Using Creative Dramatics to Foster Conceptual Learning in a Science Enrichment Program

by

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Abstract

This study made analysis of how the integration of creative drama into a science enrichment program enhanced the learning of elementary school students' understanding of sound physics and solar energy. The study also sought to determine if student attitudes toward science could be improved with the inclusion of creative drama as an extension to a well-known science inquiry program. The qualitative portion of this study explored the treatment groups' perceptions of how the use of creative drama helped them to learn science.

A treatment group of fourth and fifth grade students were taught using the Full Option Science System (FOSS) kit in sound physics and solar energy with the inclusion of creative drama, while a control group of fourth and fifth grade students were taught using only the FOSS kit. The quantitative data analysis revealed that the students who were taught science with the inclusion of creative drama showed greater understanding of the science content than the students in the control group taught without the inclusion of creative drama.

Both groups and grade levels in this study showed a slight decline in science attitudes from pre to post survey. Although the overall change was small it was statistically significant. The conclusion from this data is that the inclusion of creative drama in a science inquiry science program does not increase student's attitudes toward learning science any better than inquiry based instruction without creative drama. The drama treatment group students reported that they enjoyed participating in creative drama activities and generally viewed the creative drama

intervention as a fun way to learn more about science. The students indicated that the creative drama activities helped them to remember and think about science.

The researcher concluded that creative drama when used as an extension to an inquiry science program increases student understanding of science content better than the use of a science inquiry program alone. Although students in both treatment and control groups showed a small decline in attitude toward science, the drama treatment students responded favorably to creative drama's use and implementation in helping them to learn more about science.

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CHAPTER ONE. INTRODUCTION

Currently one of the major concerns at both the state level and national level in education is the status of the American educational system in preparing students to succeed in science, technology, engineering and mathematics. In its 2007 National Action Plan, the National Science Board (NSB) cites *Rising Above the Gathering Storm's* warning of the danger that many Americans may not know enough about basic science, technology, or mathematics to contribute significantly to, or benefit from, knowledge that has already been established (NSB, 2007).

The National Science Board (NSB) in its National Action Plan for Addressing the Critical Needs of the United States in Science, Technology, Engineering, and Mathematics (STEM) paints a darkened landscape of an educational system that is failing in its quest to fully educate the next generation of scientists, engineers, and mathematicians (NSB, 2007). Like General Motors going belly-up, America is treading in bigger competition waters, while the danger of losing world status in science and mathematical innovation seems very real. For example, the NSB STEM committee reports that "30% of students in the United States in their first year of college are forced to take remedial science and math classes because they are not prepared to take college level courses" (NSB, 2007, p. 11). The Program for International Student Assessment (PISA) reports that United States students (age, fifteen years) rank 19th behind other industrial nations in science, engineering, and mathematical critical thinking skills (NSB, 2007). The Slovak Republic is ranked above the United States with the countries of Japan and Finland tying for first place in critical thinking skills in these areas (NSB, 2007).

Creating a vision where the United States takes its position as a first place competitor in science, the National Committee on Science Education Standards and Assessment, National Research Council (NRC) describes an educational system that embraces the idea of scientific literacy for all citizens (NRC, 1996). One aspect of scientific literacy is the understanding that science knowledge will expand and deepen over a lifetime (NRC, 1996). In a lifetime, the ability to make intelligent choices about land, air, water and natural resources will demand a citizenry that will act together in the best interest of the nation in preservation of its natural resources (NRC, 1996). The best interest of the nation will require an enlightened and working knowledge about science. But for this to happen, attitudes and values about science will need to be established, and shaped in the early years through the lens of an educational system developing a scientific literacy for all citizens (NRC, 1996).

Teaching Science Every Day to Every Student in Every Grade

Empowering the elementary student through a sound curriculum to achieve scientific literacy begins with renewed emphasis of the importance of "teaching science every day to every student in every grade" at the elementary level (Alabama Course of Study: Science, 2005, p. 1). Elementary children entering school are energetic, eager to learn, and possess a natural curiosity about their world. They are eager to construct knowledge of their world through their observations and prior experiences (Alabama Course of Study: Science, 2005). Educators who are assigned the task of building a scientific literacy for these students can capitalize on the elementary student's energy and curiosity.

A case in point, according to Ausubel, Novak and Hanesian (as cited in Nussbaum & Sharoni-Dagan, 1983) is that many elementary students have a conceptual grasp of scientific concepts along with an inquisitive energy and natural curiosity. Ausubel (as cited in Nussbaum

& Sharoni-Dagan, 1983) maintains that failure to provide opportunities for readiness development for many younger students translates into wasted time at the junior and high school levels which could be used for more advanced instruction in science.

For the youngest citizen, seeking answers through the lens of science literacy for all shapes the mindset of what it means to live effectively in society as the NRC contends:

> A sound grounding in science strengthens many of the skills that people use every day like problem solving, creativity, thinking critically, working together cooperatively in teams, and using technology effectively. (NRC, 1996, p. 1)

Moreover, the National Committee on Science Education and Assessment, National Research Council (NRC,1996) frames this vision of literacy as it clearly voices the following expectations and importance of science to the nation:

> An understanding of science makes it possible for everyone to share in the richness and excitement of comprehending the natural world. Scientific literacy enables people to use scientific principals and processing in making personal decisions, and to participate in discussions of scientific issues that affect society. (NRC, 1996, p. 1)

In another section of the NRC report, the vision for a brighter future for students and teachers is the recognition that attaining the understandings and content standards needed for a scientific mindset “cannot be achieved by any single teaching strategy or learning experience” (NRC, 1996, p. 34–35). For example, inquiry, although highly stressed in the NRC vision of a science literate America, should not be regarded as the only single solitary approach to science teaching (NRC, 1996). In reality, “conducting hands-on science activities does not guarantee inquiry nor is reading about science incompatible with inquiry” (NRC, 1996, p. 34).

There is a call to action by the NRC for variety and innovation in science instruction. Seeking refinement in the practice of new approaches, teachers must become leaders involved with continuous professional development in science teaching (NRC, 1996). Furthermore, within the heart of the NRC's call for action in program development and innovation in science teaching is the additional belief that teachers should also strive to implement *different strategies* [italics added] to nurture the knowledge and abilities desired in science as described in the content standards (NRC,1996).

Science literacy for all citizens includes constructing the ground floor for children to connect and construct ideas and mindset about science. The scientifically literate citizen is the individual who has a solid base in scientific knowledge along with the ability to use scientific processes and technology to comprehend science-related decisions in a changing society (Alabama Course of Study: Science, 2005).

The Quest to Define Science Literacy: Landmarks in Science Education

There is a continuum of historical landmarks in the quest to define what it means to be scientifically literate in American education. Science educator George DeBoer (1991) writes of the crisis of the United States in failing to meet the grade in science in the mid-1950s (DeBoer, 1991). After the launching of the earth orbiting satellite Sputnik in 1957, American scientists began to take seriously the criticisms that plagued the American educational system (DeBoer, 1991). With the support of professional organizations such as the National Science Foundation (NSF), scientists launched an investigation in order to find ways to "bring renewed intellectual rigor to the school science program" (DeBoer, 1991, p. 147). The great space race in science education emerged (DeBoer, 1991).

The successful launching of Sputnik by the Soviet Union set in motion curriculum reform in which groups of scientists, backed by the federal government, made analyses of science teaching (DeBoer,1991). For two decades the federal government backed and financed these science initiatives which focused on approaches to science education that looked at the "logical structure of the disciplines" and the "processes of science" (DeBoer, 1991, p. 147).

Analysis was made of the content in science textbooks, the failure to accurately portray the "essential character of scientific activity", and enrollment declines in advanced science disciplines such as physics (DeBoer, 1991). DeBoer characterizes the curriculum movement's scope and impact as "unprecedented" (DeBoer, 1991, p. 171). He summarizes the strengths of the movement's impact during these years:

> The courses achieved the sought-after rigor, and they presented the disciplines of science in a more thorough and honest way. They presented the science disciplines as logically structured areas of human investigation, they dealt candidly with the nature of scientific research and they encouraged students to think and act like scientists within the structure that was established. (DeBoer, 1991, p. 171)

However, the movement failed in several respects according to DeBoer (1991):

> They did not take into account the importance of student interest or the pedagogical need to relate science knowledge not only to the broad unifying themes of the discipline itself, but also to the experiential world of the student, nor did they sufficiently consider the importance of readiness for learning until the student was capable of dealing successfully with such intellectual complexity. (p. 172)

Science education was failing to make science purposeful and developmentally appropriate. Future advances in cognitive brain based research would eventually evolve to suggest better ways of achieving science literacy.

