussion and Recommendations for Future Study

An examination of the correlation coefficients of the ACT Math score with course grades and with posttest scores showed mixed results. The most interesting of these results were in General Math. ACT Math scores were significantly correlated with General Math course grades and posttest scores for the total group, and they were correlated with course grades and posttest scores of the traditional-age students. ACT Math scores, however, were not correlated with either the course grades or the posttest scores of the nontraditional-age students (See Table 4.4). This lack of significant correlation for nontraditional-age students would seem to indicate that the strength of the correlation of ACT Math scores with grades and with posttest scores of traditional-age students was strong enough to carry the nontraditional-age students. When an investigation was made, however, for interactions between age and ACT Math scores, this hypothesis did not hold true. Further study is needed to investigate more fully the extent of this interaction between age and ACT Math scores in the prediction of course grades and posttest scores. An examination of correlation coefficients showed the attitudinal factor, math attitudes to be significantly correlated with posttest scores and course grades. The attitudinal variable, age-related anxieties, was significantly correlated with both course grades and posttest scores for students in General Math. The particular combination of these two attitudinal variables in an age-related study suggests a need for further study of the relationship between test anxiety and test performance for nontraditional-age students.

The addition of the academic and attitudinal variables to the ACT Math score led to much improved R-square values for the multiple regression

equations. These increased R -square values are an indication that the multiple regression equations did, indeed, enhance the prediction of course grades and posttest scores. Multiple-regression equations may provide a promising solution for colleges interested in achieving greater prediction accuracy for nontraditional-age students. The validity of prediction equations which include academic and attitudinal variables needs to be more fully tested with a larger and more generalized sample of students and instructors.

The results of this study demonstrate the need for additional investigation of the role that the factors of age and motivation play in the academic performance of nontraditional-age students in freshmen mathematics courses. The only age-related bias found in this study was in the prediction of course grades for nontraditional-age students in Developmental Math using only ACT Math scores. The addition of the variable, HSGPA, did not fully eliminate this age-related bias of the ACT Math score. The fact that the addition of a strong variable into the prediction equation did not remove all of the age-related bias would seem to indicate that age plays a larger role in the success of nontraditional-age students in Developmental Math than accounted for in this study. Perhaps this persistence of age-related bias indicates that different variables are needed in the prediction equation for nontraditional-age students. Whatever the reason, the relationship between age and academic performance needs to be investigated more fully. Further study is also needed to assess the relationship between motivation, persistence, and success in college studies.

Conclusions

In conclusion, this study did not arrive at incontrovertible evidence that an age-related prediction bias exists in the ACT Math score. The analyses of the

data both confirmed and denied the existence of such a bias. Even through the study did not arrive at any definite answers, it did formulate a way of looking at the question. This study developed and implemented a procedure for examining the validity of standardized test scores as predictors of academic success. A more thorough investigation, using the same methodology, needs to be conducted on a state-wide basis; a larger, more generalized sample would produce more conclusive results concerning the validity of ACT Math scores as a predictors of academic performance in entry-level college mathematics.

Even though an age-related bias in the ACT Math score was not conclusively found, the findings of this research have relevance to the newly-instituted placement policy of The State College System of West Virginia. Analyses of the data show that there are valid predictors of academic performance in entry-level college mathematics courses that can be used to enhance predictions of success in mathematics. High school grade-point-averages were found to contribute significantly ($P < .01$) to the prediction of both course grade and posttest score for all students regardless of age or of math course. Since high school averages are available for use with all students, it would seem expedient to augment ACT Math scores with high school grade-point-average as predictors of performance in mathematics courses.

Another fact which needs to be considered when evaluating the ACT Math score as a predictor of success in entry-level math courses is the small amount of variability in academic performance which can be explained or accounted for using only the ACT Math score in the prediction equations. Prediction equations with only the ACT Math score as the independent variable accounted for only 2 percent of the variability in Developmental Math course grades and 1 percent of

the variability in Developmental Math posttest scores. The addition of academic and attitudinal variables to the prediction equations increased the R -square values to .42 for Developmental Math course grades and .30 for Developmental Math posttest scores. R -values of the multiple-regression equation increased to .49 for predicting General Math course grades and .34 posttest scores. This large increase in R -values clearly shows that the addition of academic and attitudinal variables to the regression equation enhances the prediction of success in entry-level college mathematics courses.

