A Problem-oriented Approach to Teaching Agriscience Compared with Lecture and Study Questions: Effects on Achievement and Attitude of High School Students

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Abstract

The agricultural education profession has long advocated the problem-solving approach to teaching as superior in producing student learning and positive attitudes toward learning. This study compared the effects on both student cognitive achievement and attitude toward the subject matter of a problem-oriented approach to teaching agriscience with a lecture-and-study questions approach. The subjects in this study were high school students in two agricultural education programs in Arkansas during Spring of 2000. The study utilized a non-equivalent control group design, with a pre-test, an immediate and a delayed post-test, and an internal replication. Two different lessons in the agricultural sciences were taught. No statistically significant differences were found between the treatments on either the immediate or the delayed subject-matter post-tests for either subject matter lesson. Additionally, no significant differences were found in student attitudes toward the subject matter as a result of the treatments. Based on these results, the problem-solving and traditional approaches to teaching appeared to be equally effective in promoting student learning and attitudes toward the subject matter.

Introduction/Theoretical Framework

Teachers of agricultural science and technology possess a love for their subject matter. They often assume that their students share the same enthusiasm for agriculture and learning about it. When students exhibit behaviors and attitudes about learning which are not at the same level as that of the teacher, the teacher may react by believing that the students have little interest in the subject. However, students' negative attitudes toward learning may be related to the method of instruction. A study comparing hands-on activities versus worksheets in reinforcing instruction in agriscience (Johnson, Wardlow & Frankin, 1997) found that student attitudes toward learning were significantly enhanced by participating in hands-on learning activities compared with learning by using worksheets.

High school students may not share an enjoyment for learning just to possess more knowledge, as the adult teacher does. If students see learning as knowing an answer and remembering it for a multiple choice test, then they will surely lose interest in learning (Bracey, 1998). Therefore, it is absolutely necessary that adults who educate adolescents understand the limitations that they put upon themselves and their students by adhering to traditional methods of teaching. Teachers should create an environment in which learning takes place by the action of the learner.

Gerald Bracey (1998) stated that teachers have profoundly held ideas about the way children learn and that these ideas are incredibly resistant to change; and they are wrong. Children bring to the classroom their own profoundly held ideas about how the world works. These ideas are also resistant to change and teachers need to change them (Bracey, 1998). Encouraging students to remain in a passive role in the classroom has further unfortunate effects such as promoting rote learning, obscuring the differences between high school and college thinking and riveting intellectually immature students to a naive view of knowledge and its acquisition (Allen, Duch & Groh, 1996). If teachers continue to present information to students only with the motivation to earn a passing grade, these learners will not realize the value of education and will continue to function in this inactive learning mode throughout all of their intellectual growth. They will continue to see knowledge and its acquisition as only an end, not as a beginning to self-improvement.

To assess the progress and success of students, educators have relied too heavily on the memorization of others' answers to inquiries and their methods of discovering those answers. Over one half century ago, John Dewey was convinced that education had failed because it tried to get students to learn solutions rather than to investigate the problems and engage in inquiry for themselves (Lipman, 1991). The structure of traditional education, with teachers as lecturers bestowing information upon bound classes of stoic learners, erects numerous roadblocks to students becoming actively involved in their own learning (Allen, Duch & Groh, 1996). The roadblock is that students are not able to create a sense of ownership for their learning because they must keep it structured to the instructor's preferences. In reality, each student has a different strategy for learning (Sankaran & Bui, 2000). Some strategies may fit an instructor's preferences; some may not. Therefore, instructors must provide the opportunity for students to explore information and learn it in their own way.

According to Barr and Tagg (1995) two different types of teaching behaviors exist and two different types of student learning strategies exist. They wrote that teachers educate from either an *instructional paradigm* that focuses on what the teacher does in the classroom or from a *learning paradigm* that focuses on whether and how students learn rather that teacher behavior. Most teachers teach from the instructional paradigm that is less concerned with how students learn and more about the teacher's actions (Lasley, 1998). Learning strategies refer to the different activities that students apply and by which learning is achieved (Sankaran & Bui, 2000).

Two different types of learning strategies have been proposed: deep, to satisfy curiosity and to understand the meaning of a task by an in-depth study of a subject, and surface, which is just to satisfy requirements by memorizing facts well enough to earn a good grade without fully mastering the material (Sankaran & Bui, 2000). For teachers to foster the deep learning strategy they must teach outside of the instructional paradigm. In other words, teachers must present information in a way that encourages students to seek their own answers using their own strategies. Gallagher and Stepien (1996) wrote that instruction which fosters higher order thinking can result in learners who can construct meaningful connections between meaningful pieces of information, transfer information to new settings, and are motivated to learn. By teaching students how to think and learn independently, teachers increase their power to think and to learn outside of the classroom (Kahler, Miller & Rollins, 1988).

