EVALUATION OF THE INCUBATORS IN THE CLASSROOM PROGRAM: DOES IT INCREASE FOURTH GRADE STUDENTS' KNOWLEDGE OF AGRICULTURE-RELATED SCIENCE CONCEPTS?

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Abstract

The purpose of this study was to determine the effectiveness of agricultural literacy materials designed for the Incubators in the Classroom program used in Indiana fourth grade classrooms. The objectives were to determine the impact of these materials on the agriculture-related science concepts knowledge level of fourth grade students and the impact of these materials on the agriculture-related science concepts knowledge level of fourth grade teachers. Effectiveness of the educational materials was measured using a pretest-posttest research design with Indiana fourth grade school children (n=736) and their respective teachers (n=39). The sample of students and teachers was divided into experimental and control groups, then stratified based on community population size (less than 5,000, between 5,000-15,000, greater than 15,000). Quantitative data were collected through questionnaires. The data indicated the educational materials developed and assessed for this study were effective in increasing knowledge about agriculture-related science concepts among both the experimental students and teachers.

Introduction

In the last 50 years the population of the United States has changed such that only 2% of the population now resides on the farm, compared to 12% in 1950 (USDA, 1997). This shift away from an agrarian society has created a population that has less experience and knowledge regarding agriculture. The need for public support of agriculture and the agricultural industry increases as fewer people become directly involved in production agriculture. Further, educational need arises from the inability of the American public to receive agricultural knowledge from everyday experiences as they would have in previous decades. Terry and Lawver (1995) noted that it is vital for Americans to have an accurate understanding of agriculture because of agriculture's impact on society, the economy, and the environment.

One way in which to create public support of agriculture and agricultural practices is through the dissemination of information by public educational organizations. Many organizations strive to educate Americans about agriculture; however, few have the connections and experience to increase public knowledge and support like that of the Cooperative Extension Service (Seevers, Graham, Gamon, & Conklin, 1997). Seevers et al. defined the Cooperative Extension Service as a public-funded, nonformal, educational system that utilizes the resources of the United States Department of Agriculture (USDA), land-grant universities, and county extension offices.

In 1997-98, the Purdue University Cooperative Extension Service began planning for the future by asking communities, "What are the high-priority issues in your community, and what difference could and should we make with our educational programs?" (Purdue Extension Service, 1998, p. 1). Responses from Indiana communities generated Purdue

University's Cooperative Extension 1999 Five-Year Plan of Work. The plan includes 16 broad categories. Among this list of topics was a plan of action for increasing agricultural literacy and understanding among Indiana's citizens. The Purdue Extension Service's vision for future agricultural literacy and understanding stated, "Indiana's residents will make informed decisions about agriculture; improve farm/non-farm relations; increase their awareness of the importance of agriculture; and heighten their understanding of the food and fiber system" (Purdue Extension Service, p. 8). In accordance with the plan of action for agricultural awareness and understanding, the Purdue University Animal Science Department developed an educational program to improve the agricultural literacy of fourth grade students. This article reports on the evaluation of the program's effectiveness on improving knowledge of agricultural-related science concepts.

Theoretical Framework

Dembo (1994) stated there are two main approaches or theories of learning: cognitive and behavioral. Eggen and Kauchak (1997) viewed cognitive learning theory as "a change in a person's mental structures that provides the capacity to demonstrate changes in behavior" (p. 238). Dembo viewed behavioral learning theory as "learning as a process by which behavior is either modified or changed through experience or training" (p. 4).

Jean V. Piaget theorized learning or intellectual development occurred through schemes/structures (Dembo, 1994; Gorman 1974). This theory separated learning and development. Piaget viewed learning in the narrow sense as acquiring new information. Whereas learning in the broad sense or development involves acquiring general thought structures that can be applied to various situations (Ginnsburg & Opper, 1988). Piaget deemed development or learning in the broad sense more fundamental than learning in the narrow sense (Ginnsburg & Opper, 1988). Learning in the broad sense requires an active learner, as one must first understand each subset and then grasp the whole structure. To depict this viewpoint Gorman utilized a city as an example of a structure. Gorman chose a city as an example due to the interactions between and among the subsets of people, transportation, power, raw materials, climate, and water supply. These factors are all important in the everyday functioning of a city. The authors developed a parallel example of agriculture as a structure containing many subsets. Here, just like a city, agriculture has interactions between and among research, transportation, marketing, raw materials, processing, and education. These factors are important in the everyday functioning of the agricultural industry.