Policy implications of the poor performance by ACT Math scores as the sole predictor of success in entry-level math courses, especially Developmental Math, suggest the advisability of a re-examination of the mathematics placement policy implemented by The State College System of West Virginia. The purpose of placement systems is to assist college personnel and students in identifying classes which are best suited to the students' needs and for which students are adequately prepared. ACT Math scores, and other measures of academic performance, should only be considered as a tool for assisting in this process. Test scores should be considered as decision-support variables, not decision-making variables. Test scores should assist students in making course decisions; they should not be making the course decisions for the students.

Inaccurate placement of nontraditional-age students in Developmental Math, which was the impetus for this research, is a waste of resources of the state educational system, the individual colleges, and the students themselves. Federal, state, and local monies are spent to provide remedial instruction for students in most community colleges. These funds are not spent efficiently when they are spent on students who have been systematically misplaced in non-credit

courses. Colleges lose the instruction and preparation time of instructors who are teaching the remedial courses for students who, if properly evaluated, could be enrolled in credit-level courses. Most nontraditional-age students have limited time and money to devote to their college studies. When they are needlessly placed in a remedial course as a result of inaccurate predictions, the students must spend both time and money for courses which give them no college credit. Placement decisions based on a single test score with an age-related bias have far-reaching implications for the state educational system, the state colleges, as well as the students who have been improperly enrolled in non-credit remedial mathematics courses as a result of inaccurate predictions.

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APPENDICES

APPENDIX A

MATHEMATICS PLACEMENT QUESTIONNAIRE

MATHEMATICS PLACEMENT QUESTIONNAIRE

The procedures used by Bluefield State College for mathematics placement are being evaluated for effectiveness. Information asked for in this questionnaire will be used to assist with this process. All results will be reported for groups only and no individuals will be identified. However, in order to match this questionnaire with the posttest you will take at the end of this course you are asked to record your social security number. **Please mark your responses by filling in the blank or circling the appropriate choice. Be sure to respond to all statements on each of the four pages.**

1. Your Social Security number is _____.
2. Your sex is
 1. male
 2. female
3. Your course of studies requires
 1. Only one math class
 2. More than one math class
4. Your age is _____ years.
5. Your math class is
 1. 099 (Developmental Math)
 2. 101 (General Math)
 3. 109 (College Algebra)
6. Your home is located in a(n) _____ area
 1. Rural
 2. Urban (Less than 10,000)
 3. City (10,000 or more)
7. The size of the high school you graduated from is
 1. Fewer than 750 students
 2. 750 to 1200 students
 3. More than 1200 students
8. How much education do you expect to get during your lifetime?
 1. Some college, but less than an associate degree
 2. Associate degree
 3. More than associate degree but less than a bachelor's degree
 4. Bachelor' degree
 5. Graduate study
9. For which reasons would terminate your studies
 1. To accept a good job
 2. To enter the military
 3. Too costly
 4. Marriage
 5. Disinterest in study
 6. Lack study skills
10. Why are you taking this course?
 1. Required
 2. Elective

11. What math classes do you plan to take?

1. Only General Math (101)
2. College Algebra
3. Course beyond College Algebra

12. How many hours a week are you willing to devote to the study of math?

1. 0 to 1 hour
2. 2 to 3 hours
3. 4 to 5 hours
4. Whatever it takes

Please indicate the extent to which you agree or disagree with each of the following items. Respond to the statements below with your feelings at present or with what you expect to be true this year. Write the number of your answer to the left of each statement.

_____ 1 2 3 4 5
Strongly Agree Agree Neutral Disagree Strongly Disagree.

- _____ 13. I enjoy the study of mathematics.
- _____ 14. I try to find opportunities to learn new things.
- _____ 15. I feel anxious when I think about taking a math class. **
- _____ 16. I have studied things about my major field on my own.
- _____ 17. It should not be very hard to get a B (3.0) average in my math class here.
- _____ 18. My background should help me fit in well here.
- _____ 19. I am easily discouraged when working math problems. **
- _____ 20. If I run into problems concerning school, I have someone who will listen to me and help me. *
- _____ 21. I have learned more outside of school than in school. *
- _____ 22. I don't expect to get to know faculty personally during my first year. *
- _____ 23. I am sometimes looked up to by others.
- _____ 24. I expect to have a harder time in my math class than most of the students here. **
- _____ 25. I prefer to be spontaneous rather than to make plans. *
- _____ 26. My friends look to me to make decisions.

