A Comparison Of Experiential Instructional Strategies Upon The Science Process Skills Of Urban Elementary Students

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Matt Baker
Texas Tech University

A COMPARISON OF EXPERIENTIAL INSTURCTIONAL STRATEGIES UPON THE SCIENCE PROCESS SKILLS OF URBAN ELEMENTARY STUDENTS

Rachel Mabie, Urban Horticulture Adviser
University of California Cooperative Extension

Matt Baker, Assistant Professor
University of Florida

Abstract

Efforts to improve teaching and learning in science education are concurrent with endeavors in agricultural education to increase agricultural literacy. Science educators advancing an experiential approach to teaching might be interested in using agriculturally-oriented strategies, especially if such strategies positively impact science process skill development. Science process skills include the ability to observe, communicate, compare, order, relate, and infer. The intent of this study was to explore the impact that two types of agriculturally-oriented experiential instructional strategies had upon science process skill development. The data collection approach was qualitative in nature and included direct researcher observation of written and verbal student responses to a series of activities. Three classrooms were observed during a 10 week period in which one classroom was taught science using short, in-class projects, another was taught using an ongoing gardening project, and the other class taught using a traditional, teacher-oriented expository strategy. Science process skills were observed both prior to the study and after the study. Findings from the study supports that participation in agriculturally-oriented experiential activities positively impacts the development of science process skills.

The status of science education in the United States is in a state of transition (American Association for the Advancement of Science, 1989). The United States has been identified in several studies as among the lowest-ranking countries internationally in science education (Roark, 1990). Stuessy (1993) summarized the status well by stating: "Reformers in mathematics and science education are attempting to solve the problems of decreasing scores in indicators of mathematics and scientific literacy for the general population" (p. 55).

There is strong consensus in the education community that science instruction needs a major overhaul, but many differing view points have been forwarded as to how to improve the existing system. One of the more predominant view points is closely aligned with the experiential orientation that was long ago advanced by Dewey (1933). He argued that the context in which students learn needed to be as authentic to the "real world" as possible and argued against "cookbook" approaches to teaching subject matter (as has often been the case of science laboratory instruction).

Andersen (1994) indicated that in the future, effective science teachers must assume new classroom roles. Teachers must become more "constructive" in nature, than "instructive." This involves the teacher encouraging student interaction with their environment.

An opinion that is shared by many educators is that science education should be experiential in nature to the greatest extent possible (Harty, Kloosterman, & Matkin, 1989). Meichtry (1992) stated:

> Engaging in hands-on activities leads to a better understanding of science concepts by providing students with meaningful, concrete experiences. Science process skills such as observing, hypothesizing, measuring, collecting, and analyzing data, and drawing conclusions . . . promote problem-solving and critical-thinking skills (p. 441).

Several studies indicate that an experiential approach is indeed effective. In a Texas study, researchers compared students in a traditional text-book oriented program with those in an experiential, inquiry-oriented science program. They found that students in the experiential group had dramatically different attitudes toward learning science than their counterparts in the more traditional group. More than 75% of the students in the experiential group considered science to be fun and interesting. In addition, students in the experiential group perceived that science had relevance in their everyday lives, and wished that they had more time to participate in science. In contrast, more than 50% of the students in the traditional group said that science was boring (Kyle, Bonnstetter, & Gadsen, 1988).

A link has also been established between experiential instructional strategies and improvements in science process skills. Science process skills (observing, communicating, comparing, ordering, relating, and inferring) are the building-blocks of critical thinking and inquiry in science (Ostlund, 1992). Roth and Roychoudhury (1993) found that an experiential approach dramatically improved student science process skills of secondary students. The study was designed in such a manner that students were able to select problems that interested them. They then developed their own methods for exploring their problems, then proposed solutions based upon their own observations and measurements. After 15 months, the researchers reported that the participants developed highly competent process skills. In addition, the researchers discovered that the students gained a sophisticated grasp of the scientific process, becoming able to plan and conduct their own experiments, and place the results in a meaningful context.

At the same time that elementary school teachers have been seeking ways to increase opportunities for experiential learning in science (Roth & Roychoudhury, 1993), the agricultural community has been searching for opportunities to re-introduce our youth to the world of agriculture (W.K. Kellogg Foundation, 1984; National Research Council, 1988; Bowers & Kohl, 1986; Horn & Vining, 1986; Frick, Kahler, & Miller, 1991; Terry, Herring, & Larke, 1992; Frick, 1993; Brown & Stewart, 1993). The science framework for California public schools (California Board of Education, 1990) recommends that at least 40% of science teaching take the form of experiential activities. Since agriculture is by nature a hands-on discipline, it would seem to be a perfect match for integration into the science education curriculum. How can agricultural knowledge best be packaged to improve science process skills? To date, no research has been conducted on what instructional strategies are helpful in utilizing agricultural knowledge to improve science process skills.