Piaget's theory established four stages of cognitive development (Dembo, 1994; Eggen & Kauchak, 1997; Flavell, 1985). Stage one, sensorimotor, is reserved for infants and children up to 2 years of age. It is during this stage that imitation, memory, thought, and purposeful activity begins. Stage two, preoperational, is reserved for children between 2 and 7 years of age. This stage represents the development of egocentric language and logic. The third stage of concrete operational is reserved for children between 7 and 11 years of age. This stage represents accomplishments at the concrete level meaning students are not yet proficient at abstract thinking. The fourth and final stage of formal operational is reserved for children between 11 and 15 years of age. This stage represents the ability to solve problems in a logical fashion, scientific thinking, and complex problem solving.

Fourth-grade students are developmentally found at stage three, concrete operational (Brunk, 1977; Dembo, 1994). As previously stated, this stage represents thought processing and problem solving at the concrete level meaning students are not yet proficient at abstract thought processes. Brunk stated, "the single most important conclusion to be drawn from Piaget's work, is that children learn best when involved actively in concrete learning experiences" (p. 88). Further, "there should be teaching materials that children can see, touch, listen to, taste, smell and materials they can manipulate and explore" (p. 88).

This is especially true for children at the concrete operational stage who have little to no familiarity with content information. Piaget noted that children at all stages of development are different from adults in the way they approach reality, their views of the world, and in their language (Ginnsburg & Opper, 1988).

Conceptual Framework

The National Research Council (1988) developed the term agricultural literacy and recommended, "all students should receive at least some systematic instruction about agriculture beginning in kindergarten or first grade and continuing through twelfth grade" (p. 10). Further, the NRC suggested "the most realistic way to teach science through agriculture is to introduce modules, or units of instruction that supplement and eventually replace existing curricula and textbooks" (p. 13). With regards to elementary students, this type of instruction should include both hands-on learning activities and instructional materials. Good and Brophy (1994) believed both teacher and educational effectiveness is a direct result of motivating students to learn. Good and Brophy further believed motivating students to learn in a classroom setting is most beneficial when students are internally motivated, as compared to motivation that occurs through external factors. Elementary students can be internally motivated through hands-on learning experiences.

The need for agricultural education arises from the inability of the American public to receive agricultural knowledge from everyday experiences, as they would have in previous decades. Frick (1988) demonstrated the importance of agriculture's significance to society. He stated "agriculture significantly affects many facets of our society…our standard of living; the dimensions of world food needs; international trade; and employment opportunities" (p. 13). Dissemination of accurate agricultural information can be a cumbersome task if the term agricultural literacy is not clearly defined. Frick, Kahler, and Miller (1991) developed a definition of agriculture that encompasses many concepts.

> Agricultural literacy can be defined as possessing knowledge and understanding of our food and fiber system. An individual possessing such knowledge would be able to synthesize, analyze, and communicate basic information about agriculture. Basic agricultural information includes: the production of plant and animal products, the economic impact of agriculture, its societal significance, agriculture's important relationship with natural resources and the environment, the marketing of agricultural products, the processing of agricultural products, public agricultural policies, the global significance of agriculture, and the distribution of agricultural products (p. 52).

Trexler (1997) found that elementary students with limited exposure to agricultural production believed that farms were small (size of two football fields), grew multiple varieties of crops in rows next to each other, and were tended by one farmer. Tevis (1996) stated, "stereotypes about agriculture remain a stumbling block" (p. 64) exemplifying the perception problem facing American agriculture. In his theme article entitled "Education in Agriculture: Not Just a High School Matter" DeWerff (1989) suggested learning about agriculture should begin at younger ages. Many students see agriculture in its narrow sense of interpretation: "the farmer; the cow, plow, and sow man; the wheat farmer and livestock rancher; and many other stereotypes" (p. 15). This problem is further complicated by the productivity of the land and population growth. The combination of these factors means less land is needed for agriculture allowing the growth of residential areas. DeWerff concluded, "it is a small wonder that few Americans have an accurate understanding of modern agriculture" (p. 14).

