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AUTHOR	Frederick, Lynda R.; Shaw, Edward L., Jr.
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ABSTRACT

This paper describes a follow-up to a 1998 study that reexamined several aspects of elementary science students' achievement, attitudes, and journal writing in conjunction with an Alabama Hands-on Activity Science Program (HASP) grant utilizing the Full Option Science System (FOSS) kit. During the four weeks of the study, 20 fourth grade students were requested to reflect upon instruction through journal writing. Results suggest that an increase in posttest achievement scores may be attributed to incorporating the FOSS kit into science instruction. Results also support the use of science manipulatives as a means of increasing students' favorable attitudes toward science and science-related activities. (Contains 34 references.) (WRM)

Effects of Science Manipulatives on Achievement, Attitudes, and Journal Writing of Elementary Science Students Revisited

Lynda R. Frederick

and

Edward L. Shaw, Jr.

College of Education

Department of Curriculum and Instruction

3100 UCOM

The University of South Alabama

Mobile, AL 36688-0002

A paper presented at the annual meeting of the Mid-South Educational Research Association, Point Clear, AL, November 17-19, 1999.

Abstract

This study reexamined several aspects of elementary science students' achievement, attitudes, and journal writing in conjunction with an Alabama Hands-on Activity Science Program (HASP) grant utilizing the Full Option Science System (FOSS) kit. The sample of 20 fourth grade students was administered a 15 item pretest and posttest. During the four weeks of the study students were requested to reflect upon the instruction through journal writing. Results from data analysis using a t-test indicated a significant difference in student achievement on the pre and post test scores. These results suggest the increase in posttest scores may be attributed to incorporating the FOSS kit into science instruction. A qualitative content analysis of the journals revealed both the quality and quantity of the reflective writing did not fluctuate appreciably from the beginning to end of the study as was the case in the original study conducted by the authors in 1998. Students' responses from the survey indicated that they believed their grades in science were good, enjoyed learning science by themselves, would like a science career, learned safety rules for using electricity, and enjoyed studying about electricity. Results did support using science manipulatives as a means of increasing favorable responses towards science being their favorite subject, reading about science, science being fun, looking forward to science, science group activities, believing electricity is important, and journal writings.

Examining the Effects of Science Manipulatives on Achievement, Attitudes, and Journal Writing of Elementary Science Students Revisited

The use of manipulatives and corresponding hands-on/minds-on, developmentally appropriate activities has been advocated since the late 1950's. According to Haury and Rillero (1992), instructional approaches that involve direct experiences with natural phenomena have become collectively known as hands-on-science. Additionally, Lumpe and Oliver (1991) stated that hands-on science is any "activity that allows the student to handle, manipulate or observe a scientific process". Bashaun (1994) stated by involving "students in the learning process, they are no longer outsiders of education" (p.6). This connection is vital for the success of science teaching.

Research (Hegarty-Hazel, 1990; Hodson, 1993; Lazarowitz & Tamir, 1993) indicated hands-on activities have been considered to be very versatile in teaching science. The use of hands-on science activities typically resulted in: enhanced learning of scientific knowledge, motivation to learn science, development of skills and strategies for learning, and insight into science as taught in an inquiry mode. Kang and Keys (1999) reported that a "science teacher's beliefs about hands-on activities and teaching practices with hands-on are deeply related to his beliefs about students. The teacher had strong beliefs about the purposes of hands-on activities in science teaching, his students' characteristics and students' ways of learning." (p.1) Although this research was conducted with a high school teacher, it can be inferred that the results would be applicable to elementary teachers and students.

Elementary science education went through a massive self-evaluation which resulted in a new generation of elementary science curricula such as SCIS, ESS and SAPA. The core of these alphabet curricula was its dedication to active learning. Rutherford and Ahlgren (1990) stated "Young people can learn most readily about things that are tangible and directly accessible to their senses...." (p.186). With these experiences students understand, can reason, and use logic to make generalizations. Some curricula were process skills oriented, some were content oriented, and some were a blend of both. The various elementary science curricula had little impact on how science was taught in many elementary schools. However, the direction of the development of future curricula was greatly affected.

During the late 1980's and early 1990's a resurgence in the development of elementary science curricula emphasizing the use of hands-on/minds-on, developmentally appropriate activities occurred. According to Schmieder and Michael-Dyer (1991) almost all national reports on teaching and learning in schools call for more active learning for students with more hands-on, direct opportunities for students to construct meaning. Research on the use of hands-on science teaching techniques has indicated a positive effect upon student achievement (Mattheis & Nakayama, 1988; Brooks, 1988; Saunders & Shepardson, 1984).