These statements support the need for a teaching method that is different from the traditional methods of lecture and rote memorization still used today by teachers who view education from the instructional paradigm and by students who use surface learning strategies. The method needed involves problem-solving by directed inquiry.

If a goal is to have more students eventually choosing careers in agriculture, they must see that their learning is relevant to that work. Bruner (1973) explained that if students are going to master culturally relevant skills, they must see education as a process that is relevant to achieving. It is through the exercise of problem-solving and discovery that a student learns the working heuristics of discovery; and the more a student practices these skills, the more likely that student is to generalize what s/he has learned into a style of problem-solving or inquiry that serves for any kind of task that he may encounter.

The problem-oriented approach has been used as an educational tool for many years. Educators such as John Dewey proposed it nearly a century ago. According to Barrow (1996), problem-based learning was reintroduced into medical education in the 1960s to better prepare physicians for the demands of professional practice.

There is opposition to the use of the problem-oriented approach as a method of education. Critics of the problem-solving approach say that while the approach has a sound theoretical base, it has been accepted with very little empirical evidence to either defend or reject its usefulness in the classroom (Dyer & Osborne, 1999). Additionally, Dyer and Osborne (1999) found that problem-solving instruction might not fit the learning style of some students. In fact, abstract learners may not recognize problems as such when presented to them.

Problem-solving instruction may be an effective instructional alternative, but little empirical evidence from school settings currently exists concerning teaching for knowledge acquisition using this approach. However, a study of agriculture students from Illinois which compared the effects of the problem-solving approach to the subject matter approach found the problem-solving approach to be no more or less effective in producing student achievement or knowledge retention (Flowers & Osborne, 1988). Flowers (1986) reported no significant differences in the short-term retention of subject matter when the problem-solving approach was compared to the subject matter approach. The problem-solving approach was, however, effective in reducing achievement loss when compared to the subject matter approach (Dyer & Osborne, 1999).

Purpose of the Study

The purpose of this study was to compare the effects on both student cognitive achievement and attitudes toward the subject matter of a problem-oriented approach to teaching agriscience with a lecture-and-study questions approach. The following null hypotheses were tested at the 0.10 alpha level:

1. In an animal diseases instructional unit, there will be no significant differences on either immediate or delayed cognitive achievement post-test scores, nor on students' attitudes toward the subject matter, between students completing a problem-solving instructional activity and students completing a lecture-and-study questions activity.

2. In a plant poisons instructional unit, there will be no significant differences on either immediate or delayed cognitive achievement post-test scores, nor on students' attitudes toward the subject matter, between students completing a problem-solving instructional activity and students completing a lecture-and-study questions activity.

Methods

This was a field-based study using high school students enrolled in agriculture courses. Such a study has limitations with regard to the possibility of non-equivalent groups, subject mortality, as well as the necessary use of teacher-made tests based on the specific subject matter being taught. Given those limitations the study was conducted using the non-equivalent control group design, as described by Campbell and Stanley (1968), with an internal replication. The internal replication was to control for the potential error associated with potentially non-equivalent groups.

The subjects in this study were high school students in two agricultural education programs in Arkansas during the spring term of 2000. An intact animal science class from each program was assigned to either the treatment group or the control group. The treatment consisted of a lesson taught using a problem-oriented approach to teaching and learning about animal diseases. The control group received the same lesson taught using traditional lecture and study questions. Upon the conclusion of the first treatment and testing, the two groups were reversed and a lesson was taught about poisonous plants. The control group from the previous lesson received the experimental treatment, the problem-oriented approach. The group receiving the experimental treatment from the animal diseases lesson received the traditional lecture and study question method for poisonous plants lesson. For each lesson, each group received a pretest, a post-test, and a two-week delayed post-test based on the subject matter being taught. Each group also completed a post-test instrument to assess their attitudes toward the subject matter.

The use of intact classrooms poses a risk of error of non-equivalence. However, when conducting research with high school teachers and their students, it becomes difficult to randomly assign subjects to treatments. Thus, to determine whether the groups were equivalent, pretests were given for both lessons and pretest scores were compared to determine if significant differences existed.

Equivalent detailed lesson plans were written for both the experimental and control groups, and for both of the subject matter areas. These lesson plans were reviewed by the panel of experts and revised to insure equivalency between treatments. Prior to their use, the lesson plans were reviewed by the teachers who implemented them to insure that they were administered to all students in the same manner.