Purpose and Objective

This study assessed the impact that two types of experiential agricultural instructional strategies had upon science process skills development. The two types of experiential strategies included: (1) participation in a series of short, in-class projects (bread baking, chick rearing, and seed germination); and (2) participation in an ongoing project involving the establishment and maintenance of a vegetable garden. As a result, the following research objective was developed: (1) To ascertain whether participation in experiential instructional strategies would increase the science process skills of the students.

Procedures

This exploratory research was a part of a much broader study which included the examination of agricultural knowledge in addition to science process skills. Data were collected in two urban, inner-city Los Angeles schools during the spring of 1993. One school located in East Los Angeles had a student population consisting of 99% Hispanic. The other school located in South Central Los Angeles had a student population that was 75% African-American and 25% Hispanic.

Five fifth grade, sixth grade, or fifth/sixth combination classrooms participated in the study. Selection was based upon the teachers' and schools' willingness to participate. These groups were then randomly assigned to the following treatments: (1) a ten week garden project consisting of a fifth/sixth combination class and a sixth grade class (56 students); (2) a ten week series of three short in-class projects (including bread-baking, chick-rearing, and seed germination) for two of the fifth grade classes (57 students); and (3) one control group, a fifth/sixth combination classroom which received no treatment (31 students). A total of 147 children participated in the study.

The treatment (gardening project and short in-class projects) was developed for the purpose of integration into a 10 week instructional unit in science. Each of the two treatments were taught by one of the researchers. In terms of the control group, although the reseachers communicated the purpose of the study to the teacher, the teacher did not include the specific science process skills in the curricula that was being taught.

The curriculum for the gardening project was developed by one of the researchers and has been used extensively in the Los Angeles basin as a part of the "Gardening Angels" program, an extension education effort of the University of California Cooperative Extension Service. The science competencies taught to the gardening group included the science process skills of observing, communicating, comparing, ordering, relating, and inferring (Ostlund, 1992). For example, students were asked to make observations and comparisons between garden soil, planting techniques, qualities of differing plants, harvest dates, pest problems, and irrigation methods.

The instruction was structured as a 15-20 minute session of lecture, discussion, and demonstration in the classroom, followed by group gardening activities. Lessons were one hour each week for the ten week period. Students did not receive printed materials about gardening other than seed packets which they learned to read and interpret.

The short, in-class projects were developed by the 48th District Agricultural Association, a division of the California Department of Food and Agriculture. Three days (one day per week) were spent on each of the three activities (bread baking, chick rearing, and seed germination). The same type of competencies and instructional strategies were used for students in this treatment as were used in the gardening treatment. For example, when baking bread, students observed the dough rising, were asked to compare bread to other baked products, and asked to draw a series of steps for baking bread.

Each unit was used as an opportunity to have students practice their science process skills. A heavy emphasis was placed on observation of each project as it progressed, recording observations, making predictions, and discussing outcomes. Each child made their own loaf of bread and germinated a cup of seed. The chicks were hatched as a group project.

The research design was qualitative in nature. The data collection approach involved researcher observation of student written and verbal responses to a series of activities. Students in all groups were observed prior to the treatment and after the treatment by one of the researchers. The measurement of science process skills was adapted from Science Process Skills: Assessing Hands-On Student Performance (Ostlund, 1992). This was a hands-on assessment in which students were provided with both popped and unpopped popcorn. They were asked to describe and compare the two (which tested observing, communicating, and comparing skills). They were asked to draw the steps for making popcorn (relating, ordering, communicating). They were asked to hypothesize about what makes popcorn pop (relating and inferring). They were asked to group ten items (for example, a rubber band, an orange, a penny, a cracker, etc.) according to what they thought the different items had in common (ordering). A researcher administered the student evaluations before and after the treatment, and great care was taken when evaluating student activities to ensure intrarater reliability by frequently examining previous assessment scores. When questions arose, two researchers analyzed the assessment scores in question.

Student responses were then categorically coded in an effort to measure student science process skill improvement. First, student responses before and after the treatment were determined to be either correct or incorrect. Secondly, after the treatment, student responses were compared to their pretreatment response in an effort to determine improvement in the breadth and depth of their responses. Frequencies were then determined using the SPSS/PC+ statistical software program.

Results

The hands-on assessment of science process skills set out to evaluate the students' skills of observation, communication, comparison, ordering, relating and inferring. Children were provided with a piece of popped and a piece of unpopped popcorn. First, they were asked to describe the piece of popped popcorn, by its shape, color, texture, smell, and any other attribute that students wished to use to describe the popcorn. They were then asked to describe the kernel. This exercise tested their skills in observing and communicating. Almost all children in all groups could complete this activity easily prior to the treatment. However after the treatment, many of the students in the two experiential groups experienced improvement in their powers of observation and ability to communicate their observations.

For instance, prior to the treatment one student wrote "the kernel of corn is yellow and small," while after the treatment, the response became more detailed, "it is orangey-yellow, shaped like a tear, hard, and 1/4" long." Forty-six percent of the control group, 55% of the garden group, and 62% of short project group respondents improved in this way.

