The Problem Solving and Subject Matter Approaches to Teaching Vocational Agriculture: Effects on Student Achievement and Retention

Jim Flowers, Assistant Professor
Agricultural Education
North Carolina State University

Edward W. Osborne, Assistant Professor
Agricultural Education
University of Illinois

Accepted for Publication August 1987

Throughout the history of agricultural education, the problem solving approach has been recommended by agricultural teacher educators as the primary strategy for teaching. Several authors of agricultural education texts cite the problem solving approach as the most effective approach for teaching vocational agriculture (Binkley & Tulloch, 1981; Crunkilton & Krebs, 1982; Newcomb, McCracken & Warmbrod, 1986; Phipps, 1980).

Some agricultural educators have questioned the effectiveness of problem solving instruction, claiming that changes in vocational agriculture programs and in student backgrounds resulting from the expansion of vocational agriculture programs beyond agricultural production have reduced the effectiveness of the problem solving approach (Moore & Moore, 1984). Others have argued that problem solving instruction results in improved learning by students (Warmbrod, 1969) and increased retention of knowledge (Binkley & Tulloch, 1981; Bruner, 1961).

Little empirical evidence exists to support the problem solving approach to teaching vocational agriculture. Studies conducted by Thompson and Tom (1957) and Dawson (1956), which compared the problem solving approach with teacher-centered instructional approaches, found some advantages in increased student achievement In favor of problem solving instruction, but were conducted prior to the expansion of vocational agriculture programs resulting from the 1963 Vocational Education Act. If agricultural educators are to continue to promote problem solving as the most effective approach to teaching vocatlonal agriculture, there is a need to examine empirically the effectiveness of the problem solving approach in today's vocational agriculture classroom in terms of two of the most commonly accepted measures of teaching effectiveness--student achievement and retention of knowledge.

Purpose

The purpose of this study was to compare the effects on student achievement and retention between the problem solving approach and the subject matter approach in teaching a selected problem area in vocational agriculture. The following research hypotheses provided the framework for this study:

1. Students taught by the problem solving approach will earn higher scores on a problem area achievement test administered at the conclusion of the problem area than students taught by the subject matter approach.

2. The problem solving approach will result In higher student achievement scores for low level cognitive items and high level cognitive items than the subject matter approach.

3. Students taught by the problem solving approach will earn higher scores on a problem area retentfon test admfnfstered one week after the achievement test than students taught by the subject matter approach.

4. The problem solving approach will result in higher student retention of information for low level and high level cognitive items on the problem area retention test than the subject matter approach.

5. Students taught by the problem solving approach will exhibit less achievement loss, as measured by differences in scores for the achievement test and retention test, than students taught by the subject matter approach.

Procedures

Population and Sample

The population consisted of high school students enrolled in introductory vocational agriculture courses in Illinois. A cluster sampling technique was used to select a purposive sample from the target population. Only teachers who taught two or more introductory vocational agriculture classes and had prior knowledge and experience in using the problem solvlng approach were considered as possible participants In this study. In order to control for overall teaching ability, the teachers taught one class uslng the problem solving approach and one class using the subject matter approach.

Since this study was conducted using Intact groups, random assignment of students to treatments was not possible. A quasi-experimental design, a varlation of nonequivalent control group design, was used for this study. Using a formula suggested by Hays (1973), which incorporated the desired alpha level, power of the test, and effect size, a necessary sample size of 60 students in each group was determlned as appropr I ate. Thls sample size was based upon an alpha level of .05, a desired power of .90, and an effect size of .66 standard deviations.

Telephone interviews were conducted wlth 20 teachers who taught two or more introductory vocational agriculture classes to -determine thelr knowledge and use of the problem solvlng approach. A l 1st of steps involved in using the problem solving approach was used to determine if teachers were fami llar wlth all of the steps in using problem solving instruction. Four teachers who indicated during the interviews they used all of the steps in the problem solvlng approach were selected and agreed to participate. Treatments were randomly assigned to the classes, resulting in 68 students in the problem solving treatment group and 61 students in the subject matter treatment group. Due to absences during the testing period, data were collected from 66 students in the problem solving treatment group and 60 students in the subject matter treatment group.

I nstrumentat ion

Instruments developed by the researchers to measure the dependent variables consisted of a problem area achievement test and a parallel problem area retention test. Mehrens and Lehman (1973) described parallel tests as those with equa f content, constructed using the same specifications. of similar difficulty, and using the same format. Both instruments were constructed to i'ncfude both-high level and low level cognitive items. Content validity of the instruments was established by a panel of experts consisting of two members of the agrfculturaf education faculty at the University of Ill inois and two hlgh school

vocational agriculture teachers. The panel also evaluated the difficulty level of the Items on the instruments and determined that the tests were equal In content. In addition, student scores for both instruments in the pilot test were not significantly different. The university faculty members rated each item as either a low level or a high level cognitive item using the cognitive levels described by Bloom (1956). For this study, low level cognitive items were those which required knowledge and comprehension, and high level cognitive items required appl ication, analysis, synthesis, or evaluation. The Instruments were field tested and pilot tested for clarity and reliability using students In two vocational agriculture departments not participating in the study. The Kuder-Richardson 20 reliability coefficient for the revised student achievement instrument was .80, and a K-R 20 coefficient of .88 was calculated for the retention instrument. Reliability coefficients for the low level cognitive scale and high level cognitive scale on the achlevement and retention instruments ranged from .73 to .91.