The instruments consisted of teacher-made subject matter mastery tests based on the learner objectives identified in the detailed written lesson plans. These instruments were comprised of 22 to 35 objective questions for which student responses were recorded as either correct or incorrect. The instruments were reviewed and evaluated by a panel of experts to ensure content validity. This panel included university animal science faculty members, university agricultural education faculty members, and high school agriculture teachers. The Kuder-Richardson (KR-20) reliability coefficients were calculated to assess the internal consistency of the subject matter instruments. Student attitudes toward the subject matter were measured using modified versions of the Attitude Toward Any School Subject instrument (Purdue Research Foundation, 1986). Each instrument consisted of 20 attitudinal statements concerning the subject matter to which students responded using a 1 to 7 response scale (1 = strongly disagree; 7 = strongly agree). Coefficient alpha reliability estimates were calculated for each instrument in the study.

Results

For the teacher-made tests for both lessons, which were based on the objectives of each of the lessons, Kuder-Richardson 20 reliability coefficients were calculated to determine internal consistency. While the tests were designed to be equivalent forms of teacher-made assessment devices, differences did exist. Thus, KR-20 coefficients were calculated for each instrument. The results are presented in Table 1. Internal consistency estimates of the instruments used to assess attitude toward the subject matter were calculated using Cronbach's alpha. These values were 0.85 for the animal diseases instrument and 0.71 for the poisonous plants instrument.

Table 1. KR-20 Internal Consistency Estimates of Teacher-Made Subject-Matter Instruments

Instrument	Administration	KR-20
Animal Diseases	Pretest	0.50
Animal Diseases	Post-test	0.88
Animal Diseases	Delayed Post-test	0.78
Poisonous Plants	Pretest	0.54
Poisonous Plants	Post-test	0.17
Poisonous Plants	Delayed Post-test	0.46

Animal diseases lesson. To determine if differences existed between the experimental and control groups on the animal diseases lesson, t-tests were utilized at an a priori alpha level of 0.10. T-tests were deemed appropriate rather than analysis of co-variance (ANCOVA) after a simple t-test was performed on the animal diseases pretest scores of both groups and it was determined that no significant differences existed between the groups on their level of knowledge about the subject matter prior to the administration of the treatments (t = 0.68; 2, 37). On the 30-item pretest, the experimental group (to be taught using a problem approach) earned a mean score of 19.35 (n = 20; SD = 3.22) and the control group (to be taught using lecture and study questions) earned a mean score of 18.63 (n = 19; SD = 3.40) (See Table 2.)

Results of the comparison between the groups on the immediate post-test revealed no significant difference at the 0.10 alpha level (t = 0.84; 2, 32). Therefore, the null hypothesis is

Table 2. Comparisons of Test Scores by Treatments

Subject Area Test Administration	Treatment Group[1]	n	#items	Mean	S.D.	t-value
Animal Diseases						
Pre-test	Experimental	20	30	19.35	3.22	
	Control	19	30	18.63	3.40	0.68
Post-test	Experimental	18	25	20.83	3.76	
	Control	16	25	19.44	5.77	0.84
Delayed Post-test	Experimental	12	35	26.75	5.05	
	Control	14	35	26.57	4.85	0.09
Poisonous Plants						
Pretest	Experimental	10	31	21.50	3.50	
	Control	8	31	20.50	2.67	0.67
Post-test	Experimental	8	22	16.62	2.00	
	Control	7	22	15.71	1.89	0.90
Delayed Post-test	Experimental	8	28	22.62	2.39	
	Control	7	28	19.71	3.25	0.62

[1]Experimental = Problem-Oriented Approach; Control = Lecture and Study Questions.
*No significant differences at the 0.10 alpha level.

retained. The group receiving the problem-oriented approach to teaching earned a mean score of 20.83 (SD = 3.76) while the group receiving the traditional lecture and study questions earned a mean score of 19.44 (SD = 5.77) on the 25 item post-test. The analysis of the scores on the 35 item delayed post-test revealed that the problem-oriented group earned a 26.75 (SD = 5.50) and the lecture-study question group earned a 26.57 (SD = 4.85). This was not found to be significantly different (t = 0.09; 2, 24). The null hypothesis is retained for the delayed post-test.

Poisonous plants lesson - To determine if differences existed between the experimental and control groups prior to the poisonous plants lesson, a t-test was conducted on the pretest scores of the groups. These data are presented in Table 2. No significant difference (alpha = 0.10) between the groups was found (t=0.67; 2,16) on the 31 item pretest. The experimental group (problem approach) earned a mean score of 21.50 (SD = 3.50) while the control group (lecture and study questions) scored a mean of 20.50 (SD = 2.67). Therefore, t-tests were conducted to compare the experimental group with the control group on both the immediate post-test and the delayed post-test.

