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HANDS-ON MANIPULATIVE USE IN SCIENCE INSTRUCTION

by
Bianca Lee Domenico

A Thesis

Submitted in partial fulfillment of the requirements of the
Master of Science in Teaching Degree
of
The Graduate School
at
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Approved by _____
Professor

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ABSTRACT

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HANDS-ON MANIPULATIVE USE IN SCIENCE INSTRUCTION
2002/03
Dr. Randall Robinson
Master of Science in Teaching

This study tested the use of physical manipulatives during science instruction –in conjunction with the traditional, textbook-oriented approach- and determines whether manipulatives create more significant learning experiences than text generates alone. The subject sample consisted of 20 third-grade students from a suburban New Jersey elementary school classroom. All subjects functioned at least on a third-grade level in all subjects with the exception of three students, who participated in the Talented and Gifted Program. Subjects from the experimental group and the control group completed a science content pretest of thirteen open-ended cognition questions. Both groups completed assigned activities, and subjects completed a science content posttest identical to the pretest. Tests of significance were used to analyze data, and the conclusions of the study indicate that the research findings were not significant enough to be applied to larger populations of students.

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Chapter One

SCOPE OF THE STUDY

Introduction

Mathematics, language arts and reading, science, and social studies receive the greatest emphasis in most elementary school curriculums. However, many elementary classroom teachers will admit to allotting only limited time for science instruction each week while carefully scheduling daily lessons in other subject areas (Van Horn, 1995). While one cannot deny the positive science instruction that takes place in many elementary school classrooms, educators must plan science instruction appropriately to create meaningful, memorable learning experiences (Waite-Stupiansky & Stupiansky, 1998).

Rationale of the Study

This research study tested the use of physical manipulatives during science instruction –in conjunction with the traditional, textbook-oriented approach that many teachers are familiar and comfortable with using- and determines whether this approach creates a more momentous learning experience than the traditional approach generates alone. This research addressed the lack of physical manipulation in many elementary school science curriculums. It also discussed research promoting the increase of physical manipulative use in both science instruction and the classroom in general.

The research conducted in this study examined the effects that physical manipulatives have on elementary school students during science instruction. In

particular, the mean posttest score is compared between an experimental group and a control group. The experimental group studied science concepts using physical manipulatives, and the control group studied the same science concepts using a traditional, textbook-oriented approach. The experimental, hands-on approach was used in conjunction with the traditional materials the control group used; that is, the hands-on approach was combined with the traditional approach and then compared with the traditional approach alone.

Statement of Hypotheses

In this research study the hands-on approach was tested against the traditional textbook-oriented approach to determine whether students who participate in hands-on science instruction experience significant achievements. The following research hypotheses guided the study:

1. Students who participate in hands-on science instruction will score significantly higher science content posttest scores than they will score on science content pretests.
2. Students who participate in hands-on science instruction will score significantly higher science content posttest scores than students participating in the textbook-oriented science instructional approach.

Limitations of the Study

A number of limitations, or factors that affected the validity and reliability of the results, were present within this research study. For example, both the experimental group and control group in this study were students in one third-grade classroom studying the same solar system content, which can be associated with validity within the study. However, the experimental group completed hands-on activities at the same time and in the same room that the control group completed textbook-oriented activities. Therefore,

disturbances to the control group may have affected the validity of the results. In addition, learning differences among the students, such as varying reading comprehension levels and aversion to open-ended questioning formats, may have additionally affected both the validity and reliability of the results.

Also, because this research study was conducted with students in only one third-grade classroom, the results may not be applicable to any population of students outside of that particular classroom. In other words, the results of this research should not be assumed to be directly indicative of how other third-grade students, elementary students, or other student populations would benefit from using hands-on or textbook-oriented instructional approaches.

Operational Definitions of Terms

A number of unfamiliar terms were used to explain both the literature examined and the procedures used in this research study. The following operational definitions explain how these terms were intended to be understood:

Physical manipulatives- Any instructional material that requires management and manipulations by the student rather than lecture or demonstration by the teacher.

Textbook-oriented approach- An instructional method that relies heavily on lecture. Demonstration, reading, writing or note-taking, and other such teacher-directed activities are frequently used with this approach.

Hands-on approach- An instructional method that relies heavily on student use of physical manipulatives. This approach combines physical manipulation with various aspects of the textbook-oriented approach. For example, students using the hands-on approach may read information from a textbook and then complete learning center activities independently or with a small group.

Chapter 2

REVIEW OF THE LITERATURE

Introduction

This research study addressed the lack of physical manipulation in many elementary school science curriculums and introduced the need for the increased use of physical manipulatives in elementary science instruction. In addition, limitations of the study were discussed, and operational definitions of terms were explained.

One hypothesis guiding this research study stated that students who participated in hands-on science would score significantly higher science content posttest scores than they would score on science content pretests. Another hypothesis stated that students who participated in hands-on science would score significantly higher science content posttest scores than students participating in the textbook-oriented instructional approach.

Disadvantages of Current Science Instruction and Assessment

The United States' instructional techniques in the sciences have been condemned as providing students with far too many facts and not nearly enough ideas (Hardy, 1998). Unlike science instruction in Japan and other countries, where students learn fewer concepts over longer periods of time, the Third International Mathematics and Science Study (TIMSS) indicates that our nation's students learn numerous unrelated facts instead of focusing on significant concepts (Hardy).

As cited by Nabors (1999), "teachers can sometimes be in a rut when it comes to teaching science" (p. 744). Charnetski, an elementary school teacher, admitted finding science intimidating and unfulfilling throughout her career (Voyles & Charnetski, 1994).

