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EFFECT OF LEVEL OF PROBLEM SOLVING APPROACH TO TEACHING ON STUDENT ACHIEVEMENT AND RETENTION

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The problem solving approach to teaching has been widely accepted as the way to teach vocational agriculture. Few critics have expressed any opposition to the effectiveness of the problem solving approach on student achievement. Proponents of the problem solving approach to teaching give numerous arguments for its continued use in teaching high school vocational agriculture students. Variations of the problem solving approach have been recommended by agricultural educators since the beginning of agricultural education (Binkley and Tulloch, 1981; Crunkilton and Krebs, 1982; Hammonds, 1950; Krebs, 1967; Lancelot, 1944; Newcomb, McCracken and Warmbrod, 1986; and Stewart. 1950).

The problem solving approach has acceptance among the agricultural education profession but, have researchers confirmed the effectiveness of the problem solving teaching approach through an extensive research effort? Kirts (1983) found that student teachers of vocational agriculture who used the problem solving teaching approach asked more higher level questions, more lower level questions, and fewer procedural questions than teachers and student teachers not using the problem solving approach. Chuatong (1986) concluded that most junior and senior horticulture students do not demonstrate a very high level of problem solving activity. Flowers (1986) discovered a significant difference between students taught by the problem solving approach and students taught the subject matter approach on student achievement, retention test scores, and student attitudes toward the teaching method. For high level cognitive items, students taught by the problem solving approach exhibited lower achievement loss than students taught by the subject matter approach. Boone (1988) found that students taught with the problem solving approach first in an instructional series had higher achievement scores than students taught first with a subject matter approach. Students taught with a subject matter approach second in an instructional series had higher achievement scores than students taught second with a problem solving approach. The literature yields little evidence to support the effectiveness of the problem solving approach.

Even though little evidence was found concerning the effectiveness of the problem solving approach, there was evidence that supported individual components of the problem solving approach. Flanders (1966) recommended that instruments be developed whereby teacher behaviors could be observed and recorded and resultant patterns compared with student gain. Biddle (1964) suggested that there was a relationship between teacher classroom behavior and teacher effects. Rosenshine and Furst (1971) found a relationship between student learning and the teacher providing the opportunity for the student to learn criterion material. Stallings (Brophy and Good, 1985) concluded that pupil achievement was related to the time students were instructed by the teacher or worked independently under close teacher supervision.

Many researchers have discovered evidence that supports individual components of the problem solving approach. The agricultural education profession must continue to pursue evidence that confirms the effectiveness of the problem solving approach in teaching high school vocational agriculture students.

Purpose and Objectives

The problem was to determine the relationship between the level to which vocational agriculture teachers use the problem solving approach to teaching and student achievement and retention of agricultural knowledge. The study was designed to determine if student achievement and retention of knowledge increased with the degree to which the vocational agriculture teacher used the problem solving approach. The problem solving approach to teaching is a student-centered approach where the central and essential characteristic is solving problems (Binkley and Tulloch, 1981). Students participate in the learning process by contributing problems, analyzing the factors associated with the problems, developing possible solutions to the problems, placing the solution(s) into action, and evaluating the results of the solution. The level of the teacher application of the problem solving approach is based upon how effectively the teacher uses the essential elements of the problem solving approach (Boone, 1988).

The objectives are presented in the research questions:

1. Will an increased level of teacher use of the problem solving approach result in higher student achievement scores on a given unit of instruction in vocational education?

2. How will the level of teacher use of the problem solving approach affect student retention of agricultural knowledge from a given unit of instruction in vocational agriculture?

Procedures

The accessible population was 121 freshman students enrolled in production agriculture in seven Ohio comprehensive high schools. Usable data was collected from 99 freshman students and six vocational agriculture teachers. Teachers were purposefully selected for their ability to use the problem solving approach to teaching by a panel of experts from The Ohio State University's Agricultural Education Department and the Supervisors of the Ohio Department of Education, Vocational Agriculture Service.