Science Literacy First Coined in Science Education

The 1960s ushered in major social change. The "New Progressivism" in science, and the phrase "scientific literacy", first coined by Paul DeHart Hurd of Stanford University, came into being to describe "an understanding of science and its application to our social experience" (DeBoer, 1991, p. 174). This definition of science literacy sprung from the belief that "science can no longer be regarded as an intellectual luxury for the select few" (DeBoer, 1991, p. 174).

In the late 1960s and early 1970s concentration moved away from trying to keep pace with the Soviets to addressing the social goals of science teaching (DeBoer, 1991). According to DeBoer, the new science called for a science curriculum that was relevant to the diversity of students enrolled in public education classrooms. There was a call for sensitivity to individual differences with the introduction and popularity of individualized instructional programs which gave students opportunities for student choice in course selection (DeBoer). By 1973, the term science literacy became the "watchword" of science educators and the quest to obtain an exact and meaningful definition was initiated (DeBoer, 1991, p. 174).

Conceptual Change Models of Teaching

According to Dawes' (as cited in Tippett, 2009) study part of the continuous analysis in defining what it means to be scientifically literate involves the role of language. Barnes' (as cited in Tippet, 2009) study maintains that language requires social interaction and meaning is constructed as learners interpret and reflect upon events through previous knowledge. Researchers Driver, Asoko, Leach, Mortimor and Scott (as cited in Tippett, 2009) also found that translating this perspective into what it means to apply constructivism in the science classroom is the understanding that knowledge is socially constructed, negotiated, validated and communicated in conversations that students and teachers engage in while pursuing specific discourse about meaning in science. Research supports social constructivist models and conceptual change models of teaching *emphasize* (italics added) the need for collaboration and language in the form of dialogues between teachers and students (Kim, 2001).

According to Gredler (as cited in Kim, 2001), ideas based on constructivism stress the attention to conceptual learning which expands the learner's conceptual framework. Tytler (2002) concurs that that true conceptual learning among students stresses the need for teachers to monitor students' views, bringing them to open discussion and analysis of science based on the evidence.

Expanding conceptual frameworks in science education includes the idea that before students can learn new scientific concepts, they will need the coaching necessary to re-conceptualize misconceptions that interfere with new learning in science (Bransford, Brown, & Cocking, 2000). Current reforms in science education stress the need for students to conceptually understand science instead of just knowing the facts (American Association for the Advancement of Science, 1993; NRC, 1996). There are growing numbers of studies at all levels of the "prevalence of misconceptions and alternative frameworks in science education" (Nussbaum & Sharoni-Dagan, 1983, p. 100).

Researchers Brown and Clement (as cited in Bransford, et al., 2000) report that to understand science conceptually the learner and teacher must be able to successfully anchor and bridge conflicting views or misconceptions during instructional time in order to assist children in explaining, communicating, and predicting science phenomena. The elementary teacher struggles daily with instructional management and trying to “cover” all the subjects. Creating best practice environments for learning through conceptual change models in elementary science is not without its problems or challenges.

Most elementary level teachers are not science specialists (Dickinson & Flick, 1997). In many cases, in the elementary setting, science, when compared to other subjects, is set apart from the daily emphasis of reading and math resulting in science being given a “smaller amount of instructional time”(Dickinson & Flick, 1997, p. 4). Abell and Roth state (as cited in Dickinson & Flick, 1997), that additionally many elementary teachers hold the viewpoint that science is a topic that should be taught only when other subjects have been covered.

Dickinson and Flick (1997) propose the following factors that influence the teaching of elementary science: Teacher perception of the importance of science in an elementary curriculum, limited content knowledge held by elementary teachers, and limited experiences through formal course work in participating in and presenting hands-on science (Dickinson & Flick, 1997). Presently, much has been written to show that students have “persistent ideas that are at odds with the science taught” (Braund, 1999, p. 35).

In the same manner, researcher Bonnie Shapiro maintains that although children’s understandings about science has the potential to change as they are taught science in school, the science understood is not always in ways that teachers or curriculum designers desire (Shapiro,1994). For instance, the topic of light, Shapiro notes, is presented early (7 to 8 year olds) in the elementary science curriculum as “light and shadow” (Shapiro, 1994, p. 22). Later, the study of vision is often presented to children by the age of 9 and 10 in conjunction with the study of human body systems (Shapiro, 1994). The topics of light movement in straight lines, the nature of light reflection and refraction, the study of how light travels through media, the light spectrum, and color mixing is given limited study in grades 5 or 6. Light is studied in depth in secondary high school physics programs which Shapiro contends not all students will select as courses to study (Shapiro, 1994). Shapiro explains that despite attention to teaching light phenomena throughout the curriculum in school science, the scientific understandings about the nature of light have “traditionally been very difficult for students to understand” (Shapiro, 1994, p. 23).

Hapkiewicz (1992) identified many misconceptions students hold in several areas of science. A case in point is revealed in the misconception that students hold about the particles of solids having no motion, and that oxygen and air are the same gas (Hapkiewicz). Misconceptions, according to Hapkiewicz still persist as students define magnetic force as a pattern of lines (not a field of force) that surrounds a magnet.

There is evidence in the literature that the naive theories or misconceptions that children hold about science plays an important part in the acquisition of new knowledge by assisting in the process of changing prior misconceptions about science (Pine, Messer, & St. John, 2001). Alternative concepts held by primary students are the catalysts for further development for accepted conceptual learning in science (Pine, et al., 2001). Moreover, it has been demonstrated that misconceptions, unless addressed, may become even more resistant to change as a result of instruction (Pines, 1997).

From the constructivist viewpoint, prior knowledge is a common feature of children’s early understanding of science (Pine, et al., 2001). Therefore, it would appear that in a best case scenario, science education should strive to develop in the elementary student the readiness that includes “appropriate relevant preconceptions” free from “inhibiting misconceptions” (Nussbaum & Sharoni-Dagan, 1983, p. 101).

In tracing the patterns in science education, it surfaces that a high alert concerning the educational system has been a quest to seek refinement for improvement of practice in science while developing the skills, and science mindset for the nation's best interest (DeBoer, 1991). Heeding the present day call for a vision of a scientific literacy which includes a conceptual change model of learning for all students, the one intent of the study was to implement the NSF's call for innovation and creativity in science teaching by examining the effects of creative drama as an additional tool for teachers in promoting deeper understandings in elementary science.

Creative Drama as a Potential Tool for Promoting Learning in Science

The usefulness of implementing creative drama in classrooms to help children understand concepts is not new (Kamen, 1991, p. 339). Winifred Ward, a theater educator and pioneer in the field of creative drama, said, "What children do is more significant to them than what they see and hear" (Ward, 1957, p. 1). Drama is by definition an active experiential mode of learning which is vital in developing conceptual learning in science education.

Conceptual change is defined as learning that "changes an existing conception such as a belief, idea, or way of thinking" (Davis, 2001, p. 2). Davis further explains:

> Learning for conceptual change is not merely accumulating new facts or learning a new skill. In conceptual change, an existing conception is fundamentally changed or even replaced, and becomes the conceptual framework that students use to solve problems, explain phenomena, and function in their world. (p. 2)

It has been demonstrated that conceptual change instruction in science can help students overcome alternative frameworks of understanding that may interfere with learning in science while challenging the learner to tackle difficult concepts (Davis, 2001, p. 3).