Researchers have questioned the agricultural literacy of elementary teachers. Carlsen (1991) questioned whether schoolteachers and aspiring teachers in colleges and universities have the prerequisite knowledge, understandings, or experiences to facilitate learning as suggested by American Association for the Advancement of Science (AAAS) Benchmarks. The AAAS (1993) questioned whether elementary teachers or their students can trace the path that a food has traveled on its way to a grocery store and more specifically the "hazards that food encounters from the time it is a seed until it reaches the kitchen" (p. 184). Terry, Herring, and Larke (1992) found 75% of 510 Texas fourth-grade teachers had low knowledge about agriculture. This may point to inadequate teacher training or teacher enrichment/remediation in agriculture and agricultural concepts. Lack of agricultural knowledge was shown in Humphrey, Stuart, and Linhardt's (1994) study where only 20% of the University of Missouri-Columbia pre-service elementary education majors were confident enough to teach agricultural concepts. This is particularly disturbing, as we cannot expect students to have more prerequisite knowledge of a topic than that of their teacher. Humphrey et al. also pointed out the positive relationship that exists between the relative level of confidence and successful presentation of agricultural information in the classroom.

Balschweid, Thompson, and Cole (1998) found classroom teachers felt the greatest barriers to implementing agriculture in classrooms were time to make the necessary curricular changes and locating agricultural materials information. These barriers would be greatly lessened if teachers were agriculturally aware, meaning they possessed a better working knowledge of agriculture and agricultural practices. In this context, working knowledge refers to an understanding of basic information related to agriculture, such as crops, livestock, and agricultural products.

Purpose and Objectives

The purpose of the study was to determine the effectiveness of agricultural literacy materials designed for the Incubators in the Classroom program used in Indiana fourth grade classrooms. The objectives of the study were to:

1. Determine the impact of these materials on the agriculture-related science concepts knowledge level of fourth grade students.
2. Determine the impact of these materials on the agriculture-related science concepts knowledge level of fourth grade teachers.

Methodology

A quasi-experimental, non-equivalent groups pretest-posttest research design was used for this study (McMillan & Schumacher, 1997). Schools (n=14) were recruited for this study based on researcher contact with classroom teachers, extension educators, and postings to the Indiana Science Listserv. Specifically, schools were recruited and assessed based on the residential population size from which the school draws, any possible confounding variables, and infrastructure. The sample was stratified based on community population size from which each school district was composed. The three stratified populations used for this study were: a) small – less than 5,000 residents, b) medium – between 5,000-15,000 residents, and c) large – greater than 15,000 residents. The sample schools (n=14) were then randomly assigned as either control (n=7) or experimental (n=7), such that within each stratified sample community population size there was a control and experimental group. This study utilized cluster-sampling techniques whereby all data were in the form of classroom students and their teachers (McMillan & Schumacher, 1997). The classrooms within each school were treated as a cluster, such that all classrooms from a particular school were either control or experimental. No single school contained both control and experimental classrooms. This design eliminated information transfer between the control and experimental groups during the course of the study.

Treatment / Intervention

Hands-on instructional materials were developed as a component of the Purdue University Poultry Extension Staff program "Incubators in the Classroom." These materials consisted of daily lesson plans, student and teacher resource and reference materials, and planned hands-on activities divided across five classroom days with each day requiring at least 30 minutes of formal instruction. The instruction consisted of information related to the general concept and scope of agriculture, agricultural careers, farm animals, egg formation within the hen, chick embryonic development, and agricultural products. The Incubators in the Classroom program provided each teacher with one dozen fertile eggs, an incubator, an embryology poster, and related reference materials. All instructional materials were developed in accordance with the Indiana Science Standards for Indiana fourth grade students. The instructional materials were at Flesch-Kincaid Grade level 5.7 with a Flesch Reading Ease of 73% (Microsoft Word, 1997). This is a typical level for fourth grade science materials as science instruction contains advanced terminology and concepts. The classroom teachers, each of whom had received a short training on using the equipment and materials, delivered the educational intervention.

Sampling and Research Subjects

The sample size was determined through the Krejcie & Morgan (1970) formula and consisted of two groups: the control group (*n*=363 students, *n*=20 teachers) and the experimental group (*n*= 373 students, *n*=19 teachers). The total teacher response rate (*n*=39) was 100%. The total student response rate (*n*=736) for analysis was 86.6%. This was reduced from 850 possible student respondents due to the lack of complete data on some individuals. Students may not have completed both the pre and post-tests due to a number of factors: student illness, school activities involving certain students, short-term disciplinary actions, and/or any other miscellaneous school-related reasons. A complete dataset per student or teacher consisted of a completed pretest and posttest. The overall student sample was evenly distributed for treatment, stratified community population sizes, and gender. Demographically, students were Caucasian (89.8%), 10 years of age (81%), and non-members of the 4-H program (83.1%). Teachers were exclusively Caucasian (100%), predominantly female (94.9%), not involved in the 4-H program (76.8%), but were involved in classroom programs containing agricultural activities (56.4%).