The new curricula combine process skills and content but have also added problem solving/decision making skills. Research from the field of educational psychology, science disciplines, input from inservice teachers, new documents such as <u>Benchmarks for Science Literacy</u> (1993), and <u>Science for All Americans</u> (1990), are in accord with the <u>National Science Education Standards</u> (1996) which states, "The new vision includes the 'process of science' and requires that students combine processes and scientific knowledge as they use scientific reasoning and critical thinking to develop their understanding of science" (p. 105). Although new standards and curricula have been developed, some teachers are still reluctant to use science manipulatives. Shaw and Hatfield (1997) found that elementary teachers on average use manipulatives approximately one day per week and that the use of manipulatives was about the same in all elementary grades. Kloosterman and Harty (1987) found manipulative use greater in grades three through five than kindergarten through second.

John Wright created an inquiry-based program in response to national standards in 1990 called Hands-on Activity Science Program (HASP). HASP which incorporates exemplary curriculum using modules, Full Option Science System (FOSS), was developed and tested nationally with funding from the National Science Foundation (NSF). In view of the fact the theoretical base for incorporating manipulatives into elementary science instruction was well supported, this study was designed to examine several aspects of elementary science students' achievement, attitudes, and journal writing in conjunction with a FOSS kit. It is hoped through the use of hands-on/minds-on activities the natural curiosity young children bring to the classroom will continue and be enhanced.

According to National Science Education Standards (1996), "Scientific literacy has different degrees and forms; it expands and deepens over a lifetime, not just during the years in school. But the attitudes and values established toward science in the early years will shape a person's development of scientific literacy as an adult" (p. 22). Research involving science manipulatives indicated an improvement of students' attitudes toward science (Rowland, 1990; Kyle, Bonnstetter, Gadsden, & Shumansky, 1988; Jaus, 1977; Kyle, Bonnstetter, McCloskey, & Fults, 1985). Weinburgh (1999) reported an increase in positive attitudes toward science when a new hands-on science program was implemented in several inner city schools. This study supports research by Schibeci and Riley (1986) in which attitudes were found to influence achievement, rather than achievement influencing attitudes; while Oliver and Simpson (1988) reported a strong relationship between affective variables in the science classroom and achievment. This reinforces the idea that students with positive attitudes toward science typically have higher achievement scores.

Self-assessment and self-reflection are key traits of effective thinkers and problem solvers according to Daniels and Bizar (1998). Therefore, journal writing was included in the study in an effort to triangulate the assessment process, thereby providing a rich picture of student learning including growth, learning problems, and metacognitive reflection and thinking through the use of multiple measures. The use of learning logs or journals allowed the researchers to examine students' achievements from various perspectives. Entries in learning logs or journals enabled students to summarize, record or react to what they have learned. Further, the learning logs provided students with an opportunity to link present knowledge with new knowledge, reflect on what they had learned, and open a dialogue with the teacher. Fulwiler (1987) states, "When people write about something, they learn it better" (p. 9). Tomkins (1998) believes students not only think about what they are learning as they write in journals, they are also experimenting with connections between their past experiences and current instruction, and finding deficiencies in what they know and what they need to know.

The journal writing approach utilized in this study was in the form of a learning log in which students were asked to answer questions at the end of each lesson presented within the instructional unit. Tomkins (1990) and Romano (1987) listed several purposes for using learning logs with informal writing. These purposes included preparation for learning, recording observations and experiences, personalization of learning, exploration of different kinds of thinking, independent thought, engagement of the imagination and sharing thoughts with others. Space was also provided on each journal page for taking notes, making drawings, and constructing graphs. Thus, students were able to personally process information and make ideas their own. These entries were then reread and studied for the post test. Bromley (1993) states that learning logs facilitate further learning because of the individualized records of student learning they provide.

This study was to reexamine a study that was conducted at the end of a public school year involving achievement, attitudes toward science, and journal writings in a fourth grade classroom (Frederick & Shaw, 1998). Modifications, done to the previous study, were incorporated into the present study. The changes in the present study were the time completed, September as opposed to May, and additional direction given students for journal writings. Therefore, the purpose of the study was to reexamine the effects of the use of science manipulatives on achievement, attitudes toward science, and journal writings of fourth grade science students.

Methods

Participants

The sample consisted of 20 fourth-grade students in a suburban elementary school. The membership of each class included 55% male students and 45% female students of middle to upper class socioeconomic status. The classes were ethnically diverse with populations of approximately 55% white and 45% African-American students.

All science instruction was given by the same teacher. A crucial factor in the selection of this teacher was that she received training in the use of the FOSS Kit during Spring, 1997, and in follow up sessions which were provided in Fall of 1997 and 1998.