A variation of the non-equivalent control group design was used in the study. Each teacher taught two instructional units. One unit was taught by a problem solving approach and the second unit was taught using a subject matter approach. Each unit contained an equal amount of instructional material. the only differences were related to the two teaching approaches. The topic of the unit (Preparing Beef Cattle for Show and Controlling Weeds in Corn), the timing of the unit (first or second in the instructional series), and the approach to teaching (subject matter or problem solving) were randomly assigned to the teacher. Instruction on both units was audio taped to verify the administration of the experimental levels of the treatment.

Data were collected using a forty question achievement test (Beef Unit Knowledge Test and Weed Unit Knowledge Test) and a fourteen item teaching approach evaluation instrument (Teaching Approach Instrument). The forty questions were arranged in different ways to produce three identical forms of the exam for each instructional unit. The three forms were used as a pretest, posttest #1 and posttest #2. Reliability of the instruments was established with a Cronbach's Alpha of .76, .82, and .96 for the Beef Unit Knowledge Test, Weed Unit Knowledge Test, and Teaching Approach Instrument respectively. Content validity of the instruments was established by a panel of experts consisting of faculty and graduate students in The Ohio State University's Department of Agricultural Education.

Data analysis for student achievement and student knowledge retention was accomplished using multiple regression procedures. Independent variables were Teaching Approach Score (level of the problem solving approach utilized), and timing (first or second) of the unit in the instructional series. The dependent variables were student retention and student achievement.

Results

Each teacher was requested to audio tape all instruction conducted for the study. The audio tapes were analyzed and given an adjusted teaching method score (Boone, 1988). An adjusted score could range from one to seven. A one represented the absence of problem solving in the instructional approach while a seven indicated all ten essential elements of the problem solving approach were present (Boone, 1988).

The pretest, posttest #1 and posttest #2 instruments were scored. A forty was the maximum score on the three instruments. The difference between the score on the pretest and the score on posttest #1 was labeled student achievement. Student retention was measured as the difference between posttest #1 and posttest #2. The variables timing of the instructional unit, approach to teaching, and teachers in the study were dummy coded for the regression procedure. Timing of the instructional unit was coded first in the instructional series and second in the instructional series. Approach to teaching was coded problem solving approach and subject matter approach. The individual teachers in the study were coded teacher1, 2, 3, 6, 7, and 8.

Student Achievement on Beef Instructional Unit: The average pretest score for the Preparing Beef Cattle for Show instructional unit was 20.96 with a standard deviation of 4.31 (Table 1). Students' achievement averaged 5.76 points with a standard deviation of 5.336. Three variables, pretest, teacher2, and teacher7, entered in the stepwise multiple regression procedure (Table 2).

Table 1

Summary Data: Regression of Student Achievement on Selected Variables for the "Preparing Beef Cattle for Show" Instructional Unit

Variable	Intercorrelations														
	X1	X2	X3	X4	X5	X6	X7	X8	X9	X10	X11	X12	Y	Mean	SD
*Teacher1 (X1)	1.000	-.128	-.080	-.192	-.070	-.132	-.232	.232	-.336	.336	.259	.145	-.060	.061	.240
*Teacher2 (X2)		1.000	-.159	-.380	-.139	-.261	-.459	.459	.380	-.380	-.060	.041	-.338	.202	.404
*Teacher3 (X3)			1.000	-.239	-.087	-.164	.346	-.346	-.418	.418	.192	-.699	-.005	.091	.289
*Teacher6 (X4)				1.000	-.209	-.392	.828	-.828	.571	-.571	-.076	.399	.249	.364	.483
*Teacher7 (X5)					1.000	-.143	-.252	.252	.209	-.209	.049	-.628	-.136	.071	.258
*Teacher8 (X6)						1.000	-.474	.474	-.686	.686	-.168	.291	.164	.212	.411
*Timing First (X7)							1.000	-1.000	.311	-.311	.037	-.018	.237	.455	.500
*Timing Second (X8)								1.000	-.311	.311	-.037	.018	-.237	.545	.500
*Problem Solving (X9)									1.000	-1.000	-.100	.098	-.106	.636	.483
*Subject Matter (X10)										1.000	.100	-.098	.106	.364	.483
Pretest (X11)											1.000	-.175	-.504	20.960	4.305
Level of Problem Solving (X12)												1.000	.164	3.218	.899
Student Achievement (Y)													1.000	5.728	5.326