It has been suggested that drama is a superior tool for deeper, conceptual learning that goes beyond rote activities (Metcalfe, Abbott, Bray, Exley, & Wisnia, 1984). One potential benefit of using creative drama for deeper meaning in science education is what occurs when students engage in dramatic role playing to create models of meaning in science. Kamen (1991) demonstrated in an ethnographic pilot study that the use of role playing in creative drama can be utilized for powerful assessment by allowing teachers to evaluate a student's conceptions or misconception of a science idea (Kamen, 1991). He renders the following example of how this works:

> A fifth grade class is studying solar energy. They have watched balloons inflate on top of bottles place in front of a light bulb. The students observe that the balloon on the black bottle inflated first followed by the clear and sliver bottles. The children discuss what light does when it strikes the different colors. They use the terms heat and light interchangeably. The teacher wants to help them understand that there is a difference between heat and light. Three children are asked to be molecules in the clear bottle. These children line shoulder to shoulder. A fourth child is labeled a photon. The photon (running at 186,000 miles/per second) heads toward the molecules. The four children pantomime what happens when the photon hits clear bottle. This is repeated for the other bottles. The teacher gains clear insights into how the children are thinking about these concepts and can then address the students' conceptions in their own terms. (p. 319–320)

Students who demonstrate understanding of the concept in the above example are taking ownership of the science, and the models they design will help them to think about the science while the lesson is in progress (Kamen, 1991). In turn, the science teacher can assess for understanding and meaning and respond to the child during the lesson (Kamen, 1991). Creative drama is designed for educational purposes, and shares many objectives with science and social constructivist theory such as helping the child to think about science while providing the student with the stimulus to communicate ideas, reason critically, and work cooperatively with others in a social group.

If employed as educational theater, "drama allows the learner to examine experiences that would not otherwise be available" (Metcalfe, et al., 1984, p. 78). Drama allows the participant to take on the role of another, and cast off an egocentric perspective. This non-egocentric perspective can equally be used to explore animate or an inanimate objects in science (Metcalfe, et al., 1984).

Purpose and Research Questions

The purpose of this research will be to study how the inclusion of creative dramatics within a social constructivist framework enhances the conceptual learning of science. In order to make analysis of learning outcomes and children's perceptions of how creative drama helps them to understand science, a mixed mode, quasi-experimental design will be adopted.

The following questions will be used to guide the research:

1. Does the inclusion of creative dramatics in inquiry-based science instruction help students' understanding of science concepts significantly better than inquiry-based instruction without creative dramatics?

    1a) Are there significant differences between treatment and control groups when creative dramatics is included in an inquiry based science program?

    1b) Are there significant differences between grade levels when creative dramatics is included in an inquiry based science program?

1c) Are there significance differences between group and grade levels when a creative dramatics approach is included in an inquiry based science program?

2. Does the inclusion of creative dramatics in inquiry based science instruction help students' attitudes toward science learning significantly better than inquiry-based instruction without creative drama?

3. What do students think about the use of creative dramatics in helping their learning of science concepts?

Significance of the Study

The significance of this study is connected to the fields of arts integration and elementary school science curriculum. Studying the effects of a teaching strategy such as creative drama in elementary science may lead to greater numbers of students being involved and engaged in science learning. Establishing the desire and interest to learn science in the elementary grades may build greater student self-confidence resulting in a stronger literacy base for further learning in science. The social nature and shared interactions of creating drama to support science learning encourages thinking outside the box. Thinking outside of the box is one mindset that is summoned by the NSF's call for innovation and creativity in science teaching. Specifically, the study will be useful to the following:

- Teachers who wish to use alternative strategies to assist struggling students with learning abstract concepts in science
- Colleges of education who wish to integrate creative drama in teacher education programs as a strategy for teaching conceptual understanding and assessment in science for children
- The body of literature about science and arts integration learning

- Teacher practitioners and administrators in elementary science to help children enjoy and learn science through a social constructivist approach
- Art and music specialists who wish to integrate arts disciplines into the elementary science curriculum
- Teachers who aim for strategies that foster conceptual change models of teaching in science

Definition of Terms

Creative Drama: an improvisational, non-exhibitional process centered form of drama in which participants are guided by a leader to imagine, enact and reflect upon human experience (Davis & Behm, 1978).

Improvisation: the art of creating dialogue on the spot through group interaction in order to create a sense of story or character without the use of a scripted play (McCaslin, 2006).

Pantomime: the art of conveying ideas without words in which the body engages in physical movement much like dance to challenge the imagination and sharpen the senses (McCaslin, 2006).

Role Playing: the process in which the actor conveys meaning by acting out a character either animate or inanimate. This may be accomplished in formal theater in developing characterization or improvised in less formal theatre through the process of improvisation and creative dramatics (McCaslin, 2006).

CHAPTER TWO. LITERATURE REVIEW

Introduction

Brain-based research has revolutionized understandings of how people learn (Bransford, Brown & Cocking, 2000). The National Research Council (NRC) Committee on Developments in the Science of Learning describes several evidence-based aspects of brain-based learning. One aspect of the new science of learning is the focus of learning with understanding (Bransford, et al., 2000). The NRC contends that curricula which stress memorization of facts have given students little or no opportunities to make sense of topics on a deeper level (Bransford, et al., 2000). The literature cites that mathematics and science instruction has been less than exemplary for its lack of rigor, stressing memorization of facts while covering too many topics at the expense of deeper understandings in subject matter (NRC, 1996).

Evidence on the compiled research of how experts in fields such as chess, history, science, and mathematics do not deny that facts are important for thinking and problem solving (Bransford, et al. 2000). However, the NRC emphasizes that usable factual knowledge is in stark contrast to curricula heavy with science textbooks, and assessments which stress memorization of disconnected facts at the expense of conceptual learning (Bransford, et al., 2000). What then are the implications for applying established educational theory to the demand for better and deeper understanding in science education for the elementary student?

Hewson, Beeth and Thorley (cited in Davis, 2001) explain that the core to developing deeper conceptual understanding rather than fact memorization in science is influenced in part by Vygotsky's social constructivist theory and cognitive apprenticeship perspectives. In the investigation of how creative dramatics assists children in learning science, this translates to an instructional approach which encourages interaction in the learning environment rather than a teacher directed transmission style of teaching in the classroom. Using the metaphor of the student as an apprentice working with more knowledgeable others (i.e. teacher or a group of student peers), conversations are allowed to develop that stress conceptual understanding of science rather than the memorizing of science facts. What then are the deeper layers of meaning in Vygotsky's theory that knowledge is constructed through social interactions among individuals and their environment? How is this theory further refined and relevant to a teaching practice of integrating creative drama with science learning at the elementary level?

The Psychological Foundation of Social Constructivism

To understand how this works, it is necessary to understand the psychological theory imbedded in carrying out this research. The theoretical framework used in the research analysis of this study is grounded in the theories of Russian psychologist Lev Vygotsky. Vygotsky was also a contemporary of Jean Piaget. Slavin (as cited in McDuffie, 2010) explains that both Piaget and Vygotsky contributed to and believed in cognitive development theory, but they differed on how changes in mental processes become more complex. According to Slavin (as cited in McDuffie, 2010), Piaget believed that cognitive development occurred through four stages: sensorimotor, preoperational, concrete operational and formal operations. Vygotsky argued that cognitive development is based on the idea that children are able to learn through experience, culture and sign systems. Slavin (as cited in McDuffie, 2010) states that developmental stages for Vygotsky are described as self-regulation, private speech, zone of proximal development and scaffolding.

Piaget's work had as its focus the understanding of "the progressive cognitive structuring of individuals" (Fosnot, 1996, p. 18). Vygotsky's work focused on the effect of social interaction, language and culture on learning (Fosnot, 1996). Vygotsky argued against the inadequacy of school tasks that only looked at the child's individual problem solving. Instead, he contended that "progress in concept formation achieved by the child in cooperation with an adult was a more viable way to look at the capabilities of learners" (Fosnot, 1996, p. 19). Both the theories of Piaget and Vygotsky support a basis for the psychological theory of learning termed constructivism (Fosnot, 1996). This study is driven by Vygotsky's premise of social constructivism with its greater emphasis on the interplay of "the sociocultural effects on learning" (Fosnot, 1996, p. 23).

Social Constructivism Applied to Education

As with all psychological theory, social constructivism does not describe teaching, nor does this theory offer a "cookbook" of instructional strategies (Fosnot, 1996, p. 29). However, the general principles of this learning theory can be helpful to educators in rethinking, reforming and reorganizing educational curriculum practices across all disciplines (Fosnot, 1996). Fosnot provides the following general principles derived from constructivism:

- Learning is not the result of development: learning *is* development. It requires invention and self-organization on the part of the learner. Thus teachers need to allow learners to raise their own questions, generate their own questions, generate their own hypothesis and models as possibilities, and test them for viability.
- Disequilibrium facilitates learning. "Errors" need to be perceived as a result of learners' conceptions and therefore not minimized or avoided. Challenging, open-ended investigations in realistic, meaningful contexts need to be offered, thus allowing learners to explore and generate many possibilities, both affirming and

contradictory. Contradictions, in particular, need to be illuminated, explored and discussed.

