

Agricultural Education Teachers' Ability to Solve Agriculturally Related Mathematics Problems

Greg Miller, Assistant Professor
Iowa State University
Joe Gliem, Associate Professor
The Ohio State University

The National Commission on Secondary Vocational Education (1984) made two important recommendations for curriculum. First, vocational courses should provide instruction and practice in the basic skills including mathematics. Second, students should be allowed to satisfy graduation requirements for basic skills courses including mathematics with selected vocational education courses. Agricultural educators have begun to embrace the practice of including academic skills, particularly those related to science and to a lesser degree those related to mathematics, in secondary agriculture programs. And the need for research in this area has become more apparent (Buriak & Shinn, 1991; Johnson, 1991).

Dayberry (1987) and Loadman (1986) investigated the degree to which mathematics concepts and skills were being taught in vocational agriculture programs. Both Dayberry and Loadman concluded that concepts and skills in mathematics were being taught through vocational agriculture.

Vocational teachers may be teaching math concepts to their students, but are their students realizing any benefit? Anderson (1989) concluded that the number of vocational education courses completed does little to enhance the basic mathematics knowledge of students.

Miller and Gliem (1993) concluded that applied academics (Ohio's program for integrating academic concepts into vocational education) had reached few agriculture programs. They further concluded that the infusion of mathematics into the curriculum of vocational agriculture, done at all, will likely result from teacher initiative. Is it reasonable to expect vocational agriculture teachers to be able to apply mathematics to agriculture related problems?

A number of studies have been conducted to

determine the mathematical problem-solving ability of high school and college students enrolled in agricultural mechanics courses (Gliem & Elliot, 1988; Gliem, Lichtensteiger & Hard, 1987; Gliem & Warmbrod, 1986). Findings have consistently revealed that the mathematical problem-solving ability of students is low. Only one study was identified that investigated the mathematical problem-solving ability of vocational agriculture teachers. Gliem and Persinger (1987) found that vocational agriculture teachers scored below an expected level of competence on a mathematical problem-solving test related to agricultural mechanics.

Purpose and Objectives

The purpose of this ex post facto study was to explain variance in the mathematical problem-solving ability of vocational agriculture teachers. The study was guided by the following research objectives and hypotheses.

Describe selected background characteristics of vocational agriculture teachers.

Describe vocational agriculture teachers' mathematical problem-solving ability.

Describe relationships between vocational agriculture teachers' mathematical problem-solving ability and selected variables.

Hypotheses

There will be a significant positive relationship between the number of college-level mathematics courses completed by vocational agriculture teachers and their mathematical problem-solving ability.

There will be a significant positive

relationship between vocational agriculture teachers' ACT math score and their mathematical problem-solving ability.

Procedures

Design

In order to test the research hypotheses, Campbell and Stanley's (1963) design three, the static group comparison, was utilized. The selection threat was controlled by identifying extraneous variables and accounting for them utilizing the procedure described by Warmbrod and Miller (1974). The following extraneous variables were controlled: age, years of teaching experience, highest level of mathematics coursework completed, final college GPA, and attitude toward including mathematics concepts in the curriculum and instruction of secondary agriculture programs. Three extraneous variables were held constant. All subjects used calculators, were male, and were allowed one hour to complete the questionnaire.

Population and Sample

The population consisted of all production agriculture teachers in Ohio (N=281). The Ohio Directory of Agricultural Education was used to develop a list of all production agriculture programs (N=255). Teachers from each program were invited to attend one of four sprayer calibration workshops held in different locations around the state. Questionnaires were administered during the workshops and background data were obtained from state teacher certification files and college of agriculture records. Teachers from 34 programs participated in the study for a 13.3 percent program participation rate and a nine percent teacher participation rate.

Teachers who participated in the study were compared to representatives sample of nonparticipants to determine if participants were similar to the population on background characteristics. Comparisons were made on the following characteristics: age, years of teaching experience, number of college mathematics courses completed, highest level of college mathematics coursework completed, ACT math score, and final college GPA. Only one significant difference was found. Participants had significantly higher final college GPA's than nonparticipants. Participants were similar to the population on background

characteristics, however, caution should be exercised in generalizing the results beyond the teachers studied.

Instrumentation

Agriculture teachers' mathematical problem-solving ability was measured by a test consisting of 15 open-ended mathematical word problems scored dichotomously (right or wrong). The test was developed from a review of literature on agriculture related mathematical word problems, and from contributions of experts in various departments in the College of Agriculture. Content and face validity were assessed by a panel of experts consisting of teacher educators in agriculture and mathematics. The problem-solving instrument was pilot tested with a group of 20 undergraduates enrolled in a Methods of Teaching Agriculture course. Cronbach's Alpha for the mathematical problem-solving test was .85.