Instruments

This study utilized researcher-developed pretests and posttests for the students and teachers to collect quantitative data. The pretest and posttest for both the students and teachers were identical for the questions, response categories, and order of the questions. This was done to provide instrument reliability so that differences between responses on the pretest and posttest would have a greater likelihood of being from the intervention. The student instrument consisted of four demographic questions, eight multiple-choice questions and nine true-false questions, while the teacher instrument added a demographic question on involvement in agriculture and deleted two multiple choice questions on future plans. The authors chose to focus on key objectives from the instructional materials in order to keep the instruments at a reasonable length for fourth grade students. This article reports on the four multiple-choice questions and one true-false question pertaining to knowledge of agriculture-related science concepts. A panel of experts reviewed the instruments for content validity by comparing the instrument questions with the content of the intervention. The focus of the study was on the evaluation of the intervention rather than measuring the construct of agricultural literacy. However, to provide some indication of instrument reliability, Cronbach's alpha was calculated by combining the five questions reported on in this article into a scale. The data yielded by the instrument have a reliability of .42. The authors expected this low level of reliability because no scale development was conducted as a part of the instrument design, so no attempts were made to increase reliability nor are results from the scale reported.

Data Collection and Analysis

The experimental and control groups received the pretest one-week prior to the intervention or non-intervention and the posttest one-week following the intervention or non-intervention period. Therefore, the period between the pretest and the posttest was three weeks for both groups. Initially the data were analyzed using descriptive statistics, including frequencies of correct and incorrect responses. Chi-square analysis was then utilized to determine levels of significance between correct and incorrect responses. Statistical significance was established *a priori* at the.05 alpha level.

Results

Students

Test questions for agriculture-related science concepts were utilized to draw comparisons between the experimental and control groups and assess differences between stratified sub-samples. Table 1 provides the percent correct for five questions regarding agricultural knowledge for students. For the pretest, the experimental group was less than 50% correct on all questions except the true-false regarding farmer's concern about animal safety. For the posttest, the experimental group was greater than 50% correct for three out of the five questions. Both groups had their lowest level of correctness on the two questions for identification of correct nomenclatures of male and female farm animals. The experimental group had the highest level of posttest correctness (97.2%) for the incubation length of a chicken egg. For the experimental group, the 15,000 and greater community population size had the highest level of posttest correctness for two of the five questions (Table 2). For the control group, the 5,000 and fewer community population size had the highest level of posttest correctness for four of the five questions (See Table 3).

Table 1
Student Responses on Agricultural Knowledge by Group and Time

Question	Time	n[a]	Experimental[b]	n[a]	Control[b]	CV
How long does it take for a fertile egg	Pre	360	49.7	372	53.5	1.04
to develop into a chick?	Post	358	97.2	371	66.6	113.93*
Which of the following are names for	Pre	360	13.1	372	26.8	21.41*
female farm animals?	Post	360	38.6	371	41.9	.84
Which of the following are names for	Pre	355	10.7	372	21.6	15.85*
male farm animals?	Post	360	34.4	371	38.0	1.00
There are ______ major food groups?	Pre	360	45.8	372	49.1	.77
	Post	363	58.4	371	55.5	.63
Farmers are concerned about the safety	Pre	358	93.6	372	86.8	9.46*
of their animals.	Post	359	89.1	371	87.8	.33

[a]Number of respondents to the question.
[b]Percentages of correct responses reported.
*Significant at the .05 alpha level.

Table 2
Experimental Group Student Posttest Responses on Agricultural Knowledge by Community Population Size

Question	n[a]	<5,000[b]	>5k-15,000[b]	>15,000[b]	CV
How long does it take for a fertile egg to develop into a chick?	358	96.4	98.1	97.4	.69
Which of the following are names for female farm animals?	360	37.7	26.7	50.4	13.26*
Which of the following are names for male farm animals?	360	34.1	27.6	41.0	4.42
There are ______ major food groups?	363	48.6	54.7	73.5	17.15*
Farmers are concerned about the safety of their animals.	359	89.9	91.4	86.1	1.77

[a]Number of respondents to the question.
[b]Percentages of correct responses reported.
*Significant at the .05 alpha level.