Materials

A Full Option Science System (FOSS) unit on electricity and circuits was presented to the students by the teacher. The procedures outlined in the FOSS kit were followed by the teacher. A 15 item test, which was included in the kit, was administered as a pretest and posttest. The test consisted of application and knowledge level questions about electricity and circuits. In addition, the researchers developed a 12 item attitude survey that was administered before and after the instruction. The attitude survey included items about the science content presented, instructional strategies, use of the FOSS kit, cooperative learning groups, and journal writing. The subjects responded to the survey via a modified Likert scale. In addition to the test and attitude survey, subjects were requested to reflect upon their participation by writing in journals. The study was conducted over a four week period during September and October of the 1999 - 2000 school year.

Results

Pre and Posttests

The achievement pre and posttest's data was analyzed using SPSS for descriptive statistics and a two-tailed t-test (see Tables 1 and 2). Significant differences occurred between the pre and posttests.

Content Analysis

As defined by Holsti (1969) a qualitative content analysis is the "drawing of inferences on the basis of appearance or nonappearance of attributes in messages" (p.10). Further, Berelson (1971) states that in qualitative content analysis the interest of the researcher will "lie less often in the content as such and more often in other areas to which the content is a cue, i.e., which it reflects or expresses or which is latent in the manifest content" (p.124). Qualitative content analysis includes not only the subjective opinion of a researcher about individual documents, but an objective description of the content based on the criteria or pre-established categories which depend on the researcher's interest in certain variables as well. Berelson (1952, p.18) states that content analysis is a research technique for the "objective, systematic, and quantitative description of the manifest content of communication."

A content analysis of the students' journals revealed both the quality and quantity of the reflective writing fluctuated appreciably over the duration of the instructional unit. Each student was given a journal which contained sixteen pages with three questions on each page. Each page had questions related directly to each of the 16 lessons in the unit. The questions were placed on the page so that drawings or other types of records could be included. Students had an opportunity to write in their journals following instruction. None of the students made an entry on pages six, seven, nine, 13, and 14. On all the other pages students had written entries, made diagrams or drawings, or both. The amount of words per page were counted and averaged and as were the drawings and diagrams. (see Table 3).

Attitude Survey

Data from the attitude survey were analyzed by calculating percentages of responses and means for each item (see Table 4). Students' responses from the survey indicated that they believed their grades in science were good, enjoyed learning science by themselves, would like a science career, learned safety rules for using electricity, and enjoyed studying about electricity. Results supported using science manipulatives as a means of increasing favorable responses towards science being their favorite subject, reading about science, science being fun, looking forward to science, science group activities, believing electricity is important, and journal writings.

Discussion

Results indicated that elementary students' achievements statistically increased with the use of the FOSS kit and appropriate instruction. The results were consistent with the goals of the curriculum and research involving use of science manipulatives with elementary students and findings by Weinburgh (1999) and Frederick and Shaw (1998).

Students' responses from the survey indicated that they believed their grades in science were good, enjoyed learning science by themselves, would like a science career, learned safety rules for using electricity, and enjoyed studying about electricity. Additionally, results indicated support for using science manipulatives as a means of increasing favorable responses towards science being their favorite subject, reading about science, science being fun, looking forward to science, science group activities, believing electricity is important, and journal writings. These findings are not consistent with recent research by Frederick and Shaw (1998). One possible factor influencing those outcomes was the instructional unit was taught in the end of the fourth quarter and was completed as the school year ended. The current research was conducted in the first quarter of the school year. The time of the year and/or the time of day instruction is provided may impact attitudes and achievement of students.

The incorporation of journal writing as a tool for reflection of student learning and participation in the activities yielded negative results in the original study by Frederick and Shaw (1998). In that study both the quality and quantity of the reflective writing varied as each lesson in the unit was presented, as evidenced by the writing on the journal pages which ranged from 0 to 176 words per page with the occasional diagram and/or graph. Also, with each progressive lesson, the handwriting became more and more careless, as did the spelling, grammar, and punctuation for most of the students even though a small number of students observed writing conventions and neatness throughout the instructional unit. In contrast, the journal writing in this study ranged from 0 to 90 words per page and had diagrams or drawings on almost every page used during the instructional unit. There was consistency in handwriting, spelling, grammar and punctuation from the beginning to the end of the journal. The variance in journal entries could be directly attributed to the overall academic ability and writing skills of individual students. In other words, each journal entry made by more able students tended to be complete and contained fewer spelling and grammar errors than the journal entries made by their less able peers.

The answers to the questions on the journal pages in the original study conducted by Frederick and Shaw (1998) were repetitive, with the individual students writing the same phrase or short sentence on each page of the journal. For example, "I will need this in my future." or "It will be on the test." as a response to "What I have learned today is important because..." . The results from this study yielded varied and detailed journal entries. As previously stated, the original study asked the same three questions for each part of the unit, while in this study the students were supplied with a variety of writing prompts and reflective questions directly related to each of the sixteen lessons presented. The results of making the above mentioned changes suggests that better results are achieved for journal writing through asking a variety of questions and providing writing prompts than using the same general open-ended questions for each journal entry without direct reference to the individual lesson being taught.