In fact, so many elementary school teachers are anxious about fruitless strategies and insufficient materials that they often neglect to include science instruction into their plans on even a weekly basis (Van Horn, 1995). “Elementary teachers seem to know that it is futile to attempt to teach science without appropriate stuff, so most of them don’t even try” (Van Horn, p. 787). In addition, problem-solving skills imbedded in science instruction are often problematic for students because they are based on adults’ false impressions of what elementary-aged children can do and also because they do not meet younger students’ needs to “explore the world” (Hein, 1987, p. 9).

The content-oriented approach which, according to Mastropieri and Scruggs (cited in Scruggs & Mastropieri, 1995) is the common instructional strategy in public schools, employs dialogue and reading-based materials such as texts, and it often neglects to incorporate experimentation unless it is mainly for demonstration (para. 5). Although many textbooks provide teachers and students with trials and experiments, few of them can be considered hands-on activities (Voyles & Charnetski, 1994). These types of activities are exactly what students need to succeed in science. For this reason, Minnesota has created statewide standards that function under the belief that students learn science better when they do hands-on work with the concepts, and the importance of lecture is minimized (Hardy, 1998).

Ineffective techniques are not the only problems that science instruction faces. The common pencil-and-paper assessments do not accurately test students’ knowledge of science, even if hands-on techniques actually are used. According to Hein (1987), students who studied science with the Elementary Science Study program, which employed many manipulative-based activities, learned accurate information from their

lessons but responded to standardized test questions incorrectly; the students were required to complete nonrepresentational test exercises rather than ones similar to their actual experiences and observations. Many standardized test designs do not allow students to demonstrate their ability to “interact with the stuff of the world” (Hein, p. 8). For example, multiple-choice questions do not permit students to freely clarify answers but instead provide students with a number of possible solutions, only one of which is considered correct by the test creators; this questioning strategy also does not generally test all of the science information with which students are presented (Hein). In addition, the science portions of many standardized tests may be “flawed by one or more ambiguous or incorrect items” (Hein, p. 8).

Overall, “more passive... multiple-choice and short-answer paper and pencil tests” (Shymansky & Chidsey, 1997) do not allow students to perform activities that really represent science concepts and principles (para. 10). Because “observation, manipulation of various kinds..., problem-solving strategies, and higher-order thinking skills” (Hein, 1987) often have incomplete or absent definitions, these skills tend to be poorly tested (p. 9).

Advantages of Hands-On Science Instruction

According to Dorward (2002), a “considerable collection of published opinion and research promotes and supports the use of physical manipulatives in mathematics instruction” (p. 329). For example, Sowell, who investigated numerous research studies on manipulative use, stated that “mathematics achievement is increased through the long-term use of concrete instructional materials and... students’ attitudes toward mathematics are improved when they have instruction with concrete materials...” (cited in Dorward, p.

329). Also, Saycki, Ueno, and Nagasaka found that Japanese elementary school students' comprehension increased after using hands-on materials to learn mathematics principles such as area (cited in Ritchie & Volkl, 2000, p. 84). Overall, many researchers argue that students should be active participants in their learning process, and teachers should guide students through their experiences (Ritchie & Volkl, p. 83).

Just as endless research shows that hands-on opportunities benefit students in mathematics, students must also have opportunities to develop and apply inquiry skills if they are ever to succeed in science (Kim & Barrow, 1999). Such advantageous opportunities include “direct interaction and experimentation with scientific materials... [and] the use of ‘performance-based’ assessment procedures”, all of which may also benefit students with difficulty in school (Scruggs & Mastropieri, 1995, para. 17). For example, students with behavioral disorders, whose deficiencies in mathematics and science can be worse than learning disabled students', have much to gain from hands-on science activities (Scruggs & Mastropieri). Manipulative use “could conceivably increase the awareness of students with [behavioral disorders] of their role in the world” and may help them better understand “cause-and-effect relationships in nature” (Scruggs & Mastropieri, para. 3). Such academic improvements may also equip these students with the necessary tools for behaving responsibly and appropriately in school and in the community.

Besides getting students involved, manipulative use helps students focus on concepts being studied and “stretch their thinking” (Waite-Stupiansky & Stupiansky, 1998, Integrating Manipulatives and Other Tools section). This instructional approach has also resulted in “observed improvement in student motivation and attitudes” by

teachers (Dorward, 2002, p. 331). Overall, hands-on science teaches students to eventually shift from concrete understanding to abstract understanding, which helps them better retain information (Hardy, 1998). In turn, students learn ways in which to use science in their daily lives (Voyles & Charnetski, 1994).

A key example of successful science instruction is Minnesota's statewide implementation of hands-on science programs (Hardy, 1998). In the TIMSS, Minnesota competed against the United States and numerous other countries, where the state's eighth graders scored significantly higher than the entire United States in science and tied Singapore for the highest earth science score (Hardy). Reinitz, a Minnesota biology teacher, points out that the state's science activities teach various elements of the scientific method, such as inquiry, exploration, and inference (Hardy). According to Nabors (1999), a poll concluded that most elementary school principals support the use of hands-on science activities in the classroom. These administrators more than likely realize that adopting manipulative-based methods may be necessary to obtain achievements similar to Minnesota's.