Note. *Variables dummy coded

Teacher 1,2,3,6,7,8	Dummy coded variables for Teachers in Study
Timing First	Dummy coded variable for first in Instructional Series
Timing Second	Dummy coded variable for second in Instructional Series
Problem Solving	Dummy coded variable for Problem Solving Approach
Subject Matter	Dummy coded variable for Subject Matter Approach

Table 2
Regression of Student Achievement on Selected Variables for the "Preparing Beef Cattle for Show" Instructional Unit (Stepwise Entry of Independent Variables)

Step	Variable	R^2	F Equat.	F Sig.	R^2 Change	F Change	Sig. Change	B
1	Pretest	.25382	32.995	.001	.2538	32.995	.001	-.64247
2	Teacher2	.38969	30.648	.001	.1359	21.372	.001	-5.1712
3	Teacher7	.41642	22.596	.001	.0267	4.352	.040	-3.4161
	CONSTANT							20.5097

The linear combination of the independent variables, pretest, teacher2, and teacher7 explained 42% of the variance in the dependent variable student achievement. The R2 of .42 was significant at an alpha level of .002. The partial regression coefficient for the independent variable, pretest, indicates that for one unit of change for pretest, the researcher could expect a -.64247 unit change in student achievement when all other variables in the study are controlled. The partial regression coefficients for the dummy coded variables, teacher2 and teacher7, were also significant at a .001 and .04 level respectively.

Student Achievement on Weed Instructional Unit: The average pretest score for the Controlling Weeds in Corn instructional unit was 19.75 with a standard deviation of 5.23 (Table 3). Students' achievement averaged 5.935 points with a standard deviation of 5.76.

The variable, pretest, entered in the stepwise multiple regression procedure (Table 4). The independent variable, pretest, explained 19% of the variance in the dependent variable student achievement. The R^2 of .19 was significant at an alpha level of .001. The partial regression coefficient for the independent variable, pretest, indicates that for one unit of change in the pretest, the researcher could expect a -.48496 unit change in student achievement when all other variables in the study are controlled.

Table 4
Regression of Student Achievement on Selected Variables for the "Controlling Weeds in Corn" Instructional Unit (Stepwise Entry of Independent Variables)

Step	Variable	R^2	F Equat.	F Sig.	R^2 Change	F Change	Sig. Change	B
1	Pretest	.1942	24.830	.001	.1942	24.830	.001	-.48496
	CONSTANT							15.5029

Student Retention on Beef and Weed Instructional Units: The average retention score for the Preparing Beef Cattle for Show instructional unit was -1.54 with a standard deviation of 5.97 (Table 5). The average retention score for the Controlling Weeds in Corn instructional unit was -2.76 with a standard deviation of 7.11 (Table 6).

No variables entered the stepwise multiple regression procedure for the regression of student retention on selected variables associated with the Preparing Beef Cattle for Show instructional unit. The variable, problem solving approach, entered the stepwise multiple regression procedure for the regression of student retention on selected variables associated with the Controlling Weeds in Corn instructional unit (Table 7).

The independent variable, problem solving approach, explained 9% of the variance in the dependent variable student retention. The R2 of .09 was significant at an alpha level of .003. The partial regression coefficient for the independent variable, problem solving approach, was significant at an alpha level of .003.