- Reflective abstraction is the driving force of learning. As meaning makers, humans seek to organize and generalize across experiences in a representational form. Allowing reflection time through journal writing, representation in multisymbolic form, and/or discussion of connections across experiences or strategies may facilitate reflective abstraction.
- Dialogue within a community engenders further thinking. The classroom needs to be seen as a community of discourse engaged in activity, reflection and conversation. The learners (rather than the teacher) are responsible for defending, proving, justifying and communicating their ideas to the classroom community. Ideas are accepted as truth only insofar as they make sense to the community and thus rise to the level of "taken as shared".
- Learning proceeds toward the development of structures. As learners struggle to make meaning, progressive, structural shifts in perspectives are constructed-in-sense, 'big ideas' are learner constructed, central organizing principles that can be generalized across experiences and that often requires the undoing or reorganizing of earlier conceptions. This process continues throughout development. (Fosnot, 1996, p. 30)

Vygotsky's work and theory of social constructivism shared the intellectual stage with the science contemporaries of Ivan Pavlov and John B. Watson, both stimulus-response theorists (Cole, et al., 1978). However, Vygotsky's analysis of human development differed from the early behaviorists (Cole, et al., 1978). In *Mind in Society*, Vygotsky's theory is rendered:

> In spite of the significant advance attributable to behaviorist methodology, that method nevertheless is seriously limited. The psychologist's most vital challenge is that of uncovering and bringing to light the hidden mechanisms underlying human psychology. Though the behaviorist method is objective and adequate to the study of simple reflexive acts, it clearly fails when applied to the study of complex psychological processes. The inner mechanisms characteristic of these processes remain hidden. (p. 122)

Cognition is a Product of Socialization and Social Behavior

Characterizing the early behaviorists as having a methodology as "seriously limited", Vygotsky argued that cognition is a product of human socialization and social behavior (Vygotsky, 1978, p. 122). Believing the behaviorist methodology to be limited, nonetheless Vygotsky lived and worked in an era of Soviet society that "put a premium on science and had high hopes for the ability of science to solve the pressing economic and social problems of the Soviet people" (Cole et al., 1978, p. 9). Cole and Scribner (1978) maintain that Vygotsky's work clearly demonstrates his concern with creating a psychology that would have relevance for education and medical practice.

It is important to note that Vygotsky began his career as a teacher of literature, and much of his early written articles concerned the problems of educating the mentally and physically handicapped (Cole, et al., 1978). He was the founder of the Institute of Defectology in Moscow of which he was associated with throughout a short career and working life. His ideas included a vision of society that sought the elimination of illiteracy through educational programs which examined treatment and remediation. His beliefs included the concept that educational programs could "maximize the potential of individual children" (Cole, et al., 1978, p. 9).

In the years prior to his death, Vygotsky lectured and published articles on problems of education. He was critical of newly developed IQ tests that were gaining popularity and acceptance in Western Europe and the United States at the time (Cole, et al., 1978). It was his ambition to reform educational psychology which Vygotsky referred to as “pedology” (Cole, et al., 1978, p. 10).

Surprisingly, Vygotsky’s theories were unknown in the United States until 1962 when his work was first published for Western audiences. His social development theory contends that social interaction precedes development. Unlike contemporary Jean Piaget, who argued that development occurs in stages and precedes learning, Vygotsky contends that consciousness and cognition are the products of socialization and social behavior (Driscoll, 1994).

Vygotsky’s Major Themes of Social Constructivism

The first major theme embedded in social constructivism, according to Vygotsky, is the idea that cognitive development is dependent on the process of social interaction. Social learning precedes development (Vygotsky, 1978). Vygotsky writes: “Every function in the child’s cultural development appears twice: first, on the social level, and later, on the individual level; first, between people (interpsychological) and then inside (intrapsychological) the child (Vygotsky, 1978, p. 57).

The second theme occurring in Vygotsky’s work concerns the More Knowledgeable Other or MKO (Vygotsky, 1978). This idea refers to anyone who has more experience or a better understanding of performing a task or process (Galloway, 2001). The MKO can be a teacher, a coach, a parent, older adult, or even other students in a classroom who have greater ability or experience with a task or concept. In the twenty-first century, an MKO can be a computer or educational social networking (Galloway, 2001). Applying the MKO premise in social constructivist environments requires the interaction of others to support meaning with individuals taking control of their thinking, always seeking clarification, and experimentation which is then constructed and reconstructed in order to produce understanding (Galloway, 2001).

The third major theme of Vygotsky's work is the idea of the Zone of Proximal Development or ZPD (Vygotsky, 1978). Vygotsky used the term "zo-ped" which translates to Zone of Proximal Development. Kozulin (as cited in Fosnot) states that the ZPD describes the area where a child's spontaneous concepts meet the "systematicity and logic of adult reasoning" (p. 19). In *Mind in Society,* a collection of Vygotsky's essays, the following translation on the theory of ZPD is provided:

> ... an essential feature of learning is that it creates the zone of proximal development. That is, learning awakens a variety of internal developmental processes that are able to operate only when the child is interacting with people in his environment and in cooperation with his peers. Once these processes are internalized, they become part of the child's independent developmental achievement. (p. 90)

Vygotsky believed that learning occurred in this zone and described the ZPD as the distance between a student's ability to perform a task under adult guidance or with peer collaboration and the student's ability in solving that problem independently (Vygotsky, 1978). The ZPD defines a cognitive apprenticeship in learning as "the distance between the actual developmental level as determined by independent problem solving and the level of potential development as determined through problem solving under adult guidance or in collaboration with more capable peers" (Vygotsky,1978, p. 89). That is, the ZPD apprenticeship is the area between the things a learner can do on his or her own, and the things a learner cannot yet do. According to social constructivist theory, with the application of scaffolding from a more knowledgeable other, the learner will eventually learn the task (Galloway, 2001).

Vygotsky's Themes of Scaffolding, Self-Regulation and Private Speech

Social constructivist theory includes the metaphor of scaffolding to support the child in the early stages of learning. In the beginning, the child is provided a frame of help which is gradually reduced as the child is able to assume responsibility to solve problems or tasks on his or her own (Slavin, 2009). Vygotsky's relevance to educational practice is found in his thinking that "humans are active, vigorous participants in their own existence" (Vygotsky, 1978, p. 123). Vygotsky converged on the connections between people and the sociocultural setting in which shared interactions exist (Crawford, 1994). Generally, Vygotsky's theory supports learning in a variety of rich and varied contexts. Making Vygotsky's theory relevant to modern educational practice requires a reciprocal role between student and teacher. Teachers collaborate with students in order to assist in meaning construction (Driscoll, 1994).

The activities associated with joining science instruction and creative dramatics parallels the child who constructs knowledge from participating in experiences that challenge individual interest and uses prior knowledge to learn. To the constructivist framework, learning, like the discipline of science, is about sense making. Constructivist learning is not a stimulus-response phenomenon (Von Glasersfeld, 1996). It requires self-regulation and the building of conceptual structures through reflection and abstraction (Von Glasersfeld, 1996). Concept development and deep understanding of subject matter is the overlying aim of constructivist learning (Fosnot, 1996).

The socialist constructivist framework supports this idea further by "viewing discourse about the world not as a reflection or map of the world, but as an artifact of communal interchange" (Gergen, 1985, p. 266). The terms in which the world is understood is viewed as cooperative "interchanges among people" in persons in relationships (Gergen, 1985, p. 267).

Teachers are coordinators, facilitators, resource advisers, tutors, or coaches in helping the learner to reach sense making in science through cooperative interchanges and instructional activities that center on understanding.

Active, experiential learning strategies such as drama has been shown as a way of developing understanding in science because the learners have high levels of engagement with ideas often through collaboration with other learners (Braund, 1999). Drama is first and foremost an authentic group effort and with the support of more knowledgeable others can easily translate social constructivist theory into a useable strategy for bringing children together to achieve understanding in science through activities such as pantomime, role playing and improvisation.