Another factor that may have contributed to the students' unengaged attitude toward the journals in the original study by Frederick and Shaw (1998) was the assignments that were copied from the board onto the back of the reflective thinking pages. This may have given the students the impression that the journal was more of a notebook to be turned in for a grade than a record of their thinking and learning. This study did not suggest a lack of interest in writing in the journals as was demonstrated in the original study. On the contrary, analysis of the journals in this study revealed that few pages were left blank, and the writing of incomplete sentences or short repetitive phrases were the exception rather than the rule.

For both studies, the journal entry that contained the greatest detail and apparent interest in writing and expressing ideas was the one immediately following a lesson on making your own flashlight. The students in both groups related very well to that lesson and most drew detailed diagrams of their flashlight plans. Additionally, students wrote elaborate plans for using these designs in their lives. These pages yielded the most variation in expression among the students in both groups. Additionally, the students in this study drew more diagrams and seemed to enjoy the lesson involving the wiring of a model house. The teacher presented it as a haunted house with ghosts and other spooky things living there which may account for the increased detail in written response from the students.

The increase in students' test scores suggests the FOSS kits were effective instructional tools for teaching science. The negative attitudes towards science and journal writings indicated by the responses given on the attitude survey may have implications for science educators at all levels. Longitudinal research needs to be done to determine if using science manipulatives has a negative impact on how students feel about science and journal writing. Therefore, replication of this study and additional research using the FOSS kit is recommended.

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Table 1

Descriptive Statistics of Pretest and Posttest

Descriptors	Pretest		Posttest	
	Sp	F	Sp	F
Sample size	45	20	45	20
Mean*	12.8	10.6	34.5	20.0
Standard deviation	4.73	3.73	6.08	6.38

*Out of a possible 40 points

Table 2

T-test for Pretest and Posttest

	Pre-Post Paired Differences	
	Sp	F
Mean	-21.71	-9.40
Standard deviation	5.96	5.99
Standard error of mean	.86	1.34
T-test	-25.23	-7.02
Degrees of freedom	44	19
Significance (Two-tailed)	.000	.000

Table 3

Totals and Average Words and Diagrams Per Page of the Students' Science Journals

Page Number	Total Words Per Page	Average Words Per Page	Total Diagrams Per Page	Average Diagrams Per Page
1	939	85.36	0	0
2	18	01.63	107	09.72
3	371	33.72	38	03.45
4	747	67.90	21	01.90
5	120	10.90	9	00.81
6	0	0	0	0
7	0	0	0	0
8	301	27.36	24	02.18
9	0	0	0	0
10	0	0	44	04.00
11	95	08.63	9	00.81
12	224	20.36	32	02.90
13	0	0	0	0
14	0	0	0	0
15	6	00.54	12	01.09
16	319	29.00	20	01.81

Table 4

Results in Percentages of the Science Attitude Survey

Items		Yes Sp	Yes F	Don't Know Sp	Don't Know F	No Sp	No F
1. Science is my favorite subject.	Pre*	49	70	33	10	18	20
	Post*	29	70	29	10	42	20
2. My grades in science are good.	Pre	49	75	42	25	9	0
	Post	69	85	31	15	0	0
3. Reading about science is easy for me.	Pre	58	85	18	5	24	10
	Post	27	95	29	5	44	0
4. Science is fun because we get to do fun things.	Pre	96	95	2	0	2	5
	Post	91	100	9	0	0	0
5. I look forward to science class.	Pre	78	70	11	25	11	5
	Post	67	80	22	15	11	0
6. I enjoy learning science by myself.	Pre	18	30	9	35	73	35
	Post	22	70	18	5	60	25
7. I enjoy learning science with a group.	Pre	84	85	7	15	9	0
	Post	80	65	7	25	13	10
8. I would like to have a career that uses science everyday.	Pre	31	40	49	30	20	30
	Post	36	45	31	25	33	30
9. I believe electricity is important.	Pre	96	95	4	5	0	0
	Post	91	100	2	0	7	0
10. I know safety rules when using electricity.	Pre	89	90	9	5	2	5
	Post	98	100	2	0	0	0
11. I enjoy studying about electricity.	Pre	44	80	36	15	20	5
	Post	62	95	27	5	11	0
12. I enjoy journal writing.	Pre	51	50	16	0	33	50
	Post	22	60	31	5	47	35

*Out of 100%
Sample size = 45 Sp/20 F

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