Hands-On Strategies and Materials

“The activities-oriented approach typically employs scientific materials and apparatus to allow students to observe scientific phenomena first-hand” (Scruggs & Mastropieri, 1995); this type of instruction eliminates dependence on texts and vocabulary and is mostly implemented in elementary school, where students profit from physical practice (para. 5). The materials used with this instructional method include “interest center activities, teaching pictures, puzzles, ...games, storybooks, ...and all the other hands-on things that elementary school teachers need in order to do their job (Van

Horn, 1995, p. 786). The following resources and methods, which are only a few of the numerous existing measures, are available to assist elementary school teachers in successfully implementing hands-on science in their classrooms.

Computer-Based Manipulatives. The National Science Foundation (NSF) and the National Council of Teachers of Mathematics (NCTM) support the use of computer versions of commonly employed mathematics manipulatives (Dorward, 2002). While the use of hands-on materials “has been shown to increase student achievement [, virtual] manipulatives enhance physical manipulatives” (Dorward, p. 330). Benefits of computer manipulatives include easier review of student work, effective material organization, and availability of materials to students outside of the classroom (Dorward). Research suggests that students using virtual manipulatives are more successful than students using only physical materials or none at all (Dorward).

Community Involvement. In an effort to cause students to think about science outside of the classroom, Minnesota teachers from hundreds of schools plan trips to amusement parks, where students measure such physics principles as acceleration, force, and friction while enjoying rides (Hardy, 1998). Activity-based science instruction that takes place in actual community areas, such as “neighborhoods, parks, ponds, forests, libraries, the town hall, courtrooms, [and] businesses”, prepares students for participation in society (Van Horn, 1995, p. 788), as well as illustrates ways in which students use science in their daily lives.

Assessment. It seems that the most effective approach to assessing students’ achievement with hands-on learning is observation of their performance (Hein, 1987). Performance assessments have been used throughout history to observe progress and

products in art and numerous vocations (Shymansky & Chidsey, 1997). As suggested by Meyer, “Performance assessment refers to a broad set of strategies that allows an examiner to observe what a student knows and can do when confronted with problems in context” (cited in Shymansky & Chidsey, para. 8). In other words, appropriate assessment of students’ achievement with hands-on science includes examining the products they create and the manner in which they manipulate various materials (Hein).

Teachers who employ performance tests as a component of their hands-on science programs should use this assessment technique as a means of illustrating and directing instructional activities in order to reach all students’ abilities (Shymansky & Chidsey, 1997). However, clearer instructional standards will help teachers recognize advanced performances so that they may urge all students to aim towards higher levels of science achievement (Hein, 1987). Educators who find implementation of performance assessments difficult may choose to alter pencil-and-paper science tests so that they include open-ended questions, which “provide teachers with insight into the students’ thinking” and, since most students’ responses tend to be similar, “[allow] for reasonably easy compilation of the answers” (Hein, 1987, p. 11).

Teacher and Student Roles. Simple modifications to the roles both educators and students play in the science classroom may prove beneficial to the learning process. For example, team teaching not only provides partners with opportunities to investigate new topics and explore various instructional techniques, but it may also rejuvenate teachers and stimulate students (Voyles & Charnetski, 1994). Students also benefit from experiencing such hands-on techniques as tutoring, which give them meaningful opportunities to practice what they’ve learned; “you never really know something until

you've learned it twice – once when you learn it, and once when you teach it” (Van Horn, 1995, p. 788).

Expectations for Implementation

As with any other instructional method, many educators and researchers have discovered a number of weaknesses to the hands-on approach. Research has found few classrooms that employ hands-on materials due to difficulty in “classroom management; structuring, monitoring, and assessing the use of manipulatives” (Dorward, 2002, p. 329). According to Scruggs and Mastropieri (1995), “there are potential disadvantages to activities-oriented approaches. Specifically, the reduced structure of hands-on lessons, the number and variety of manipulative objects, and the amount of physical activity and stimulation may lead to increased behavior problems” (para. 18).

In addition to maintaining a positive classroom environment, teachers must pay close attention to students' participation in hands-on activities to be certain that they are intellectually involved as well as physically involved in their work (Waite-Stupiansky & Stupiansky, 1998). Students' intellectual participation is essential to their success, for Ritchie and Volkl (2000) point out that students who explore a concept through manipulation before understanding all components of the idea may only understand certain elements of hands-on activities rather than “adequately [comprehending] the big picture” (p. 89).

Teachers who use manipulatives during science instruction often feel as though they cannot effectively manage and plan for hands-on activities. According to Charnetski, “there [is] a significant gap between the workshops... and the reality of one adult and a classroom of second graders” (Voyles & Charnetski, 1994, p. 25). Even the teachers who

benefit from workshops and successfully implement hands-on science into their classrooms will find that merely planning their lessons may be overwhelming, for they must always plan substitute activities to gainfully employ students when misbehavior disrupts the hands-on work or when students find the activities too difficult (Scruggs & Mastropieri, 1995).

While some educators are not concerned with classroom management or planning, most are aware of the out-of-pocket money they'll spend simply equipping their classrooms with the most basic manipulative materials. Most schools and districts do not offer teachers a large enough yearly budget to help them buy the materials necessary for implementing hands-on programs (Van Horn, 1995). Teachers recognize that many useful hands-on materials that they'd like to use with their students, such as Montessori manipulatives, are too expensive for them to buy themselves for their classrooms, so they often dismiss hands-on science as an instructional option (Van Horn).