The attitudinal instrument was composed of 15 Likert-type items with response categories ranging from strongly disagree (1) to strongly agree (5). Content and face validity were assessed by a panel of experts consisting of faculty and graduate students in the Department of Agricultural Education. The instrument was field tested with a group of 18 secondary agriculture teachers not included in the sample. Cronbach's Alpha was used to assess the reliability of the instrument and yielded a coefficient of .87.

Data Analysis

The data were analyzed using the SPSS/PC+ statistical package. The alpha level was set *a priori* at .05, and Davis' (1971) descriptors were used to interpret all correlation coefficients.

Results

All of the teachers participating in the study were male. Participants had a mean age of 38.24 years with a standard deviation of 8.86, and on average, had 12.71 years of teaching experience with a standard deviation of 7.55. Teachers had completed an average of 2.47 college mathematics courses, possessed a mean ACT math score of 24.27, and had an average final college GPA of 2.77. In regards to highest level of college mathematics coursework completed, 10 percent (3) completed basic math courses, 53.3 percent (16)

completed intermediate math courses, and 36.7 percent (11) completed advanced mathematics courses (From Table 3).

Agriculture teachers' scores on the 15-item mathematical problem-solving test ranged from a low of 4 (26.67%) to a high of 15 (100%). The distribution of scores on the mathematical problem-solving test was negatively skewed with a mean of 9.97 (66.47%) and a standard deviation of 2.96 (Table 1).

Table 1. Agriculture Teachers' Score on the Fifteen-Item Mathematical Problem-Solving Test

| Score | Frequency | Percent | Cumulative Percent |
|-------|-----------|---------|--------------------|
| 4-6 | 4 | 11.8 | 11.8 |
| 7-9 | 12 | 35.3 | 47.1 |
| 10-12 | 11 | 32.3 | 79.4 |
| 13-15 | 7 | 20.6 | 100.0 |

Mean = 9.97; Standard deviation = 2.96

Pearson correlations and multiple regression were utilized to describe the relationships between vocational agriculture teachers' mathematical problem-solving ability and selected variables. The relationships between teachers' problem-solving ability and age and years of teaching experience were low and positive. The relationship between teacher's problem-solving ability and highest level of college mathematics coursework completed, final college grade point average, and attitude toward including mathematics concepts in the curriculum and instruction of secondary agriculture programs were positive and moderate. The relationships between teachers' mathematical problem-solving ability and the following variables were statistically significant; years of teaching experience, final college grade point average, and attitude toward including mathematics concepts in the curriculum and instruction of secondary agriculture programs. (From Table 3)

Tests of Hypotheses

In order to test the research hypotheses, the procedure described by Warmbrod and Miller (1974) was used. According to Warmbrod and Miller, extraneous variables significantly related to both the dependent variable and the major independent variables pose a serious threat to the internal validity of the major hypotheses. None of

the extraneous variables were significantly related to the major independent variables (Table 2).

Table 2. Summary of Relationships Between Major Independent Variables and Extraneous Variables

| Extraneous variables | Number of Math ACT Courses Math | |
|------------------------------|---------------------------------|------|
| | | |
| Age | -.12 | .26 |
| Years of Teaching Experience | -.02 | .23 |
| Highest Level of Math | .29a | .05a |
| Final College GPA | -.25 | .04 |
| Attitude | -.01 | .17 |

^aMultiple R

The research hypothesis that the relationship between teachers' mathematical problem-solving ability and the number of college level mathematics courses completed would be significant and positive was rejected ($r = -.21, p > .05$) (Table 3).

The research hypothesis that the relationship between teachers' mathematical problem-solving ability and ACT math score would be significant and positive was accepted ($r = .67, p < .05$) (Table 3).

Conclusions

The relationship between the number of college level mathematics courses completed and agriculture teachers' mathematical problem-solving ability was negative and nonsignificant. This finding supports those of Hague and Phua (1990), Gliem and Elliot (1988), and Gliem, Lichtensteiger, and Hard (1987). On the other hand, several researchers (Gliem & Persinger, 1987; Gliem & Warmbrod, 1986; Van Blerkom, 1986) report positive relationships between mathematical problem-solving ability and the number of mathematics courses completed.

How students are taught mathematics in general and problem-solving specifically may have a greater influence on their mathematical problem-solving ability (Gliem & Elliot, 1988; Gliem, Lichtensteiger, & Hard, 1987; Polya, 1987; The Commission on Teaching Standards for School Mathematics, 1991).