- _____ 27. I am at least as skilled mathematically as the average college student here.
- _____ 28. I am comfortable interacting with people of different ages.
- _____ 29. I expect to encounter difficulty in learning math because of my age. **
- _____ 30. I have already learned something in my proposed major outside of high school.
- _____ 31. In groups where I am comfortable, I am often looked to as a leader.
- _____ 32. I expect to encounter difficulty in learning math because of the number of years I have been out of school. **
- _____ 33. I enjoy working with others.
- _____ 34. I find I am more comfortable in a new place as soon as I make some friends.
- _____ 35. I was a leader in my high school or in my community last year
- _____ 36. I have talked about my career goals with people in those areas of interest.
- _____ 37. My friends and relatives don't feel I should go to college. **
- _____ 38. I expect the faculty to treat me differently from the average student here. *
- _____ 39. I keep to myself pretty much. * **
- _____ 40. My family has always wanted me to go to college.
- _____ 41. I usually mark important dates on my calendar.
- _____ 42. I am not good at getting others to go along with me. **
- _____ 43. I have talked about my career goals with someone who has worked in that field.
- _____ 44. If I run into difficulty in my math class, I would take advantage of the free tutoring that is available.

- _____ 45. I often make lists of things to do.
- _____ 46. I expect to have little contact with students who are significantly older or younger than I am. *
- _____ 47. I want a chance to prove myself academically.
- _____ 48. I expect to be involved in many off-campus activities while enrolled here. *
- _____ 49. When I believe strongly in something, I act on it.
- _____ 50. I can do better than my high school grades indicate.*
- _____ 51. I expect to find many people here who are like me.*
- _____ 52. I know what I want to be doing 10 years from now.
- _____ 53. My friends on campus are exclusively the same age as I am.*
- _____ 54. My ACT-Math score does not really reflect what I can do in math. *
- _____ 55. I know the areas where I am weak and I try to improve them.*

Please circle the numbers which correctly answers the next eight questions.

- | | |
|---------------------------------------------------------------------------|--------------------------------------------------------------------------|
| <p>56. Is this your first college math class?</p> <p>0. Yes
1. No</p> | <p>57. Are you still in high school?</p> <p>0. Yes
1. No</p> |
| <p>58. Do you have a high school diploma?</p> <p>0. Yes
1. No</p> | <p>59. Do you have a GED?</p> <p>0. Yes
1. No</p> |
| <p>60. Did you take Algebra I in high school?</p> <p>0. Yes
1. No</p> | <p>61. Did you take geometry in high school?</p> <p>0. Yes
1. No</p> |
| <p>62. Did you take Algebra II in high school?</p> | <p>63. Did you take a pre-cal</p> |

* Statement not included in any attitudinal variable composite factor.

** Statement is reverse coded.

APPENDIX B

POSTTESTS

Name _____ Soc Sec # _____

General Math Posttest

Fall 1991

In each of the following problems select the one letter which correctly answers the question. Place your answer on the correct line on the scantron sheet. (Be sure to fill in the circle completely.) NOTE: Answer "e" is "none of the other answers are correct."