Some researchers have also suggested that certain manipulative materials and hands-on strategies do not generate the achievements that teachers hope to observe. For example, research studies have shown that computer manipulatives may not necessarily increase student success (Dorward, 2002). Sixth grade teachers participating in a study found that the achievements of students using computer manipulatives were not significantly higher than those of students using similar physical materials or no manipulatives at all (Dorward). Also, teachers, students, and parents agree that performance assessments tend to be more complicated for students, even when the science content on performance assessments and multiple-choice tests are equally difficult (Shymansky & Chidsey, 1997).

In summary, researchers and educators may discover that difficulties managing student behavior and accurately assessing hands-on approaches create classroom environments where manipulative use can be overwhelming (Dorward, 2002). However, despite some of the limitations of manipulative-based instruction, educators such as the teachers in Minnesota agree that hands-on science stimulates the learning environment and equips students with useful skills (Hardy, 1998).

Chapter Three
METHODOLOGY

Introduction

This research study addressed the lack of physical manipulation in many elementary school science curriculums and introduced the need for the increased use of physical manipulatives in elementary science instruction. In addition, limitations of the study were discussed, and operational definitions of terms were explained.

One hypothesis guiding this research study stated that students who participated in hands-on science would score significantly higher science content posttest scores than they would score on science content pretests. Another hypothesis stated that students who participated in hands-on science would score significantly higher science content posttest scores than students participating in the textbook-oriented instructional approach. A review of the literature relevant to this topic discussed the advantages of hands-on science instruction and suggested hands-on strategies and materials available to teachers.

Description of Sample

In this study, the population of interest was a suburban New Jersey elementary school classroom of third-grade students. A sample of 20 students was conducted in this classroom from a total student population of 25 students. The students in the total population ranged in age from eight to nine years.

The total population of students was randomly assigned to either the experimental group or the control group. All twenty-five of the students, however, were not present during science instruction and, therefore, were unable to participate in this study.

Therefore, the sample was composed of the students available to participate in science instruction during the time that the research took place. Within the sample, eleven of the students (55%) were female, and nine of the students (45%) were male. All of the students in this sample were functioning at least on a third-grade level in all subjects with the exception of three students. These students were excused from class for ninety minutes per week for the Talented and Gifted program. However, all three students were available to participate in the research.

Design of the Study

Data was analyzed in terms of the pretest and posttest scores. In both the experimental group and the control group, a mean pretest score and a mean posttest score was found. For the first hypothesis, which proposed that students who participated in the hands-on science instructional approach would score significantly higher science content posttest scores than they would score on science content pretests, a paired samples t-test was used.

For the second hypothesis, which proposed that students who participated in hands-on science would score significantly higher science content posttest scores than students participating in the textbook-oriented instructional approach, an independent samples t-test was used.

Procedure

The subjects in this research study were randomly divided into an experimental group and a control group. The researcher taught both the experimental group and the control group. All subjects were given the same pretest (see appendix A), which tested their existing knowledge of the science content that they investigated in the lessons.

The researcher then taught the same solar system topics, which included stars and constellations, to both groups. The experimental group then studied the topics using a hands-on approach. These subjects learned all skills and concepts by first reading information from text and then exploring physical manipulatives before completing the posttest. The control group, in contrast, studied the topics using the textbook-oriented instructional approach. The subjects learned all skills and concepts directly from text and did not complete manipulative activities before completing the posttest (see appendix B for lesson plans).

All students were given the same posttest (see appendix A), which was identical to the pretest. This posttest tested their increase in knowledge of the science content that they investigated in the activities.

Description of the Instrument

The data collection instruments in this study were a pretest and a posttest (see appendix A). The pretest asked questions prior to the lessons identical to the posttest questions asked upon completion of the lessons. The general format of these tests was thirteen open-ended cognition questions on the concepts and skills presented in the text and activities. The questions covered the topics of stars and constellations.

Chapter Four
ANALYSIS OF FINDINGS

Introduction

This research study addressed the lack of physical manipulation in many elementary school science curriculums and introduced the need for the increased use of physical manipulatives in elementary science instruction. In addition, limitations of the study were discussed, and operational definitions of terms were explained.

One hypothesis guiding this research study stated that students who participated in hands-on science would score significantly higher science content posttest scores than they would score on science content pretests. Another hypothesis stated that students who participated in hands-on science would score significantly higher science content posttest scores than students participating in the textbook-oriented instructional approach. A review of the literature relevant to this topic discussed the advantages of hands-on science instruction and suggested hands-on strategies and materials available to teachers. The population of interest was a suburban New Jersey elementary school classroom of third-grade students, and a sample of 20 students was conducted in this classroom. Within the sample, eleven of the students (55%) were female, and nine of the students (45%) were male. All of the students in this sample were functioning at least on a third-grade level in all subjects with the exception of three students, who were excused from class for ninety minutes per week for the Talented and Gifted program. The students were randomly divided into an experimental group and a control group.

The mean posttest score for the students participating in hands-on science was found to be significantly higher than the mean pretest score. Also, the mean posttest score for the students participating in hands-on science was not found to be significantly higher than the mean posttest score for the students participating in the textbook-oriented approach. Therefore, the first hypothesis guiding this study can be asserted, and the second hypothesis guiding this study fails to be asserted.

Tabulation of Raw Scores

A paired samples t-test was used to verify the first hypothesis, which stated that students who participated in the hands-on science instructional approach scored significantly higher on science content posttests than they scored on science content pretests. Where $t = -4.797$, the mean pretest score for the experimental group, who participated in the hands-on science instructional approach (n , or sample size, = 11), was 14.64% with a standard deviation (SD) of 10.98. The mean posttest score was 45.55% with a standard deviation of 29.09 (see table 1). The p-value was .001 at the critical alpha level of .05 and, therefore, it was found that the mean posttest score for the students who participated in the hands-on science instructional approach was significantly higher than the mean pretest score for the experimental group. Thus, the first hypothesis guiding this research study can be asserted.