From Theory to the New Science of Learning

Emerging technologies have led to the development of opportunities to guide and enhance learning that were unheard of even a few years ago (Bransford, et al., 2000). To illustrate, researchers in cognitive psychology have shown that young children understand more than once was thought about "basic principles of biology and physical causality, about number, narrative, and personal intent" (Bransford, et al., p. 4). With knowledge and technologies developing at such rapid rates, preparing students for the skills of the workplace demands a "high literacy" that moves beyond the acquisition of the simple reading, writing, and arithmetic curriculum used the early part of the twentieth century (Bransford, et al., p. 4).

From theoretical assumptions to the new science of learning there are hallmarks in brain-based research that assist in designing learning environments for children in elementary science. The National Research Council (NRC, 2000) has described these hallmarks as follows: (a) learning with understanding which focuses on the processes of learning, (b) learning as using prior knowledge to understand, and (c) learning as an active process in which students engage in meta-cognition and concept development in order to take control of their learning (NRC, p.14–18).

Children's Misconceptions or Alternative Frameworks in Science

Along with the necessity of the elementary teacher applying the new science of learning research into their practice of science instruction, there is significant concern regarding the quality of elementary science in education and the misconceptions that children hold (Kamen, 1991; Nussbaum & Sharoni-Dagan, 1983; Shapiro, 1993). Kamen (1991) describes the typical lesson in the elementary classroom setting:

> The typical lesson in the elementary classroom requires students to read a chapter and choose the "right" answers to a set of questions. Science is usually not presented in ways that encourage students to construct models and maximize their conceptual understanding of the phenomena. Students generally have to memorize the correct answers. Even when a hands-on approach is used, students tend to hold on to their original conceptions. Students may use the correct words but fail to understand those words. (p. 374)

From the field, teacher-researcher Mary Dylan Thiel describes elementary science instruction in her school as relying too heavily on text driven assessment (Thiel, 1991). Theil further explains that assessments characterized by "low-level cognitive focus" provide little attention to the affective and psychomotor domains of learning (p. 351). Kamen (1991) states that many assessment practices require little more than asking students to restate a definition or scientific concept. Furthermore, standardized tests encourage and reinforce the memorization of facts (Thiel, 1991). Reforms in elementary assessment practice are needed if scientific knowledge is viewed as a human construction (Kamen, 1991).

Furthermore, Ausubel, et al. (as cited in Nussbaum & Sharoni-Dagan, 1983), state that there is concern by educators for the misconceptions children develop in science which become resistant to change once embedded in thinking. The literature is well-documented in the number of studies at all levels on the prevalence of misconceptions or alternative frameworks in various areas of science (Nussbaum & Sharoni-Dagan, 1983).

In the elementary classroom the role of misconception plays a crucial role in the content of what is learned (Nussbaum & Sharoni-Dagan, 1983). Studies on student misconceptions ignite much needed issues of what approaches should be used in the elementary classroom in order to enrich students' readiness to learn science at the secondary and college levels (Nussbaum & Sharoni-Dagan, 1983).

According to Ausubel (as cited in Nussbaum & Sharoni-Dagan, 1983), many elementary students have a conceptual grasp of scientific concepts and elementary science teachers can capitalize on this fact. Unfortunately, failure to provide opportunities for readiness development for many elementary students translates into wasted time at the junior and high school levels which could be used for more advanced instruction in science (Nussbaum & Sharoni-Dagan, 1983).

Effective Conceptual Models for Teaching Elementary Science

The new science of learning established by brain-based research has implications for the way science is taught in schools today. This research is an indicator for best practice in teaching conceptual understanding in science. Some of the key findings are as follows:

1. Students come to the classroom with preconceptions about how the world works. If their initial understanding is not engaged, they may fail to grasp the new concepts and information that are taught or they may learn them for purposes of a test but revert to

their preconception outside of the classroom.

2. To develop competence in an area of inquiry, students must: (a) have a deep foundation of the factual knowledge, (b) understand facts and ideas in context of a conceptual framework, and (c) organize knowledge in ways that facilitate retrieval and application.
3. A meta-cognition approach to instruction can help students learn to take control of their own learning by defining learning goals and monitoring their progress in achieving them. (Bransford, et.al., 2000, p. 14–18)

The principles mentioned above have meaning for teaching science and integrating creative drama as a tool for understanding a child's thinking and preconceptions about how the world works. Referring to item one, teachers must inquire into a child’s prior knowledge creating the tasks and activities (group investigations on science concepts, role playing, pantomime and improvisation) that draw out a child’s thinking in science. Drawing out a child’s thinking during group projects and inquiry investigations also include being sensitive to the child’s communication of general understanding of science to include any alternative misconceptions held.

It has been demonstrated that in order to tap into a child’s thinking, the traditional concept of testing must be replaced with authentic assessment practice. Application of the process of creative drama can help identify misconceptions while bridging children’s science reasoning more in line with accepted scientific thought (Kamen, 1991; Theil, 1991).

Additionally, the current practice of trying to cover all the topics in a subject must be altered so that time is spent on understanding key concepts in all subject matter (Bransford, et al., 2000). Current effective instructional practices call for teachers to develop deeper conceptual learning in students while utilizing meta-cognition strategies or the skill of knowing how to learn by monitoring progress and practicing self-evaluation (Bransford, et al., 2000).

Current teaching models in science which can help students to monitor progress and set goals in science include models like the Glasson Learning Cycle (Tytler, 2002). Glasson (as cited in Tytler, 2002) has offered a learning model that is more in line to social constructivist theory as a guide for current best practice in science thinking. The important aspect of this model is that students' prior ideas are taken into consideration which invites the student to reflect on their understanding, to test their ideas and to change views, if needed, based on evidence (Tytler, 2002). This model has a component of building consensus with others in the learning community which is primarily social in nature (Tytler, 2002). Glasson's (as cited in Tytler, 2002) learning cycle is provided in Table 1.

Table 1

Glasson's Learning Cycle

Phase	Teacher Activity	Pupil Activity
Preliminary	Explores student views and classifies these Explores literature about science views and evidence which challenges student alternative conceptions	Completes surveys or activities designed to identify existing ideas
Focus	Establishes a context. Provides motivational experiences. Ask open-ended questions of individuals. Interprets and clarifies student's views.	Becomes familiar with materials used to explore the concept. Clarifies own view to the class or group through discussion or poster display
Challenge	Facilitates exchanges of views. Ensures all views are considered. Keeps discussion open. Suggests demonstrations or experiments as necessary. Presents the evidence from the scientists' views. Accepts the tentative nature of the students' reactions to the new view.	Considers the view of others in the class, evaluating these. Tests the validity of different answers by seeking evidence. Compares the science view with views of students.
Application	Contrives problems which are simply and elegantly solved using the accepted science view. Assists students to clarify the science view, asking that it be applied to a range of situations. Teacher joins in, stimulates and contributes to discussion of solutions to problems. Helps in solving advanced problems.	Solves practical problems using the concept as a basis. Presents solutions to others in class. Discusses and debates merits of the science view, and critically evaluates its use in different situations. Suggests further problems arising from the application of the science view.

Aligned with conceptual-based learning, the learning cycle model, and meta-cognition strategies in science teaching, current best practice in elementary science asks the question: What evidence is available that demonstrates exemplary science teaching? One source of evidence is the substantial research that has been written about the conversations of the elementary students in Sister M. Gertrude Hennessey's science classroom (Beeth & Hewson, 1998). Sister Gertrude's strategies are central to conceptual change models in students (Beeth & Hewson, 1998). These include: a teacher designed curriculum with students' ideas of science as the central focus of each unit; teacher inclusion of parallel curriculum strands; teacher understanding of students' conceptual knowledge, beliefs, values, and views on learning; explicit clarification of curriculum expectations through a variety of instructional methods; supportive instructional strategies for exploration of individual ideas and others; and management of sufficient time for every student to engage fully in the social and conceptual practices that are needed in order to learn science (Beeth & Hewson, 1998).

Creative Drama to Promote Conceptual Change Learning in Science

Creative drama can be a resourceful tool for conceptual change models in science. Significant literature has been established concerning the integration of drama in teaching subjects in schools to help students learn (Braund, 1999). A teacher who uses creative drama as a tool for conceptual change will have opportunities to observe how children are thinking about science. Once observed, a teacher can plan science based on the children's thinking. Integral to these processes is the idea of designing models to explain science thinking. Role playing, improvisation, pantomime and even script writing in *Science Theater* in the classroom are active processes of how students can create models to demonstrate thinking.