Table 3
Control Group Student Posttest Responses on Agricultural Knowledge by Community Population Size

Question	n[a]	<5,000[b]	>5k-15,000[b]	>15,000[b]	CV
How long does it take for a fertile egg to develop into a chick?	371	71.3	71.0	55.9	8.18*
Which of the following are names for female farm animals?	372	50.6	37.4	33.3	9.23*
Which of the following are names for male farm animals?	371	45.7	34.3	30.0	7.60*
There are ______ major food groups?	373	42.0	56.0	74.8	28.71*
Farmers are concerned about the safety of their animals.	368	90.6	86.9	84.5	2.30

[a]Number of respondents to the question.
[b]Percentages of correct responses reported.
*Significant at the .05 alpha level.

Teachers

There were no questions on the teacher pretest in which significant differences existed between the experimental and control groups (Table 4). For the teacher posttest, the experimental group had a significantly higher level of correctness for the question on the incubation length of a chicken egg. The lowest level of correctness on any teacher test question was a 36.8% recorded by the experimental group on the pretest. This question dealt with the nomenclature of male farm animals. The highest overall level of correctness on any test question was a 100% recorded by both groups on several questions on the pretest and posttest. There were no significant differences on the posttest within either the control or experimental group when stratified by community population sizes (Tables 5 and 6).

Table 4.
Teacher Responses on Agricultural Knowledge by Group and Time

Question	Time	n[a]	Experimental[b]	n[a]	Control[b]	CV
How long does it take for a fertile egg to	Pre	19	68.4	20	70.0	.01
develop into a chick?	Post	19	100.0	20	80.0	4.23*
Which of the following are names for	Pre	18	44.4	20	70.0	2.54
female farm animals?	Post	19	57.9	20	70.0	.62
Which of the following are names for	Pre	19	36.8	20	45.0	.27
male farm animals?	Post	19	42.1	20	60.0	1.24
There are ______ major food groups?	Pre	19	52.6	20	50.0	.03
	Post	19	68.4	20	50.0	1.37
Farmers are concerned about the safety	Pre	19	100.0	20	100.0	----
of their animals.	Post	19	100.0	20	100.0	----

[a]Number of respondents to the question.
[b]Percentages of correct responses reported.
*Significant at the .05 alpha level.

Table 5
Experimental Group Teacher Posttest Responses on Agricultural Knowledge by Community Population Size

Question	n[a]	<5,000[b]	>5k-15,000[b]	>15,000[b]	CV
How long does it take for a fertile egg to develop into a chick?	19	100.0	100.0	100.0	----
Which of the following are names for female farm animals?	18	71.4	80.0	28.6	4.00
Which of the following are names for male farm animals?	19	71.4	40.0	14.3	4.70
There are ______ major food groups?	19	71.4	60.0	71.4	.22
Farmers are concerned about the safety of their animals.	19	100.0	100.0	100.0	----

[a]Number of respondents to the question.
[b]Percentages of correct responses reported.
*Significant at the .05 alpha level

Table 6.
Control Group Teacher Posttest Responses on Agricultural Knowledge by Community Population Size

Question	n[a]	<5,000[b]	>5k-15,000[b]	>15,000[b]	CV
How long does it take for a fertile egg to develop into a chick?	20	80.0	80.0	80.0	.00
Which of the following are names for female farm animals?	20	80.0	60.0	60.0	.95
Which of the following are names for male farm animals?	20	60.0	60.0	60.0	.00
There are ______ major food groups?	20	30.0	60.0	80.0	3.60

[a]Number of respondents to the question.
[b]Percentages of correct responses reported.
*Significant at the .05 alpha level.

Student Conclusions

For objective one, it can be concluded that the educational materials were effective in increasing the agriculture-related science concepts knowledge level of fourth grade students. As hypothesized in the theoretical framework (Brunk, 1977; Dembo, 1994), hands-on, concrete educational materials had a positive impact on student learning. Initially the control and experimental groups demonstrated some differences in level of knowledge. Prior to the non-intervention period, the control group demonstrated more knowledge of agriculture-related science concepts in nomenclature of domestic farm animals and the importance of agriculture. Prior to the intervention period, the experimental group demonstrated more knowledge of agriculture-related science concepts in farmers' concerns about the safety of their animals. The initial differences among the two student groups are interesting and may be attributed to the combination of student experiences and classroom activities prior to the educational intervention or non-intervention.