An independent samples t-test was used to verify the second hypothesis, which stated that students who participated in the hands-on science instructional approach scored significantly higher on science content posttests than students participating in the textbook-oriented instructional approach. Where $t = -0.119$, the mean posttest score for the experimental group, who participated in the hands-on science

table 1
Experimental Group Pretest and Posttest Data

Tests	Scores	Mean	n	SD
Pretest	8	14.64	11	10.98
	0			
	15			
	15			
	8			
	8			
	38			
	15			
	31			
	8			
	15			
Posttest	23	45.55	11	29.09
	15			
	62			
	31			
	8			
	46			
	92			
	31			
	77			
	31			
	85			

instructional approach (n = 11), was 45.55% with a standard deviation of 29.09. The mean posttest score for the control group, who participated in the textbook-oriented instructional approach (n = 9), was 47% with a standard deviation of 24.85 (see table 2). The p-value was .907 at the critical alpha level of .05 and, therefore, it was found that the mean posttest score for the students who participated in the hands-on science instructional approach was not significantly higher than the mean posttest score for the students who participated in the textbook-oriented instructional approach. Thus, the second hypothesis guiding this research study fails to be asserted.

table 2
Experimental Group and Control Group Posttest Data

Group	Posttest	Mean	n	SD
Experimental	23	45.55	11	29.09
	15			
	62			
	31			
	8			
	46			
	92			
	31			
	77			
	31			
	85			
Control	69	47	9	24.85
	77			
	46			
	23			
	31			
	15			
	23			
	77			
	62			

In addition to these results, a paired samples t-test also showed that the mean posttest score for students in the control group, who participated in the textbook-oriented instructional approach, was significantly higher than the mean pretest score for the control group. These findings, however, are not applicable to either of the hypotheses guiding this research study.

Chapter Five

SUMMARY, CONCLUSIONS, AND RECOMMENDATIONS

Introduction

This research study addressed the lack of physical manipulation in many elementary school science curriculums and introduced the need for the increased use of physical manipulatives in elementary science instruction. In addition, limitations of the study were discussed, and operational definitions of terms were explained.

One hypothesis guiding this research study stated that students who participated in hands-on science would score significantly higher science content posttest scores than they would score on science content pretests. Another hypothesis stated that students who participated in hands-on science would score significantly higher science content posttest scores than students participating in the textbook-oriented instructional approach. A review of the literature relevant to this topic discussed the advantages of hands-on science instruction and suggested hands-on strategies and materials available to teachers. The population of interest was a suburban New Jersey elementary school classroom of third-grade students, and a sample of 20 students was conducted in this classroom. Within the sample, eleven of the students (55%) were female, and nine of the students (45%) were male. All of the students in this sample were functioning at least on a third-grade level in all subjects with the exception of three students, who were excused from class for ninety minutes per week for the Talented and Gifted program. The students were randomly divided into an experimental group and a control group.

The mean posttest score for the students participating in hands-on science was

found to be significantly higher than the mean pretest score. Also, the mean posttest score for the students participating in hands-on science was not found to be significantly higher than the mean posttest score for the students participating in the textbook-oriented approach. Therefore, the first hypothesis guiding this study can be asserted, and the second hypothesis guiding this study fails to be asserted.

Summary of the Problem

According to Van Horn (1995), many elementary teachers admit to scheduling only weekly science lessons but plan daily lessons in other subject areas. More importantly, elementary teachers often neglect teaching science even on a weekly basis because they are apprehensive about instructing their students without the proper resources (Van Horn). When educators do plan science instruction, they commonly exercise the content-oriented approach, which employs text-based materials and neglects to integrate hands-on instructional techniques unless the teachers themselves are presenting demonstrations (Mastropieri & Scruggs, 1995, para. 5).

While many elementary teachers may be aware of the potentially beneficial results of hands-on science instruction, weaknesses of this instructional technique include difficulty with classroom management and assessment (Dorward, 2002). Teachers are overwhelmed by the amount of planning that is required for hands-on science lessons (Scruggs & Mastropieri, 1995). In addition, educators are concerned about the out-of-pocket expenses they'll suffer as they attempt to purchase basic manipulatives for their classrooms with little help from their school budgets (Van Horn, 1995).

As a result of this problem, this research discussed the need for the increased use of physical manipulatives in elementary science instruction. A number of hands-on

strategies and materials that teachers may find useful were recommended, as well.

Summary of Hypotheses

In this research study the hands-on approach to science instruction was compared to the traditional textbook-oriented approach to science instruction. The following research hypotheses guided the study:

1. Students who participate in hands-on science instruction will score significantly higher science content posttest scores than they will score on science content pretests.
2. Students who participate in hands-on science instruction will score significantly higher science content posttest scores than students participating in the textbook-oriented science instructional approach.

Summary of the Procedure

The total population of 25 third-grade students was randomly assigned to either the experimental group, which studied science content using the hands-on instructional approach, or the control group, which studied the same science content using the textbook-oriented approach. However, because five students were unavailable to participate in the study, the sample used consisted of 20 third-grade students.