The immediate post-test scores in the poisonous plants lesson earned by students who were administered the problem-oriented approach was 16.62 (SD = 2.00) on the 22 item test. Students who participated in the lecture-study question instruction earned a mean score of 15.71 (SD = 1.89). This difference was not found to be statistically significant (t = 0.90; 2, 13). The null hypothesis is therefore retained. When the delayed post-test was administered, students who had experienced the problem approach earned a mean score of 22.62 (SD = 2.39, 28 item test), and students who were in the lecture-study question group earned a mean score of 19.71 (SD = 3.25). This was not a significant difference (t=0.62; 2,13). The null hypothesis is retained.

Attitude Toward the Subject Matter. After the immediate post-test was administered in each group, the "Attitude Toward the Subject Matter" instrument was administered to each student. Table 3 presents the results of the t-tests. These analyses indicated that there were no significant differences (alpha = 0.10) between the groups in their attitudes toward the subject matter for either the animal diseases or the poisonous plants lesson. Students in both the problem-oriented approach and the lecture-study question approach had similar attitudes toward the subject as a result of either instructional mode.

Table 3. Comparisons of Attitude Toward the Subject Matter by Treatments.

Subject Area	Group[1]	n	#items	Mean[2]	S.D.	t-value
Animal Diseases	Experimental	7	20	110.57	16.25	
	Control	8	20	100.63	12.96	1.32
Poisonous Plants	Experimental	8	20	104.13	8.76	
	Control	6	20	105.67	11.36	0.25

[1]Experimental = Problem-Oriented Approach; Control = Lecture and Study Questions.
[2]Possible range of scores = 20 to 140, Response categories = 1 to 7.
*No significant differences at the 0.10 alpha level.

Conclusions and Recommendations

The experimental treatment, a problem-oriented approach to teaching two lessons to high school students in animal science courses, resulted in no statistically significant differences when compared with the use of a traditional lecture and study question approach to teaching on the dependent variable, student learning, on either immediate or delayed post-test achievement tests. Students in either instructional approach learned the subject matter equally well, and retained it equally well.

When students' attitudes toward the subject matter were measured immediately following participation in the lesson, the attitudes of students who were taught using the problem-oriented approach were not significantly different than those of students who were taught using the traditional approach. Students seem to have no preference toward learning by either instructional approach.

These results are not surprising and are consistent with previous research which compared instructional approaches among high school agriculture students (Johnson, Wardlow & Franklin, 1997). While the study measured effect on retention of the subject, both short-term and long-term (two week), it did not assess the level of learning. The possibility exists that the subject matter that was taught and expected to be learned in this study was at the lower levels of cognition, and that problem-oriented approaches would prove more effective at producing measurable differences at higher levels of subject matter complexity and levels of cognition. This question should be the subject of further study.

This was a field-based study, using intact classrooms of high school students. While the use of intact classrooms is less desirable than the random assignment of subjects to treatments, it is more feasible within school-based field studies such as in single-teacher agriculture programs. This precipitated the use of the internal replication to insure that all subjects received both treatments. It also served as a rationale to administer the pretests. This may have lead to some pretest sensitization, precluding the production of sufficient variance in the post-test scores. Random assignment of subjects to treatments could eliminate the need for the pre-tests.

Some research mortality occurred, reducing the numbers of students who completed the study. Some students missed the administration of the post-tests because of competing school activities and absences. While they were allowed to complete the tests, their scores were not included in the study because of the possibility of contamination from other students. This could have had some effect on the results. Increasing the numbers of subjects in the study would allow for more robust statistical analysis procedures. Further, producing three alternate forms of the instruments across two different lessons to be used in actual classroom settings, including their use for grading purposes, is a difficult task. Attempts were made to insure the validity and reliability of the instruments. However, the utility of the instruments as classroom subject matter tests was a primary consideration.

Since this study was of a short duration, across only two units of subject matter, the question of whether long-term use of particular teaching approaches would result in measurable differences between them should be studied. Would a longer term, over more units of instruction, likely result in significant differences in learning, or in attitudes toward the subject matter?

One could also question whether the treatments were sufficiently different to maximize any possible differences between the groups. Were the different forms of each lesson too much alike? Were the instructional approaches too much alike? Did the treatments maximize the possible variance within the study? Were the instruments capable of measuring real differences between the student knowledge, the dependent variable of interest?

This study serves as an exploratory study of alternative teaching approaches among high school agriculture students. The agricultural education profession has long advocated the problem-solving approach as superior in producing student learning and satisfaction toward learning. This study, and studies like it, deserve expanding in order to better substantiate that claim. Such studies will continue to serve agricultural educators in their quest to improve their instructional strategies.

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