Table 3

Summary Data: Regression of Student Achievement on Selected Variables for the "Controlling Weeds in Corn" Instructional Unit

Variable	Intercorrelations														
	X1	X2	X3	X4	X5	X6	X7	X8	X9	X10	X11	X12	Y	Mean	SD
*Teacher1 (X1)	1.000	-.163	-.129	-.259	-.103	-.169	.330	-.330	.431	-.431	.236	.166	-.152	.114	.320
*Teacher2 (X2)		1.000	-.163	-.329	-.131	-.214	.417	-.417	-.379	.379	-.197	-.068	-.069	.171	.379
*Teacher3 (X3)			1.000	-.259	-.103	-.169	-.391	.391	.431	-.431	-.127	-.499	.125	.114	.320
*Teacher6 (X4)				1.000	-.207	-.340	-.787	.787	-.602	.602	-.262	.327	.223	.343	.477
*Teacher7 (X5)					1.000	-.135	.264	-.264	-.239	.239	.172	-.745	-.002	.076	.267
*Teacher8 (X6)						1.000	.431	-.431	.564	-.564	.307	.452	-.184	.181	.387
*Timing First (X7)							1.000	-1.000	.298	-.298	.331	.007	-.293	.543	.501
*Timing Second (X8)								1.000	-.298	.298	-.331	-.007	.293	.457	.501
*Problem Solving (X9)									1.000	-1.000	.311	.139	-.161	.410	.494
*Subject Matter (X10)										1.000	-.311	-.139	.161	.590	.494
Pretest (X11)											1.000	.041	-.441	19.752	5.231
Level of Problem Solving (X12)												1.000	-.092	4.452	1.282
Student Achievement (Y)													1.000	5.924	5.756

Note. *Variables dummy coded

Teacher 1,2,3,6,7,8	Dummy coded variables for Teachers in Study
Timing First	Dummy coded variable for first in Instructional Series
Timing Second	Dummy coded variable for second in Instructional Series
Problem Solving	Dummy coded variable for Problem Solving Approach
Subject Matter	Dummy coded variable for Subject Matter Approach

Table 5

Summary Data: Regression of Student Retention on Selected Variables for the "Preparing Beef Cattle for Show" Instructional Unit

Variable	Intercorrelations														
	X1	X2	X3	X4	X5	X6	X7	X8	X9	X10	X11	X12	Y	Mean	SD
*Teacher1 (X1)	1.000	-.131	-.085	-.206	-.074	-.123	-.250	.250	-.363	.363	.256	.153	.009	.064	.246
*Teacher2 (X2)		1.000	-.164	-.397	-.143	-.236	-.482	.482	.362	-.362	-.047	.052	-.052	.202	.404
*Teacher3 (X3)			1.000	-.256	-.092	-.153	.340	-.340	-.453	.453	.183	-.698	.011	.096	.296
*Teacher6 (X4)				1.000	-.223	-.370	.822	-.822	.566	-.566	-.122	.427	-.013	.383	.489
*Teacher7 (X5)					1.000	-.133	-.272	.272	.204	-.204	.036	-.627	.012	.074	.264
*Teacher8 (X6)						1.000	-.450	.450	-.654	.654	-.125	.270	.048	.181	.387
*Timing First (X7)							1.000	-1.000	.284	-.284	-.011	.005	-.006	.479	.502
*Timing Second (X8)								1.000	-.284	.284	.011	-.005	.006	.521	.502
*Problem Solving (X9)									1.000	-1.000	-.145	.135	-.050	.660	.476
*Subject Matter (X10)										1.000	.145	-.135	.050	.340	.476
Pretest (X11)											1.000	-.161	.028	21.181	4.250
Level of Problem Solving (X12)												1.000	-.008	3.196	.917
Student Achievement (Y)													1.000	-1.543	5.974

Note. *Variables dummy coded

Teacher 1,2,3,6,7,8	Dummy coded variables for Teachers in Study
Timing First	Dummy coded variable for first in Instructional Series
Timing Second	Dummy coded variable for second in Instructional Series
Problem Solving	Dummy coded variable for Problem Solving Approach
Subject Matter	Dummy coded variable for Subject Matter Approach