All subjects were given the same pretest (see appendix A), which tested their existing knowledge of the science content that they investigated. The research then taught both the experimental group and the control group lessons on stars and constellations. The experimental group employed the hands-on approach by first reading information from text and then exploring physical manipulatives. The control group employed the textbook-oriented approach by reading information from text without exploring any physical manipulatives (see appendix B for lesson plans). After the students had completed the lessons, all subjects were given the same posttest (see appendix A), which

was identical to the pretest and tested their increase in knowledge of the investigated science content.

Summary of the Findings

A paired samples t-test was used to verify the first hypothesis, which stated that students who participated in the hands-on science instructional approach (the experimental group) scored significantly higher on science content posttests than they scored on science content pretests. The mean pretest score for the experimental group ($n = 11$) was 14.64% with a standard deviation of 10.98. The mean posttest score for the experimental group was 45.55% with a standard deviation of 29.09. The p-value was .001 at the critical alpha level of .05 and, therefore, the mean posttest score for the experimental group was significantly higher than the mean pretest score. The first hypothesis guiding this study can be asserted.

An independent samples t-test was used to verify the second hypothesis, which stated that students who participated in the hands-on science instructional approach (the experimental group) scored significantly higher on science content posttests than students participating in the textbook-oriented instructional approach (the control group). The mean posttest score for the experimental group was 45.55% with a standard deviation of 29.09. The mean posttest score for the control group ($n = 9$) was 47% with a standard deviation of 24.85. The p-value was .907 at the critical alpha level of .05 and, therefore, the mean posttest score for the experimental group was not significantly higher than the mean posttest score for the control group. The second hypothesis guiding this study fails to be asserted.

Implications and Recommendations

The results of this research indicate that students who participate in hands-on instructional approaches to science content will score significantly higher on posttests than on pretests. However, as was discussed in the *Tabulation of Raw Scores* section of Chapter Four, a paired samples t-test also showed that the mean posttest score for students in the control group was significantly higher than the mean pretest score. These results indicate that students who participate in the textbook-oriented instructional approach to science content will also score significantly higher on posttests than on pretests.

In addition, the results of this study indicate that students participating in hands-on instructional approaches to science content will not score significantly higher on posttests than students participating in the textbook-oriented instructional approach. In fact, the mean posttest score for the experimental group (mean = 45.55) was actually lower than the mean posttest score for the control group (mean = 47).

Despite previous research, the findings of this study do not implicate that the hands-on approach was a more successful instructional method with this particular sample of third-grade students than the textbook-oriented approach. These implications, however, should not be misunderstood to negate previous research in this area, for this particular study was conducted with a very small sample of students in one elementary school classroom. Therefore, the results of this research should not be applied to any population of students outside of that particular elementary school classroom.

There are a number of recommendations for researchers interested in repeating the procedures used in this research study. First, researchers should consider separating

the experimental group from the control group while research is taking place. Although subjects' performances may be affected by dissimilar learning environments or varying times that lessons are taught to each group, the distractions that the students in this particular study suffered may have been far worse. In addition, the researcher in this study was unavailable to assist and observe the subjects in both groups because of the number of activities taking place at one time.

Also, it will undoubtedly be beneficial for researchers to have a much larger sample of elementary school students, perhaps from different grade levels and several schools in a particular region. This may ensure that the results could be applied to a larger population of elementary school students.

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Appendix A
PRETEST AND POSTTEST

Stars and Constellations Pretest

Directions: Read each question carefully. Then, write your best answer in 1-2 complete sentences. When you are finished, check your answers.

1. When we look at the night sky, why do the stars look so small? _____

2. What is the closest star to our planet? _____

3. About how far is the sun from Earth? _____

4. Why wouldn't you be able to live on a star? _____

5. Explain what the surface of a star looks like. _____

6. a) What are the biggest stars called? _____

b) What are the smallest stars called? _____

c) Compared to other stars, how big is the sun? _____

7. Why are scientists so interested in the different colors of stars? _____

8. What are constellations? _____

9. a) What is the name of one constellation? _____

b) What does the constellation look like? _____

c) When can we see this constellation? _____

Stars and Constellations Posttest

Directions: Read each question carefully. Then, write your best answer in 1-2 complete sentences. When you are finished, check your answers.

1. When we look at the night sky, why do the stars look so small? _____

2. What is the closest star to our planet? _____

3. About how far is the sun from Earth? _____

4. Why wouldn't you be able to live on a star? _____

5. Explain what the surface of a star looks like. _____

6. a) What are the biggest stars called? _____

b) What are the smallest stars called? _____

c) Compared to other stars, how big is the sun? _____

7. Why are scientists so interested in the different colors of stars? _____

8. What are constellations? _____

9. a) What is the name of one constellation? _____

b) What does the constellation look like? _____

c) When can we see this constellation? _____

Appendix B
LESSON PLANS

Stars and Constellations

Every night when you look at the sky, you can see many small, bright lights that we call stars. Stars look really small to us here on Earth, but they are actually very large. The reason that they look so tiny is because they are millions, or even *trillions*, of miles away from us. The sun is the closest star to our planet, but it is still 93 million (93,000,000) miles away! The next closest star after the sun is call Alpha Centauri, and it is 26 trillion (26,000,000,000,000) miles away!

Although it would be fun to visit a star you would not be able to get very close to one. This is because all stars are large, round balls of very hot gases called hydrogen and helium. These gases swirl around and cause stars to become so hot that flames actually leap up from their surfaces. Because all stars are so hot, nothing can live on them. However, as star's heat can help living things on other planets. For example, the sun (which can be about 27 million (27,000,000) degrees Fahrenheit at its center) helps keep Earth warm and people, plants, and animals alive.