The educational intervention had a positive effect on agricultural knowledge among the experimental group students. Although the experimental group students as compared to the control group students achieved a significantly higher level of correctness on only one posttest question, they were able to increase their levels of correctness on four of the five posttest questions related to knowledge of agriculture-related science concepts. It is unclear why the experimental group students scored lower on nomenclature questions on the posttest than the control group students.

The stratified sub-samples for the control and experimental groups yielded differing conclusions. In general, the control group's small (<5,000) stratified sub-sample achieved higher levels of correctness than the medium sub-sample (5-15,000), followed by the large stratified sub-sample for four of the five questions. This finding is consistent with Frick, Birkenholz, Gardner, and Machtmes (1995) where students from rural populations were found be more to knowledgeable about agriculture when compared to urban students. This study hypothesized similar results for the experimental group on the posttest. However, the findings do not support this hypothesis. Instead, there were no discernable patterns among experimental group stratified sub-sample responses on the posttest. This is both encouraging and surprising, as the researchers did not anticipate these results. A possible conclusion based on the results of this scale involves student interest. The present research suggests student interest and subsequent knowledge was heightened among students from increasing sub-sample size due to the possibility of a lesser background with agriculture and the applied sciences. Recommendations by Williams and White (1991) and Gorman (1974) support the above speculation. Williams and White reported that including agriculture in day-to-day curriculum would increase student knowledge of and interest in agriculture. Gorman advocated intrinsic learning activities for learners during novel learning activities. Thus, the authors speculate students may have been more motivated to learn about agriculture-related science concepts due to their unfamiliarity with agriculture.

This study utilized stratified sub-samples such that the results could be generalized to the population of Indiana fourth grade students. The focus of this research was not to compare different sub-samples. Instead the research focused on the differences that existed between the experimental and control groups. There was a difference in the number of questions found significantly different within each group, control or experimental, of the stratified sub-samples. This information is pertinent to the study because significance on a large number of questions strengthens the notion that the educational materials were effective in increasing agricultural knowledge of experimental group students. The larger number of significant differences on posttest questions among the control group stratified sub-samples means the control group stratified sub-samples were less homogeneous than the experimental group stratified subsamples on agricultural issues. Thus, the educational materials created homogeneity among the experimental group stratified student sub-samples.

Teacher Conclusions

For objective two of this study, it can be concluded that the educational materials were effective in increasing the agriculture-related science concepts knowledge level of fourth grade teachers. Overall, the teachers from the experimental and control groups were similar in nature, with both groups performing well on the tests. Experimental and control group teachers scored 100% on many test items. However, due to concerns of teacher knowledge of agriculture in the literature (Humphrey, Stuart, & Linhardt, 1994; Terry et. al, 1992), the researchers felt it was necessary to test the teachers via the same test instrument completed by the students before and following the educational intervention or non-intervention. The teacher groups were not significantly different on any question on the pretest. The experimental teachers did however, demonstrate significant differences in levels of correctness on one posttest question. Significance on only one posttest question does not mean the educational materials were significantly ineffective among teachers. The relatively small number of teachers involved in this study may have minimized significance between the experimental and control groups. In addition, as previously indicated, both teacher groups scored 100% on some pretest questions. Thus, there was limited room for teacher improvement on the posttest questions.

No significant differences were found among teachers in the stratified experimental or stratified control groups on the posttest questions. Thus, experimental group and control group teachers were relatively homogeneous with regards to the stratified samples.

Recommendations

It is recommended that future educational intervention materials for fourth grade students include hands-on activities designed to increase knowledge of basic agriculture-related science concepts. This is in line with the theoretical framework for this research that advocates hands-on learning activities for learners at the concrete-operational level (Dembo, 1994). Furthermore, educational intervention materials should include manipulative objects, preferably real ones. By involving fertilized eggs as part of the educational materials, students were able to use all their senses for exploration of the content as recommended by Brunk (1977). Agriculturally related intervention programs designed for the students, such as the one evaluated by this research, have the potential to impact agricultural literacy by allowing students to explore the complexity of agriculture and its impact on everyday life. Therefore, it is recommended that the "Incubators in the Classroom" educational materials be continued and more widely distributed across Indiana fourth grade classrooms.

Although the "Incubators in the Classroom" educational materials were developed using the Indiana fourth-grade science standards, the evaluation only covered agricultural knowledge. A follow-up study needs to evaluate the impact on student performance of the "Incubators in the Classroom" educational materials for the Indiana fourth-grade science standards.

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