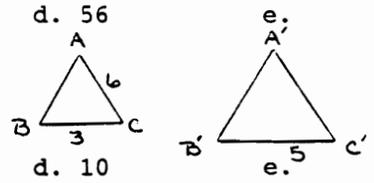
- _____ 1. Simplify: $3[7-(x-2)]$
a. $27 - x$ b. $3x - 27$ c. $15 - x$ d. $27 - 3x$ e.
- _____ 2. Solve for x: $2x-5 = 13$
a. 4 b. -4 c. 9 d. 8 e.
- _____ 3. Write 348000 in scientific notation.
a. 3.48×10^{-5} b. 34.8×10^4 c. 3.48×10^5 d. 34.8×10^{-4} e.
- _____ 4. The sum of 6 and twice a number is equal to four times the number. Find the number.
a. 3 b. 12 c. 1 d. 4 e.
- _____ 5. Given the right triangle ABC shown to the right find the measure of the hypotenuse.
a. 7 b. $\sqrt{7}$ c. 5 d. 1 e.
-
- _____ 6. Given set $A = \{1,2,4,6\}$ and set $B = \{1,3,4,5\}$, find $A \cup B$.
a. $\{1,4\}$ b. $\{1,2,3,4,5,6\}$ c. \emptyset d. $\{1\}$ e.
- _____ 7. Evaluate $2x^2 + 3xy$ for $x = -1$ and $y = -2$.
a. 4 b. 8 c. 10 d. -4 e.
- _____ 8. Solve for x: $2 - x > 6$.
a. $x > 4$ b. $x < 4$ c. $x < -4$ d. $x > -4$ e.
- _____ 9. If $f(x) = 2x - 5$, find $f(3)$.
a. -1 b. 11 c. 0 d. 1 e.

_____ 10. Which of the following points does not satisfy the equation $3x + y = 10$.
 a. (4,-2) b. (1,6) c. (2,4) d. (3,1) e.

_____ 11. Simplify: $(2x^2 - 6x - 5) - (x^2 - 4x + 2)$
 a. $x^2 - 10x - 3$ b. $x^2 - 2x - 7$ c. $3x^2 - 2x - 7$
 d. $x^2 - 10x - 7$ e.

_____ 12. Evaluate: $16 - 3 \cdot 2^2 + 8 \div 2$.
 a. 8 b. -16 c. 6 d. 56

_____ 13. Given two similar triangles, ABC and A'B'C', as shown to the right. If $a = 3$, $b = 6$, and $a' = 5$, find b' .
 a. 3 b. 4 c. 5 d. 10



Name _____ Social Security # _____

MATH 099 POSTTEST

Fall 1991

In each of the following problems choose the one letter that best answers the question asked. Place the letter on the line beside the problem number and on the scantron sheet. NOTE: The letter "e" is "none of the other answers are correct."

- _____ 1. Solve for x: $3x = 12$
a. 9 b. 4 c. -9 d. -16 e.
- _____ 2. Evaluate: $6-2\cdot 4$
a. 16 b. 2 c. -2 d. -16 e.
- _____ 3. Solve for x: $2x + 1 = 11$
a. 5 b. 6 c. -5 d. -6 e.
- _____ 4. Divide: $0/7$
a. 7 b. undefined c. 0 d. meaningless e.
- _____ 5. Simplify: $x^3 x^9$
a. x^6 b. x^{27} c. x^3 d. x^{12} e.
- _____ 6. Simplify: $\sqrt{64}$
a. 32 b. -8 c. 4 d. 8 e.
- _____ 7. Simplify: $3[7-(x-2)]$
a. $27 - 3x$ b. $27 - x$ c. $3x - 27$ d. $15 - 3x$ e.
- _____ 8. Simplify: $9a-(6-5a)$
a. $-2a$ b. $4a - 6$ c. $4a + 6$ d. $14a - 6$ e.
- _____ 9. Simplify: $|-5|$
a. -5 b. 5 c. $-|-5|$ d. $-|5|$ e.
- _____ 10. $-7-(-6)$
a. 1 b. 13 c. -1 d. -13 e.

- _____ 11. Divide $7/0$
 a. 7 b. not possible or undefined c. 0 d. 1 e.
- _____ 12. Twenty-four more than 2 times an unknown number is 34. Find the unknown number.
 a. 39 b. 5 c. 29 d. 10 e.
- _____ 13. Expand: $(x + 4)(x - 1)$
 a. $x^2 + 3x - 4$ b. $x^2 + 3x + 4$ c. $x^2 + 5x - 4$ d. $x^2 - 3x - 4$ e.
- _____ 14. Simplify: $(2x^2 + 6x - 5) + (x^2 - 8x + 5)$
 a. $2x^2 - 2x + 10$ b. $3x^2 - 2x$ c. $3x^2 + 2x + 10$ d. $2x^2 + 2x$ e.
- _____ 15. Find the reciprocal of 10.
 a. -10 b. $\frac{1}{10}$ c. .0 d. $\frac{-1}{10}$ e.
- _____ 16. Replace the ? with > or <: $-8 ? -2$
 a. $-8 > -2$ b. $8 < 2$ c. $-8 < -2$ d. $2 > 8$ e.
- _____ 17. The graph of $x > 2$ is:
 a.  b.  c.  d.  e.
- _____ 18. Write 48000 in scientific notation.
 a. 48.0×10^3 b. 4.8×10^{-4} c. 4.8×10^4 d. 48.0×10^{-3} e.
- _____ 19. Evaluate: $2x + 3y$ for $x = -1$ and $y = 2$.
 a. 4 b. -4 c. 8 d. -8 e.
- _____ 20. Evaluate: $16 - 3 \cdot 2^2 + 8 \div 2$
 a. 8 b. -16 c. 6 d. 56 e.