According to the NSB, many students fail to understand basic science concepts at the elementary level leading to gaps in understanding at the middle school and high school levels (NSB STEM Report, 2007). Likewise, Braund (1999) suggests that science is viewed as difficult to understand for students because of the abstract nature of many science core concepts. Yet brain-based research suggests that children are capable of learning more abstract concepts then once thought even possible (Bransford, et al., 2000). The NSB STEM committee maintains that science is not always taught in ways that young students learn best (NSB STEM Report 2007). Could it be that more emphasis should be given to conceptual change models of teaching, and more emphasis should be given to meta-cognition strategies in preparing students? The research supporting conceptually based models of teaching and learning clearly indicates it. Creative drama is designed to support conceptual models, and shares many objectives with science and social constructivist theory such as the ability to help students communicate ideas, reason critically, and work cooperatively with others in a social group (Braund, 1999).

Children, according to theater educator Winifred Ward, would prefer to be involved in a game than to be passive onlookers (Ward, 1957). “Children glory in action” (Ward, 1957, p. 1). Active, experiential learning is the foundation for conceptual change models. A child comes to the elementary classroom with ideas and these ideas are built upon understanding in science through active and experiential learning. The teacher serves as coach and monitors understanding, seeking to clarify misconceptions and build on further understanding by developing the activities that help the child to move toward conceptual knowledge of science. It has been shown that active, experiential learning strategies such as drama nurtures understanding in science because the learners have high levels of engagement with ideas often through collaboration with other learners (Braund, 1999).

Moreover, if science is taught in ways that often fail to be child-centered, or in ways that children learn best, as the National Science Board (NSB) STEM Committee maintains, then the addition of creativity and the support of creativity in science are needed along with science inquiry, conceptual change models and meta-cognition skills. These mindsets about science teaching will additionally include an appropriate balance of content and process skills.

Sternberg and Lubart (1988) are clear on the need for investing in creativity. Creativity development through creative drama is important when solving problems in the workplace and in daily life. According to Sternberg and Lubart, creativity can lead to scientific findings. Other researchers agree. Shanahan and Nieswandt (2009), addressing the need for creativity in the science classroom, expressed the following:

> If we are attempting to prepare students to understand and use science either as professionals or as informed responsible citizens, then it seems very surprising that something deemed essential to both professionals in science and to the development of the discipline itself is not more thoroughly addressed in science education. Science students need to know that scientists are creative individuals who use their imagination to discuss, explain, and hypothesize in science. (p. 6)

Duveen and Solomon (1994) have shown that students find creative dramatic role playing in science “memorable”, and can employ it in order to construct authentic meanings of the nature of science (p. 576). Christofi and Davies (as cited in Duveen & Solomon, 1994) contend that drama is rated highly by British students and maintain that role playing in drama produces gains in understanding of scientific concepts as demonstrated on student examinations.

Arts Research Across Disciplines

The change endorsed by the NRC (1996) in science education along with the vision for establishing a new mindset for science, especially in the early years, can be accomplished, in part, with integrating creative drama for the purpose of teaching science. However, this position is not without its share of critics.

Leading authorities criticize this assumption, even in view of the evidence that supports academic gain for students through arts teaching. Art researchers suggest that studies should be investigations of what the arts can teach that no other subject can teach (Hetland & Winner, 2000). Art programs in their view should be justified on their own merits, and should never be justified on what the arts can do for other subjects (Hetland & Winner, 2000). Eisner (1998) states that "We do the arts no service when we try to make their case by touting their contributions to other fields" (p. 15).

Traditionally, art educators justify the position of the arts within schools by arguing that the arts can increase achievement in other subjects (Hetland & Winner, 2000). This approach is the favored strategy in the United States for making sure that every child has access to arts training (Hetland & Winner). Viewing the arts only in terms of what it can do for other subjects is self-defeating, and there is risk of undermining their importance if policy makers believe that the arts cause academic improvement, and academic improvement does not occur (Hetland & Winner). It is unrealistic, the researchers argue, to think that the arts can be as effective a means of teaching an academic subject as is the direct teaching of that subject (Hetland & Winner). Arts researchers argue that teachers do not teach history because of what it can do for the study of mathematics, and neither should arts educators teach the arts only in terms of what it can do for other subjects (Hetland & Winner).

Researchers Hetland and Winner (2000) recommend more theory building and ethnographic studies of schools that place serious emphasis on the arts. They put forward the theory that schools which promote the arts also embrace other kinds of innovations that are favorable to academic learning (Hetland & Winner). They suggest the theory that schools may become more inquiry-oriented, more project-based, more demanding of high standards as a result of an arts-rich curriculum (Hetland & Winner).

Hetland and Winner (2000) oppose the justification of the arts for their secondary effects, but the researchers do agree that there is educational value in programs that integrate the arts in order to foster learning in other non-arts areas. The research, in their view, should consist of experimental studies which compare academically strong vs. academically at-risk students. The research emphasis should be directed to how the arts effect motivation to learn in other academic subjects (Hetland & Winner, 2000). Research and best practice teaching reveal the wealth of benefits and particularly the academic gain to students and schools who are supported in the arts (Gullatt, 2007). Findings reveal that "the performing arts and visual arts challenge students to use reasoning skills, draw conclusions, and formulate ideas" (Gullatt, 2007, p. 212). Scientific reasoning, drawing conclusions, and formulating new ideas are important to a nation concerned with global leadership in science knowledge acquisition and innovation.

Regarding the NRC's assertions that just as no one method in science should be interpreted as the end all and cure all, the question remains why has the vision of using the arts as a springboard to developing science understanding being overlooked and underutilized in view of research claims? In Wee's case study on the effective use of creative drama with primary children, drama was highly praised as an instructional strategy, but the least practiced of learning experiences in schools (Wee, 2009).

Teacher research into different strategies and the use of alternative methods which seek to understand best practice for students is needed because elementary teachers who seek variety in instructional strategies are more likely to be able to meet the diverse learning needs of students in the elementary classroom (Baker, 2005). In one study, Baker (2005) ascertained that teachers who are trained to use different instructional as well as disciplinary strategies may be better *able (italics* added) to educate a variety of learners in an elementary setting.

Teaching the arts for art's sake alone looks and sounds good as Hetland and Winner of Harvard University Project Zero's REAP (Reviewing Education and the Arts Project) maintains, but solid research which supports what drama can do for academic achievement is still needed in Alabama, and in many public schools beyond Boston and Cambridge, Massachusetts. Many researchers maintain this view of positive benefits to students engaged in the arts as Catteral, Iwanaga, and Chapleau (1994) state:

> Students in middle school and high school who were involved in the arts earned better grades, were less likely to drop out of school, watched fewer hours of television, were less likely to report boredom, and had a more positive self-concept, and were more involved in community service. (p. 80)

Research Support of Creative Drama in Education

The data base for arts research is supportive. For example, in a ten year longitudinal study, 25,000 students participating in the National Educational Longitudinal Study (NELS, 1988) found that an arts rich learning environment is associated with positive educational measures (Catteral, et al., 1999). These positive educational measures were demonstrated in content knowledge, skills acquisition and better attitudes about learning which crossed over SES levels. Other researchers have shown the effects of arts integration on other subjects. Dupont's study of the effects of creative drama in reading comprehension is such an example.

Dupont's (1992) comparative study measuring the growth of comprehension skills in fifth grade remedial students who were exposed to a treatment of creative drama showed significant mean gain scores at the .05 level. In DuPont's study, three remedial reading groups were compared. Group One read selected children's literature and engaged in creative drama activities. Group Two read and discussed the same stories in a traditional format, and did not engage in creative drama activities. Group Three followed the normal Chapter One remedial curriculum during the treatment (Dupont, 1992).

The Metropolitan Reading Comprehension test (MAT6) was given as pre- and posttests to all three groups (Dupont, 1992). Criterion-referenced tests were given additionally to Groups 1 and 2. Using an analysis of variance (ANOVA), Group 1 had significant mean gain scores at the .05 level on the MAT6. Groups two and three showed no gain from pretest to posttest (Dupont). The weekly analysis of criterion-referenced tests demonstrated that "Group one's mean scores were significantly higher at the .01 level than Group 2's mean scores on four of the six tests given" (Dupont, 1992, p. 41).