Data Col lection

Prior to the beginning of the study, teachers who were selected to participate received inservice education on the proper use of the two teaching approaches. The problem solving approach was a student-centered instructional approach, while the subject matter approach in this study was a teacher-centered approach. While the problem solving approach focused instruction on problems and concerns raised by the students, the subject matter approach focused upon agricultural subject matter selected by the teacher. With the problem solving approach, emphasis was placed upon using informatlon to develop solutions to problems, while the subject matter approach emphasized learning agricultural facts. Specific teaching techni ques and learning activities to be used during the problem solution step (problem solving approach) and the presentation step (subject matter approach) were determined by the teachers.

The steps involved in the problem solving approach, as outlined in Crunkllton and Krebs (1982), i nc l uded conduct l ng an i nterest approach, developing student objectives for studying the problem area, identification of specific problems and concerns of students related to the problem area, developlng possible solutions to problems and concerns, drawing conclusions or summarizing the appropriate solutions, and student eval uation. The steps involved in the subject matter approach Included an introduction (in which the teacher presented the reasons for studying the problem area), presentation of subject matter, review of important points, and student evaluation.

Data were collected In all four schools between mid-April and early May of 1986. A problem area in corn production which required approximately 10 class periods of Instructional time was selected for this study, since corn production was included in the course of study for each of the schools selected. The problem area focused upon seedbed preparation and planting procedures for corn. Each class participating in the study was vi sited by the researcher during the study to observe the teaching approaches used and to verify that the proper treatments were being used In the assigned groups. The problem area achievement test was administered Immediately following the treatment, and the problem area retention test was administered one week following the achlevement test. In order to control for possible preexisting group differences, average grades for the first semester of vocational agriculture and student IQ scores were collected for each student to be used as covariate measures In the study.

Analysis of Data

For the purpose of statistical analysis, appropriate null hypotheses were developed for each research hypothesis and were tested at the .05 alpha level. Multivariate analysis of covariance (MANCOVA) techniques were used to examine the data, which allowed the two dependent variables to be examined simultaneously and took into account existing correlations between the variables. Hotelling's T^2 statistic was used to determine if differences existed between the two treatment groups with univariate analysis of covariance used as a follow-up procedure. The selection of covariate measures was supported by within group correlations computed for the covariate measures and student achievement and retention scores which indicated that the covariate measures were related to the major dependent variables. In addition, t-tests indicated significant differences between treatment groups for both average grade in vocational agriculture and student IQ, suggesting that analysis of covariance techniques were appropriate.

Results

A multivariate analysis of covariance was performed on student scores for the problem area achievement test and the problem area retention test. Hotelling's T^2 statistic was .041 [$F(2,121) = 2.50$, $p = .08$], indicating there was no difference at the .05 alpha level between the treatment groups when student achievement and student retention were considered simultaneously. In addition, univariate follow-up tests indicated no difference in student achievement or retention between the groups when cognitive levels of the items were considered. Therefore, the data did not support Research Hypotheses 1 through 4.

Findings Related to Student Achievement

Student achievement was measured by the number of correct responses on the 25-item problem area achievement test. Due to pre-treatment differences between the groups, the mean scores for student achievement were adjusted using the covariate measures. Summary statistics for student performance on the problem area achievement test which included 16 low level cognitive items and 9 high level cognitive items are presented in Table 1.

Table 1

Mean Student Achievement for Problem Area Achievement Test by Teaching Method

Teaching Method	n	Total Score		Low Level Items		High Level Items	
		Observed $\bar{x}$	Adj. $\bar{x}$	Observed $\bar{x}$	Adj. $\bar{x}$	Observed $\bar{x}$	Adj. $\bar{x}$
Problem Solving	66	13.59	13.13	9.55	9.20	4.05	3.92
Subject Matter	60	13.38	13.85	9.10	9.44	4.28	4.40

FIndIngs Related to Retention of Knowledge

Two measures of retention of acquired knowledge were used: (a) the number of correct responses on the 25-item problem area retention test and (b) achievement loss, or the difference between student scores on the achievement test and the parallel retention test. Student scores on the retention test were adjusted using the covarlate measures of average grade In vocatlonal agriculture and IQ scores. Summary statistics for student performance on the retention test are presented In Table 2.