Table 6

Summary Data: Regression of Student Retention on Selected Variables for the "Controlling Weeds in Corn" Instructional Unit

Variable	Intercorrelations														
	X1	X2	X3	X4	X5	X6	X7	X8	X9	X10	X11	X12	Y	Mean	SD
*Teacher1 (X1)	1.000	-.163	-.126	-.265	-.106	-.157	.334	-.334	.447	-.447	.261	.171	.180	.112	.317
*Teacher2 (X2)		1.000	-.163	-.341	-.137	-.202	.431	-.431	-.365	.365	-.170	-.058	-.171	.173	.381
*Teacher3 (X3)			1.000	-.265	-.106	-.157	-.378	.378	.447	-.447	-.144	-.481	-.012	.112	.317
*Teacher6 (X4)				1.000	-.222	-.329	-.792	.792	-.593	.593	-.284	.352	-.232	.357	.482
*Teacher7 (X5)					1.000	-.132	.280	-.280	-.237	.237	.175	-.760	.111	.082	.275
*Teacher8 (X6)						1.000	.415	-.415	.555	-.555	.312	.431	.251	.163	.372
*Timing First (X7)							1.000	-1.000	.287	-.287	.364	-.033	.231	.531	.502
*Timing Second (X8)								1.000	-.287	.287	-.364	.033	-.231	.469	.502
*Problem Solving (X9)									1.000	-1.000	.312	.126	.299	.388	.490
*Subject Matter (X10)										1.000	-.312	-.126	-.299	.612	.490
Pretest (X11)											1.000	.035	.197	19.776	5.294
Level of Problem Solving (X12)												1.000	.001	4.422	1.294
Student Achievement (Y)													1.000	-2.765	7.110

Note. *Variables dummy coded

Teacher 1,2,3,6,7,8	Dummy coded variables for Teachers in Study
Timing First	Dummy coded variable for first in Instructional Series
Timing Second	Dummy coded variable for second in Instructional Series
Problem Solving	Dummy coded variable for Problem Solving Approach
Subject Matter	Dummy coded variable for Subject Matter Approach

Table 7
Regression of Student Retention on Selected Variables for the "Controlling Weeds in Corn" Instructional Unit (Stepwise Entry of Independent Variables)

Step	Variable	R^2	F Equat.	F Sig.	R^2 Change	F Change	Sig. Change	B
1	Prob Solving	.0896	9.444	.003	.0896	9.444	.003	4.34474
	CONSTANT							-4.4500

Conclusions and Discussion

The problem solving approach to teaching increases the level of student retention of agricultural knowledge learned during an instructional unit in vocational agriculture.

Student achievement on an instructional unit in vocational agriculture is affected by their knowledge of the subject prior to studying the unit. Individual teacher characteristics play a role in student achievement on vocational agriculture instructional units.

Two of the conclusions reached were the effect of previous student knowledge and the characteristics of individual teachers on student achievement. Even with the selection of outstanding teachers, a significant amount of the variance in student achievement could be explained by characteristics of two teachers.

A major finding was the effect of the problem solving approach on increasing the amount of knowledge students retain from instructional units in vocational agriculture. The problem solving approach offers students the opportunity to solve real problems as a part of their classroom instruction. When students solve real problems, use the scientific method to reason through a problem solution, test potential problem solutions, and evaluate the results of the solution, retention of knowledge learned through this activity has to be increased.

Recommendations

The effect of the problem solving approach on student achievement and retention must continue to be studied. Every effort must be made to reduce individual teacher effect as a contaminating variable, while maximizing the variance in the levels of the independent variable teaching approach. This will be reflected in the variance of the variable, adjusted teaching approach score.

Participants in this type of study should be monitored carefully with audio or video tape. This is important in determining if the levels of the independent variable are administered properly and in calculating the adjusted teaching approach score.

Teachers who participate must be carefully instructed on how units are to be taught and given assistance on how individual components of the instructional units are to be presented.

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