Creative drama as an instructional tool to "enhance reading comprehension, is a strategy that warrants recognition and continued investigation" (Dupont, 1992, p. 51). Dupont suggests that these reading comprehension results could be further used to support the reading and comprehension of non-fiction science texts such as "acting out the actions of water molecules as they move through phase changes" (p. 51). Dupont's research theorizes that reading about the abstract nature of molecules in science could enhance comprehension of science concepts for students by engaging in the role play and acting out of science texts.

Kamen (1991) tested the effectiveness of creative drama as a strategy in the teaching of science in the elementary classroom. Kamen's qualitative case study focused on teacher-led creative drama activities which revealed improved achievement in both teacher and student understanding of science content. The data included open-ended pre- and posttests and triangulated pre- and post-interviews of teachers and students. The study's findings of strong positive gains and positive perceptions of teachers and students supports the research's conclusion that creative drama enhances science instruction. Kamen suggests that creative drama should be used to "supplement and enhance a good-hands-on, minds-on science program" (p. 227). In view of Kamen's "minds-on" science, the idea of meaningful learning involves drama in science. Teachers who are trained in a variety of teaching strategies such as creative drama are better prepared to address the different learning needs of elementary age students (Baker, 2005).

Vygotsky says that the nature of knowledge is not fixed and transmitted by a single authority figure, but knowledge is socially constructed, and reality is created during physical and social activity (Vygotsky, 1978). Could this physical notion of learning be constructed to mean the movement children experience in a social activity such as creative drama? According to Wee (2009), using the body expressively is not encouraged in school; instead, academic subjects and cognitive development are given greater emphasis. Young children in an early childhood program experience drama because it places the body and its movements at the center. Thus, using creative dramatics as a tool for deeper understanding in science is driven by the constructivist ideas about the nature of language and thought with deeper understanding in any given discipline being driven by the underutilized idea of using kinesthetic awareness in students in order to know or understand content (Osmond, 2007).

Researcher Osmond (2007) classifies this as using the movement of the body to know and then using the body to make meaning in drama education. No other species has the human's mind and ability to represent through symbols, and this would include dance or creative movement created by the human body. Whereas language is one major symbol system that is viewed as having a relationship to thinking and learning, other meaning is created and expressed through symbol systems such as art, drama, music, dance, or creative movement (Osmond, 2007). The tenets of modern constructivism and Osmond's classification of moving the body as a means to understanding is one portion of what it means to engage learners in creative drama activities in order to learn science. Creative drama supports the constructivist idea that students must interact with ideas and things in order to make knowledge for themselves. This includes verbal interactions for the linguistic centered learner and kinesthetic movement for the learner who learns best through kinesthetic movement and participation.

The use of the word "guided" gives this researcher a clue to how this strategy of learning and experiencing parallels social constructivist theory and the use of creative dramatics. For example, social constructivist theory supports the role of the learner and teacher as a relationship of transactional learning (Vygotsky, 1978). It is far removed from a transmission model of stimulus-response teaching (Fosnot, 2005). Activities associated with creative dramatics such as pantomime and improvisation give learning a constructivist structure and transactional learning pathway in order to help build knowledge of concepts. Pantomime engages the kinesthetic learner while providing the drama facilitator a vehicle to transport conversation among and with students. Shared meanings enhanced by pantomime and improvisation which are grounded on prior knowledge, or even lack of knowledge will lead the teacher-facilitator to help students construct deeper understanding of concepts while clarifying misconceptions in science. Creative drama supports the constructivist paradigm that the learner makes meaning through firsthand experience (pantomime, improvisation, script writing, and dialogue creation) in a social setting with an informed facilitator.

The assumption is that activities associated with both formal and informal creative dramatics such as the use of a prop, improvisation, role playing, and pantomime offer the child and teacher a tangible approach method to explore concepts not only in science, but in other subjects, too. This research will make an analysis of the ways creative drama helps students to learn science concepts.

Summary

There is a call for improvement in science education in the United States. The over dominance of a transmission style teaching, with the no talking rule attached, is obsolete in science classrooms that aim for conceptual learning. Conceptual change learning for deeper understanding is no longer viewed as being solely influenced by cognitive factors alone, but rather includes the affective, social, and cultural factors that share bonds of what it means to foster conceptual change in learning (Davis, 2003). Deeper conceptual understandings based on prior knowledge of how the world works in science prepares the way for what is experienced and understood by children in middle and high school classes in science. Teaching practices that aim for examining students' conceptions or alternative ideas of science can be used to launch conceptual-based learning. It can lead to better understanding and teaching practice.

Science literacy for all is a vision in which students engage in restructuring or challenging their ideas for authentic learning in science. It is not merely the memorizing of isolated facts for the purposes of standardized testing. It is a vision where teachers are better trained to lead the student in defining problems, looking for evidence, examining what others have to say about the evidence, and then knowing how to find the information in order to weigh what the accepted scientific community has to tell us about the phenomena observed. The better aim of science is that this process is ongoing throughout life.

Creative drama is one art-based tool that can be used to anchor children's prior knowledge and experience in order to cross the bridge of understanding in science education. It creates the setting where children must create models of their thinking, and it allows the teacher to view and give meaning to what children understand about science. It provides an additional opportunity for better learning in a social setting where meaning is negotiated and evaluated by self and peers for greater understanding. The process of creative drama involves problem solving very much like the discipline of science. It allows children to work in a social instructional setting in which higher level thinking at the synthesis and evaluation stage is paramount in solving problems and developing new ways of thinking.

CHAPTER THREE. METHODOLOGY

This chapter will describe in detail the research methodology used in the study. The research questions that formed the basis of the study will be stated. This will be followed by a description of the researcher's role in conducting the study, consent procedure, time frame in carrying out the research, and information about the enrichment program participants who agreed to be in the study. The research instrumentation and instructional procedure will be discussed, along with the creative drama implementation, data collection procedures, method of data analysis employed and finally, the limitations of the study.

Overview and Purpose

The purpose of the study was to examine how creative drama affected the learning outcome of science content at the elementary level. The study is related to the assumption that the arts have value in developing learning in other academic subjects and that creative drama can be utilized by teachers to assess, enrich, and extend science understanding (Hetland & Winner, 2000; Kamen, 1991).

The following research questions guided the study:

1. Does the inclusion of creative dramatics in inquiry-based science instruction help students' understanding of science concepts significantly better than inquiry-based instruction without creative dramatics?

   1a) Are there significant differences between treatment and control groups when creative dramatics is included in an inquiry based science program?

1b) Are there significant differences between grade levels when creative dramatics is included in an inquiry based science program?

1c) Are there significance differences between group and grade levels when a creative dramatics approach is included in an inquiry based science program?

2. Does the inclusion of creative dramatics in inquiry based science instruction help students' attitudes toward science learning significantly better than inquiry-based instruction without creative drama?

3. What do students think about the use of creative dramatics in helping their learning of science concepts?

A mixed mode, quasi-experimental design was determined to be the best analytical approach in addressing the study's research questions, aims and purpose. The purpose and goals of the study were as follows:

1. To determine possible changes in achievement between treatment and control groups in science based on the inclusion of creative dramatics in conjunction with the FOSS program
2. To determine possible changes in science attitude among participants in this study
3. To determine additional insights from the drama treatment group of how creative drama helps learning in science

Role of the Researcher

During the period of this research, the researcher was employed with the Opelika City School System as an enrichment teacher. The role of the researcher was to examine if the inclusion of creative dramatics in inquiry-based science instruction helped students' understanding of science concepts significantly better than inquiry-based instruction without creative dramatics. As an enrichment teacher, the researcher had opportunity to implement this creative dramatics approach in her classroom to fourth and fifth grade students. The researcher's own professional orientation toward using dramatic arts integration into school subject matter led her to seek additional insight into the value of using creative drama as a pedagogical approach to teaching science. The researched wanted to understand if application of creative dramatics had any significant effects on increasing children's learning of science conceptual content. The researcher also wanted to know what meaning the children in the treatment group placed on how creative drama helped them to better understand science. The researcher's orientation as a former Title One Reading teacher and drama teacher led her to seek additional clarification in how a language arts activity such as creative dramatics could be used to teach science.