Table 2

Mean Student Retention for Problem Area Retention Test by Teaching Method

Teach I ng Method	n	Total Score Observed $\bar{x}$	Total Score Adj. $\bar{x}$	Low Level I terns Observed $\bar{x}$	Low Level I terns Adj. $\bar{x}$	High Level Items Observed $\bar{x}$	High Level Items Adj. $\bar{x}$
Prob I em Solving	66	12.24	11.89	8.02	7.75	4.23	4.14
Subject Matter	60	10.90	11.25	7.27	7.53	3.63	3.73

As shown in Tables 1 and 2, students In the subject matter treatment group had sl ightl y h lgher adj usted mean scores on the ach levement test than students In the problem solvlng treatment group. However, the reverse was found for the retention test, with students In the problem solvlng group earnlng hlgher adjusted mean scores than students in the subject matter treatment group. While the differences between the groups were not significant for either achievement or retention, this reversal indicated a lower achievement loss for students in the problem solving treatment group (see Table 3).

Table 3

Mean Student Achievement Loss by Teaching Method

Teaching Method	n	Tota l Achievement Loss	Achievement Loss for Low Level Items	Achievement Loss for High Level Items
Problem Solving	66	-1 .24	-1.45	+0.21
Subject Matter	60	-2.60	-1.91	-0.67

Note. Mean student achievement loss was calculated from mean scores adjusted for covarlate measures. Negatlve values Indlcate achievement loss. Posltlve values Indlcate achievement gain.

Because of th is reversal in scores, an exploratory analysis of variance was performed for achievement loss on the adjusted mean scores for the two groups to determ ine I f the difference in achievement loss was statistically significant (see Table 4). When the total test scores were considered, there was a significant difference In achievement loss in favor of the problem solving treatment group. Research Hypothesis 5 was supported by the data, and the hypothesis of no difference In achievement loss between students taught by the problem solving approach and students taught by the subject matter approach was rejected.

Table 4

ANCOVA Summary Table for Achievement Loss

Source of Variation	SS	df	MS	F
Covariates	13.33	2	6.67	0.54
Average Grade	5.62	1	5.62	0.46
IQ	1 .II	1	1.11	0.09
Teach ng method	54.60	1	54.60	4.40*
Residual (error)	1500.52	122	12.30	
Total	1568.44	125		

*$p < .05$.

In order to examine the nature of the difference I n achievement loss between the two treatment groups, further analysis was performed on achievement loss for the two cognitive levels of the Items. For low level cognitive items, achievement loss for the problem solving group was slightly lower, but not significantly lower, than for the subject matter group [F (1,222) = 0.84, p = .36]. The sub-hypothesis of no difference in achievement loss for lower level cognitive Items was not rej ected.

However, for hlgh level cognltlve items, students in the problem solving treatment group scored slightly higher on the retention test, resulting in an achievement gain, while students in the subject matter group experienced an achievement loss. An analysis of covariance was performed to determine the signif icance of the difference between the treatment groups. The F test Indicated a significant difference between the treatment groups (see Table 5), indicating that for high level cognitive items, students taught by the problem solving approach had less achievement loss than students taught by the subject matter approach. Therefore, the data supported the sub-hypothesis associated w i th Research Hypothesi s 5, and the hypothesis of no difference between treatment groups for achievement loss for high level cognltlve items was rej ected .

Table 5

ANCOVA Summary Table for Achievement Loss for High Level Items

Source of Variation	SS	df	MS	F
Covariates	5.69	2	2.85	0.82
Average grade	3.82	1	3.82	1.10
IQ	4.88	1	4.88	1.40
Teaching method	23.59	1	23.59	6.79**
Residual (error)	423.94	122	12.30	
Total	453.21	125		

**$p < .01$.

Conclusions

The conclusions drawn from this study were limited to the extent that the sample was not randomly selected from the population. Therefore, the conclusions are generallzable to the extent that the sample was representative of the population of students enrolled in Introductory vocatlonal agriculture courses In Illinois.

The problem solvlng approach Is no more or less effectlve than the subject matter approach as measured by student achievement, regardless of the cognitive level of the questlons.

The problem solvlng approach Is no more or less effective than the subject matter approach in producing hlgher scores on the delayed retention test, regardless of the cognltlve level of the questlons.

For hlgh level cognltlve items, students taught by the problem solving approach exhlblt lower achievement loss than students taught by the subject matter approach.

Recommendations

Because of the slight advantage of the problem solving approach In the area of student retention of knowledge, the problem solving approach may be used wlth confidence to teach Introductory vocational agriculture courses.

Studies of similar purpose and deslgn with a varlety of problem areas and students from both rural and urban backgrounds should be conducted In vocational agrlculture classrooms to Increase the generalizability of the flndlngs of this study.

Additional studles shou Id be conducted to determl ne the effect of the problem solving approach on retention over longer periods of time.

Studies involving students In vocational agriculture courses should be conducted to determine the effectiveness of problem solving instructlon in Improving problem solvlng and decision maklng skills.

(Continued on page 52)