The students were also asked to compare popped popcorn to a kernel of unpopped popcorn, and describe their difference. This activity sought to measure the students' skills in comparing. Again, while the students handled the task easily prior to the treatment, their posttreatment efforts at comparing the kernel and the popcorn were often more detailed. For example, one child before the treatment wrote "the popcorn is white and the kernel is yellow." After the treatment, he wrote "the popcorn is soft, white, shaped like a cloud but the kernel is much harder, and smaller and yellow. One is popped and the other is not popped. One is good to eat, the other is no good to eat." Twenty-seven percent of the control group, 48% of the garden group, and 53% of the short projects group showed improvement in their ability to compare the two items.

The students were then asked to "draw pictures that show someone how to make popcorn." This exercise tested the science process skills of ordering, relating, and communicating, and was somewhat more difficult for the students. Everyone knew how to make popcorn, whether on a stove or in a microwave, but some children found it difficult to break the process down into distinct steps. Seventy-four percent of the control group, 64% of the garden group, and 46% of the short projects group were able to draw a logical series of steps for making popcorn before the treatment. After the treatment, 64% of the control group (10% decline from their pretreatment response), 84% of the garden group (20% increase), and 65% of the short projects group (19% increase) could complete the activity.

Students were then asked, "What do you think makes popcorn pop?" This question challenged students to use their skills of relating and inference. Prior to the treatment, 68% of the control group, 71% of the garden group, and 60% of the short projects group were able to state that heat had something to do with the popping process. There was some gain after the treatment for the students in the two experiential treatement groups. Sixty-four percent of the control group (four percent decline from pretreatment scores), 79% of the garden group (8% increase), and 79% of the short projects group (19% increase) could answer the question with some accuracy.

More dramatic improvements came with the activity in which each student grouped 10 items in a "mystery bag" according to what each he or she felt the items had in common. This activity measured skills in ordering and categorizing. Before the treatment, 49% of the control group, 42% of the garden group, and 35% of the short projects group could complete the activity. After the treatment, 50% of the control group (1% increase from their pretreatment scores), 79% of the garden group (37% increase), and 80% of the short projects group (45% increase) were able to carry out the exercise successfully.

Conclusions and Recommendations

The researchers acknowledge that the results of this study must be interpreted with caution. Projecting these findings to populations other than the schools purposefully selected for this study presents an external validity threat. Based upon student responses when asked to describe popped and unpopped popcorn, and comparing the two (popped and unpopped popcorn), students participating in the experiential activities had greater increases in observational, communication, and comparison science process skills, then did students in the control group. Participation in short, in class projects resulted in greater gains in these three science process skills than did participation in gardening projects.

The differences between the treatment groups were not as dramatic regarding the science process skills of ordering, relating, communicating, and inferring when measured by drawing the process of making popcorn, and describing why popcorn pops. However, students in the control group digressed in these same science process skills. Perhaps the ability to order, relate, and infer are closely related to student attitude about the topic, and in the absence of experiential activities, students lose the motivation to perform these skills.

When the mystery bag activity measuring the science process skill of ordering was examined, students in the experiential treatment groups substantially outperformed students in the control group. Once again, students in the short projects group exhibitied the greatest increase in their ability to order objects.

Overall, participation in the experiential activities helped students in their ability to observe, communicate, compare, relate, order and infer. By improving these critical thinking skills, students may become better consumers of scientific knowledge in the future. They possibly will become better able to question, hypothesize and make educated conclusions based on their observations.

Students in the short projects group improved somewhat more than those in the garden group in the area of science process skills. This may be due to the fact that a garden project takes longer than the allotted 10 weeks to complete, while the short projects (which included bread-baking, chick hatching, and seed germination) were all completed quickly.

Elementary teachers should seriously consider introducing some experiential activities into their science curriculum. However, are elementary teachers prepared to teach science in such a manner? Andersen (1994) contends that they are not. He has called for major reform in science teacher education. To what extent should agricultural educators be involved in this reform? To what extent are our own secondary agricultural educators or extension professionals capable of delivering education via an investigative nature? These are certainly questions worthy of agricultural industry and university debate. The agricultural community must look closely at how to make agricultural material more valuable to children.

The method in which the subject matter was taught in this study was somewhat teacher oriented. In the future, researchers should examine the extent to which science process skills can be learned by way of student-centered, open-ended laboratory experiments. At what age are students actually capable of conducting their own investigations without a great deal of teacher control? To what extent should science process skills be taught holistically without being taught explicitly?

The researchers conducting this study did not overtly encourage cooperative learning among the students. Perhaps future research needs to focus upon the extent to which laboratory instruction in an authentic context combined with cooperative learning strategies would influence science process skills.

How can agriculture best be used to help generate excitement for learning? How can it be used to make science and other curricula come to life, and help children develop critical thinking skills? Hopefully, future research will look closely at these issues.

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