VITA

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- Representative, 1987 NCTM National Delegate Assembly
- Member, BSC Title III, BRACE Committee, 1991-92.
- Member, BSC General Studies Assessment Committee, 1991-92.
- Member, BSC Faculty Senate: 1991-92
- Moderator, BSC Panel on International Exchange, 1991
- Chairman, GCCC Search Committee for Title III position, Counselor, 1990
- Member, State steering committee for American Mathematics Project of the Collaborative Mathematics Project, 1989.
- Member, GCCC Search Comm for Title III position, Computer Sp, 1991
- Member, WV Board of Governors, WV Mathematics Coalition, 1990-
- Member, West Virginia-STEP Program (K - 6) Assessment Program, 1989
- Coordinator and head coach, WV State Math Team -
- Participant, Conference on AP calculus, University of Charleston, 1988.
- Presenter: various county in-service continuing ed workshops. 1983 -

Chairman, test question writer, grader, and/or coordinator of RESA IV Region
Math Field Day, Grader, WV State Math Field Day, 1978 - 89.
Member, North Central Evaluation Teams - Woodrow HS Beckley, WV laeger
High School, laeger, West Virginia

PROFESSIONAL PRESENTATIONS:

- 1992: NCTM National Meeting - Nashville, TN.
- 1992: WVCTM State Meeting Workshop: "Teaching Discrete Graphs
- 1991: NCTM National Meeting - New Orleans, LA.
- 1991: WVTCM State Meeting "Discrete Graphs vs Cartesian Graphs. More Over
DesCartes and Let Euler Cycle Through."
- 1990: NCTM National Meeting - Salt Lake City, Utah. Workshop: "Using
Puzzles and Games to Teach Graph Theory".
- 1990: WVCTM State Meeting - "Graph Theory in the High School"
- 1989: WV Tech Math and Science Mini-Conference - Montgomery, WV
"Teaching Graph Theory With Instant Insanity Cubes."
- 1987: NCTM National Meeting, Anaheim, California "EDA, Statistics the Easy
Way."
- 1987: WVCTM State Meeting - Oak Hill, West Virginia "Problem Solving
Activities for Pre-Calculus Students."
- 1986: NCTM Regional Meeting, Casper Wyoming "EDA, Statistics the Easy
Way"
- 1984: University of Delaware - "Statistical Representation of Data Stem & Leaf
and Boxplots."
- 1984: WVCTM State Meeting - Cedar Lakes, Ripley, WV "Incorporating
Statistics into The High School Curriculum."
- 1972: WVCTM State Meeting - Athens, West Virginia "Teaching Computer
Programming to High School Students."

PUBLICATIONS:

"Stem and Leaf Plots". Focus on Statistics. The Woodrow Wilson National
Fellowship Foundation, 1984. pp. 313-316.

COMMUNITY ACTIVITIES:

- 1965 - St. James Episcopal Church; Chalice Assistant, Altar Guild, Lector
- 1977 - Greenbrier County Volunteer 4-H Leader, various capacities.
- 1985 - National Executive Comm, Youth Div: National Safety Council

AWARDS AND HONORS:

- 1989 - ARML's Sam Greller Distinguished Coach Award
- 1989 - State Winner: Presidential Award for Excellence in Teaching Math
- 1987 - WVCTM Secondary Mathematics Teacher of the Year
- 1986 - Finalist, Lewisburg Volunteer of the Year Award
- 1985 - National Safety Council's Award of Honor
- 1984 - State 4-H Volunteer Leader of the Year Award