The sun probably seems like it's a very big star, but it is actually only a medium-sized one. The biggest stars are called supergiants, and the smallest stars are called white dwarfs.

Scientists like to study stars' sizes and colors. The color of a star can tell scientists how hot it is. The hottest stars are usually white, and the coolest stars are usually red. Stars can also be black, blue, orange, or yellow.

Scientists aren't the only ones who like to observe the sun and other stars. Throughout history, people around the world connected the stars into shapes of people and animals, and they would make up stories about these pictures in the sky. Today, we

call these patterns of stars constellations. We can see different constellations at different times of year. For example, Orion the Hunter can be seen during the winter while Leo the Lion is a spring constellation. Also, the Signs of the Zodiac are 12 different constellations in the sky that represent the path that the sun, moon, and planets travel during the year. Each 'sign' can be seen during different months.

Stars and Constellations

Experimental Group Lesson Plans

Lesson #1

Objective: After completing a pretest, students will independently read information about stars from text and complete hands-on activities. If students are unable to read the text independently, the researcher/teacher may choose to have the students read the text aloud.

Materials: Materials necessary for each student to participate in this lesson include the Stars and Constellations Pretest, a pencil, the Stars and Constellations text, a globe, a yellow rubber ball or foam ball, 10 rulers, white drawing paper, crayons, and encyclopedia, picture book, or Internet pictures of stars' surfaces.

Introduction:

1. Ask students to imagine that it is nighttime and that they are looking up at the sky. Ask them to talk about some of the things they might see.
2. Explain to students that they will be learning some new and interesting information about stars and constellations over the next two lessons.
3. Also, explain to students that in addition to reading about stars and constellations and completing activities, they will be taking a pretest and a posttest. Remind the students that they should be sure to do their best work on these tests. *If these lessons will not be counted towards a grade for the students, the researcher/teacher may reassure students of this.
4. Have students clear everything from their desks except for a pencil, and pass out the pretests. Read the directions aloud with the students, and answer any

questions about the pretest. When students have completed the pretests, have them check their answers and then hand them into the researcher/teacher.

Development:

1. Have students clear everything from their desks, and pass out the text. Have the students independently read only the first four paragraphs of the text. *The researcher/teacher who has beginning or struggling readers may decide to have students read the text aloud. The researcher/teacher *should* help struggling readers with unfamiliar words –even if the rest of the students are reading independently- so they do not misunderstand the information within the text.
2. After students have completed reading the text, ask if they have any questions about the information they just read. Answer questions clearly, but limit class discussion so that the teacher/teacher can be certain that students have learned any new information from the text. *The researcher/teacher *should not* use resources other than the text to answer questions.
3. Direct students to the areas of the room where the three hands-on activities are. Read each activity aloud to the students, and show them the correct materials that are necessary for completing each activity. Have students complete all three activities. *The researcher/teacher should monitor the students completing the activities in order to ensure that all students are displaying appropriate behavior and are completing the activities in a timely fashion.

Summary & Evaluation:

1. Using the text and the activities, ask students a few questions that require them to recall information learned from the text and activities. Students may use the text to find answers to the questions. If students struggle with questions, have them locate the information in the text and read it aloud to the class.

Stars Activity #1

Materials Needed for This Activity:

A globe, a yellow ball, and some rulers.

The closest star to Earth, which is the sun, is still 93 million miles away! Show how far the sun is from Earth by using the globe, the yellow ball, and some rulers. Put the globe at one end of the room. Then, pretend that one inch equals 1 million miles. Measure 93 million miles (or 93 inches) from the globe, and place the yellow ball there. Now you can see a smaller version of how far the sun is from Earth!

Stars Activity #2

Materials Needed for This Activity:

A pencil, crayons, white drawing paper,
and a picture of a star's surface.

The surface of a star is very hot! In fact, a person could never visit a star because flames shoot out from their surfaces. Imagine that scientists invented a spacesuit that would let you visit a star without getting burnt. Draw what you think the surface of a star might look like up close. Then, look at the picture of a star's surface to see how close you were. Fix your picture so that it is drawn correctly.

Stars Activity #3

Materials Needed for This Activity:

A pencil, crayons, and white drawing paper.

The biggest stars are called *supergiants*, and the smallest stars are called *white dwarfs*. The hottest stars are usually white, and the coolest stars are usually red. The sun is an average star, which means that it isn't too large or too small. Draw what you think a red supergiant looks like.

Write a sentence about its size and temperature. Draw what you think a white dwarf looks like. Write a sentence about its size and temperature. When you are finished, compare your inferences with someone else's.

Stars and Constellations

Experimental Group Lesson Plans

Lesson #2

Objective: Students will independently read information about constellations from text and complete hands-on activities before completing a posttest. If students are unable to read the text independently, the researcher/teacher may choose to have the students read the text aloud.

Materials: Materials necessary for each student to participate in this lesson include the Stars and Constellations Posttest, a pencil, the Stars and Constellations text, black construction paper, white and blue chalk, and encyclopedia, picture book, or Internet pictures of Orion the Hunter and Leo the Lion.

Introduction:

1. Ask students to recall some of the information they learned about stars in the last lesson. Explain to students that they will be learning about constellations in this lesson.
2. Also, explain to students that in addition to reading about constellations and completing activities, they will be taking a posttest. Remind the students that they should be sure to do their best work on this test, just as they did on the pretest. *If these lessons will not be counted towards a grade for the students, the researcher/teacher may reassure students of this.