Table 3. Summary of Relationships Between Major Independent Variables, Extraneous Variables, and Mathematical Problem-Solving Ability

| Variable | n | Mean | SD | Degree of Assn. |
|------------------------------|----|-------|------|------------------|
| <u>Major IV</u> | | | | |
| Math Courses | 30 | 2.47 | 1.33 | -.21 |
| ACT Math Score | 11 | 24.27 | 3.95 | .67* |
| <u>Extraneous Variables</u> | | | | |
| Age | 34 | 38.24 | 8.86 | .19 |
| Years of Teaching Experience | 34 | 12.71 | 7.55 | .29* |
| Final College GPA | 30 | 2.77 | .39 | .38* |
| Attitude ^a | 34 | 4.47 | .35 | .35* |
| Level of Math | 30 | | | .38 ^b |
| Basic | 3 | | | |
| Intermediate | 16 | | | |
| Advanced | 11 | | | |

* $p < .05$

^aBased on scale: 1=strongly disagree, 2= disagree, 3=undecided, 4=agree, 5=strongly agree.

^bMultiple R

Gliem and Warmbrod (1986) suggested that one strategy for improving the competence of prospective teachers in mathematical problem-solving would be to incorporate mathematical problem-solving as an integral part of agricultural engineering and agricultural mechanics courses that prospective teachers complete. Subsequent research by Gliem and Persinger (1987) revealed that teachers completing a course that utilized the "unit factor method" of solving problems scored significantly higher on a mathematical problem-solving test than teachers who did not complete such a course. Gliem, Lichtensteiger, and Hard (1987) concluded that students completing an applied mechanics course designed to increase students' problem-solving skills exhibited significantly greater competence in mathematical problem-solving ability after completing the course and retained their increased competence for at least six months.

The finding that ACT math score and mathematical problem-solving ability were significantly related supported findings of Gliem and Elliot (1988) and Gliem, Lichtensteiger, and Hard (1987). The association between ACT math score and mathematical problem-solving ability was

positive and substantial in all three investigations.

Agriculture teachers participating in the study tended to take more mathematics courses than was required for the bachelor's degree in agricultural education. More than one-third of the agriculture teachers took advanced mathematics courses in addition to or instead of basic or intermediate mathematics courses.

The highest level of mathematics coursework needed to correctly solve all of the problems included in the test was algebra. Agriculture teachers, on average, correctly solved 9.97 (66.47%) of the fifteen mathematical word problems. Agriculture teachers attained lower scores than would be expected of persons teaching secondary students how to solve agricultural related mathematics problems. It was concluded that the agriculture teachers studied were not proficient in solving agricultural related mathematics problems.

Although the magnitude of the relationship was low, teachers completing fewer mathematics courses tended to attain higher scores on the mathematical problem-solving test.

Teachers with higher ACT math scores tended to achieve higher scores on the mathematical problem-solving test.

Recommendations

Although the participants were not a probability sample of all production agriculture teachers in Ohio, the results support those of several other research studies. Based upon this study and other related research the following recommendations were made.

Findings of the current investigation suggest that more and higher levels of mathematics coursework are not positively related to teachers' mathematical problem-solving ability. How students are taught may be as important as how much they are taught. It is recommended that mathematical problem-solving be incorporated into technical agriculture courses taken by undergraduates in agricultural education.

Teacher educators and state supervisors of agricultural education in Ohio should jointly plan inservice education activities to improve the mathematical problem-solving ability of secondary

agriculture teachers. Inservice activities in mathematical problem-solving could be specifically targeted at applying mathematics to agricultural related problems or incorporated into workshops designed to address specific technical agriculture competencies.

Research has shown that secondary agriculture students lack competence in solving agricultural related mathematics problems. In order for agriculture students to become better mathematical problem-solvers, teachers must become better mathematical problem-solvers. Simply improving teachers' ability to apply mathematics to agricultural related problems will not fully address the issue. It is recommended that high quality instructional materials involving the application of mathematics to agriculture be developed cooperatively by teacher educators in mathematics and agriculture as well as secondary agriculture and mathematics teachers. Inservice education should be provided to agriculture teachers regarding ways to utilize these instructional materials in their agriculture programs.

Two indicators of academic ability (ACT math score, and final college grade point average) were significantly related to agriculture teachers' score on the mathematical problem-solving test. In light of current efforts to upgrade the academic content of secondary agriculture programs, persons with high scores on measures of academic ability should be recruited to fill future openings for secondary agriculture teaching positions.

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