Development:

1. Have students clear everything from their desks, and pass out the text. Have the students independently read the final paragraph of the text. Allow students

to reread the entire text when they have finished. *The researcher/teacher who has beginning or struggling readers may decide to have students read the text aloud. The researcher/teacher *should* help struggling readers with unfamiliar words –even if the rest of the students are reading independently- so they do not misunderstand the information within the text.

2. After students have completed reading the text, ask if they have any questions about the information they just read. Answer questions clearly, but limit class discussion so that the teacher/teacher can be certain that students have learned any new information from the text. *The researcher/teacher *should not* use resources other than the text to answer questions.
3. Direct students to the area of the room where the hands-on activity is. Read the activity aloud to the students, and show them the correct materials that are necessary for completing this activity. Have students complete the activity.
*The researcher/teacher should monitor the students completing the activity in order to ensure that all students are displaying appropriate behavior and are completing the activity in a timely fashion.

Summary & Evaluation:

1. Using the text and the activity, ask students a few questions that require them to recall information learned from the text and activity. Students may use the text to find answers to the questions. If students struggle with questions, have them locate the information in the text and read it aloud to the class.
2. Have students clear everything from their desks except for a pencil, and pass out the posttests. Read the directions aloud with the students, and answer any

questions about the pretest. When students have completed the pretests, have them check their answers and then hand them into the researcher/teacher.

Constellations Activity

Materials Needed for This Activity:

Pictures of Orion the Hunter and Leo the Lion, black construction paper, white and blue chalk, and some rulers.

Think of some of the constellation names that you've heard before. Have you ever found that constellation in the sky?

Look closely at the two constellation pictures. One is called Orion the Hunter, and the other is called Leo the Lion. You learned in the reading that these two constellations are seen during different seasons of the year. Which constellation do you think we'd be able to see at this time of year? Pick one of the two constellations, and try to draw the stars on black construction paper with white chalk. Then, connect the stars with blue chalk. Does your constellation look like the one in the picture?

Stars and Constellations

Control Group Lesson Plans

Lesson #1

Objective: After completing a pretest, students will independently read information about stars from text with limited or no dependency on class discussion. If students are unable to read the text independently, the researcher/teacher may choose to have the students read the text aloud.

Materials: Materials necessary for each student to participate in this lesson include the Stars and Constellations Pretest, a pencil, and the Stars and Constellations text.

Introduction:

1. Ask students to imagine that it is nighttime and that they are looking up at the sky. Ask them to talk about some of the things they might see.
2. Explain to students that they will be learning some new and interesting information about stars and constellations over the next two lessons.
3. Also, explain to students that in addition to reading about stars and constellations, they will be taking a pretest and a posttest. Remind the students that they should be sure to do their best work on these tests. *If these lessons will not be counted towards a grade for the students, the researcher/teacher may reassure students of this.
4. Have students clear everything from their desks except for a pencil, and pass out the pretests. Read the directions aloud with the students, and answer any questions about the pretest. When students have completed the pretests, have them check their answers and then hand them into the researcher/teacher.

Development:

1. Have students clear everything from their desks, and pass out the text. Have the students independently read only the first four paragraphs of the text. *The researcher/teacher who has beginning or struggling readers may decide to have students read the text aloud. The researcher/teacher *should* help struggling readers with unfamiliar words –even if the rest of the students are reading independently- so they do not misunderstand the information within the text.
2. After students have completed reading the text, ask if they have any questions about the information they just read. Answer questions clearly, but limit class discussion so that the teacher/teacher can be certain that students have learned any new information from the text. *The researcher/teacher *should not* use resources other than the text to answer questions.

Summary & Evaluation:

1. Using the text, ask students a few questions that require them to recall information in the text. Students may use the text to find answers to the questions. If students struggle with questions, have them locate the information in the text and read it aloud to the class.

Stars and Constellations

Control Group Lesson Plans

Lesson #2

Objective: Students will independently read information about constellations from text –with limited or no dependency on class discussion- before completing a posttest. If students are unable to read the text independently, the researcher/teacher may choose to have the students read the text aloud.

Materials: Materials necessary for each student to participate in this lesson include the Stars and Constellations Posttest, a pencil, and the Stars and Constellations text.

Introduction:

1. Ask students to recall some of the information they learned about stars in the last lesson. Explain to students that they will be learning about constellations in this lesson.
2. Also, explain to students that in addition to reading about constellations, they will be taking a posttest. Remind the students that they should be sure to do their best work on this test, just as they did on the pretest. *If these lessons will not be counted towards a grade for the students, the researcher/teacher may reassure students of this.

Development:

1. Have students clear everything from their desks, and pass out the text. Have the students independently read the final paragraph of the text. Allow students to reread the entire text when they have finished. *The researcher/teacher who has beginning or struggling readers may decide to have students read the text

aloud. The researcher/teacher *should* help struggling readers with unfamiliar words –even if the rest of the students are reading independently- so they do not misunderstand the information within the text.

2. After students have completed reading the text, ask if they have any questions about the information they just read. Answer questions clearly, but limit class discussion so that the teacher/teacher can be certain that students have learned any new information from the text. *The researcher/teacher *should not* use resources other than the text to answer questions.

Summary & Evaluation:

1. Using the text, ask students a few questions that require them to recall information in the text. Students may use the text to find answers to the questions. If students struggle with questions, have them locate the information in the text and read it aloud to the class.
2. Have students clear everything from their desks except for a pencil, and pass out the posttests. Read the directions aloud with the students, and answer any questions about the pretest. When students have completed the pretests, have them check their answers and then hand them into the researcher/teacher.

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