As a teacher participant in the study, the researcher's role is defined in part by the methods used in a study. The researcher of this study acted as a teacher participant which is a research approach that views the teacher as researcher and facilitates teachers using their "expert knowledge and understanding of practice in the research of their practice" (Loughran, Mitchell & Mitchell, 2002, p. 3). Therefore, the researcher's role in the study can be further defined as using action research participant methodology and analysis. Participant methodology focuses on the relationship between teaching and learning and addresses the gap between theory and practice (Loughran, et al., 2002). The researcher of this study was the main investigator using twenty-five years of classroom drama teaching in researching and understanding practice. The researcher's role in the study is described as participant observational which supports the teacher as a researcher of his or her own practice. The central question to this research is how the applied treatment of creative drama affects the learning of scientific concepts in the elementary school science curriculum above the use of a well-known inquiry-based curriculum, FOSS.

Consent Procedure and Time Frame

In September of the 2010–2011 school year, permission from the superintendent and the principal was obtained by the researcher in order to conduct the study as part of the researcher's regular teaching responsibilities as an enrichment teacher in the Opelika City School System. Upon Institutional Review Board approval in October, the process of informed consent was instigated with a pre-study recruitment letter. The letter was carried home by students in the pull-out enrichment classes to their parents explaining the purpose of the study. A week later, after the distribution of the recruitment letter, approved consent forms were passed out by the researcher to each student in the fourth and fifth grade small group enrichment classes. Students were informed that the study was voluntary, and that if they wished to take part in the study, or even if they wished not to participate in the research study, that would be a choice they could make together with their parents. Each student carried home parental and student informed consent forms (see Appendix D).

Several safeguards were implemented to address the issue of coercion in the study. In order to address the issue of student coercion in the study, letters of parental consent and child assent were mailed directly to Dr. Charles Eick in a self-addressed envelope provided by the researcher to the department of Curriculum and Teaching at Auburn University. In order to minimize coercion, the researcher did not know the names of students who consented to be in the study, or those who chose not to participate in the study. In addition, no grades were given to participants in the study in keeping with school policy for all exploratory enrichment classes in the Opelika City School System. To encourage a good response rate, one follow-up letter was mailed home to parents and students as a reminder to mail the self-addressed envelope with the permission forms to Dr. Eick. To insure that consented participant data be used, parents and students were asked to sign, and return the consent and assent forms even if the child had decided not to participate in the study.

Instructional Procedure

Commencing in October, participants in the treatment group in the study received inquiry-based instruction using the Full Options Science System (FOSS) Module (The Regents of the University of California, 2005) plus the addition of creative dramatics as a learning strategy in science. The control group received inquiry-based science instruction using the FOSS Module, but did not receive creative drama treatment. Two treatment groups of fourth and fifth grade small group enrichment classes were used in this study. Group A (the creative drama treatment group) was composed of 19 fourth grade and fifth grade male and female pull-out small group enrichment students. Group B (the non-drama control group) consisted of 19 fourth and fifth grade male and female small group pull-out enrichment students. Treatment groups consisted of one fourth grade class (n = 9) of small group enrichment students and one fifth grade class (n = 10) of small group enrichment students. The study's control groups consisted of one fourth grade small group of enrichment students (n = 12) and one fifth grade small group of enrichment students (n = 7). Only data from participants who consented to be a part of the study was used in analysis. The design was non-random assignment. Participants in Group A(treatment group) and Group B (control group) of the study were members of the small group pull-out enrichment classes and attended morning or afternoon classes based on the school's master scheduling of small group enrichment.

The FOSS investigations in the modules *The Physics of Sound* and *Solar Energy* were taught by the researcher. The pacing and length of time for the FOSS Investigations used in the study was based on enrichment classes meeting weekly for ninety minutes. Fourth grade study participants were taught using the FOSS investigations for the Physics of Sound Module and fifth grade study participants were taught using the FOSS investigations in the Solar Energy Module. The Physics of Sound and the Solar Energy pre- and posttest developed by the Full Option Science System (FOSS) was administered to both groups of fourth and fifth grade participants in the study, respectively (see Appendix A). Students were not taught the Sound and Solar Energy information in the FOSS modules in the general classroom during the time of this study.

In the *Physics of Sound* Module, fourth grade students conducted four investigations that explored the content of sound physics by observing and manipulating materials in the science enrichment room utilizing simple tools. In the same manner, the FOSS *Solar Energy* module for fifth grade students supported the students in developing skills of investigation, in order to build and communicate science explanations based on knowledge and evidence. All participants in the study were taught using the investigative FOSS modules.

In order to insure greater validity to the results of the study, careful fidelity in the teaching of the FOSS investigations was addressed by following the exact sequencing of the FOSS investigations as presented in the teacher's guide for both modules. The adherence to following the sequence of the investigations as presented in the teacher's guide provided greater control that the teaching approach was the same for both the treatment and control groups in the study.

Minimizing Research Bias

The researcher is aware that bias can be present in any study. Schwandt (2007) explains bias in inquiry as any individual preferences or predispositions for a particular group which renders the researcher as incapable of producing an objective or neutral account (p. 20). To minimize researcher bias and to minimize any breaches of confidentiality, a participant number ID code was developed for the open-ended drama questionnaire, the Three Dimensional Science Attitude Survey (TDSAS) Science Surveys and the FOSS pre- and posttests. Student names were matched to the numbering code and were unknown to the researcher. The code lists and student names were kept under lock and key in room 5058 of Haley Center in the College of Education at Auburn University. Two non-consenting participants in the study were pulled and the data from these students were not used and were unknown to the researcher. The researcher was only aware of the grade level of the numbered consenting participant and whether the science surveys, the pre- and posttests, and/or drama questionnaire were treatment or control. The codes were used for purposes of grading the FOSS pre- and posttests, the open-ended drama questionnaire, and TDSAS survey analysis in SPSS.

The Small Group Enrichment Participants

Participants in the study were students who receive small group enrichment services through the Opelika School System's Enrichment Program. As a teacher-participant observer in the study of my own teaching practice, the students in this study purposefully informed an understanding of the research problem and central phenomenon in the study (Creswell, 2003, p. 125).

Selection of students for small group pull-out instruction is based on Joseph Renzulli's model of school-wide enrichment. This type of enrichment program is a state-approved alternative program to Individualized Educational Plans (IEP) used in traditional Talented and Gifted Programs. Renzulli's school-wide model targets three areas of behavioral dispositions used in the identification of talented and gifted students: creativity, above average ability, and task commitment (Renzulli, 1977). The participants in the study were identified as talented and gifted through the Alabama State Department of Education's Child Find Identification Program (Rules of the Alabama State Board of Education, Alabama Code Title 16. chapter 290-8-9, 2007).

The students in this study were screened and identified through the Alabama State Department of Education Child Find. The Alabama State Department of Education Child Find is an assessment procedure in Alabama for identifying high potential students. The process of identifying high potential students for inclusion in services in talented and gifted education begins in second grade.

A configural analogy and assessment for creativity of ideas using drawings are collected to document creative ability. These assessments do not focus on students' drawing or artistic abilities, but documents students' fluency of ideas and elaboration of ideas through a transformational drawing process. The configural analogy and assessment for creativity carries a possible score of twenty points and grading is based on a rubric supplied by the Alabama State Department of Education.

The Renzulli Triad Index (RTI), which identifies behavioral dispositions, is used in addition to the configural analogy and transformational drawing assessments. The RTI instrument is divided into 3 categories: creativity, above average ability, and task commitment. Teachers rate the identifiable behavior observed on the following scale: seldom or never = 1, occasionally = 2, often = 3, almost always = 4. This instrument has a possible score of one hundred points. Scores are combined and totaled with a possible score totaling one hundred and twenty points. Students are then ranked based on points and selection is made. Anecdotal information such as collecting a writing sample or an oral transcription of a student's storytelling is used for additional documentation.

Beginning in the 2010–2011 school year, in order to reduce costs in standardized testing, second grade screenings of students did not include the Stanford Achievement Test. The new guidelines now include the above described configural analogy and line drawing assessment for creativity as the initial identification of candidates eligible in the small group enrichment program. Once the child has been identified by teachers and the enrichment specialist, parents/guardians are informed of the selection, and permission letters are sent home requesting parental consent to serve the student in the enrichment pull-out program.

Students continue to be placed in the enrichment program unless there are factors that would lead to withdrawal such as a drop in grades, parent request for withdrawal, failure to keep up with assignments in the general classroom, or participating in other extracurricular activities (e.g., the violin training program). Unless placement is changed based on the factors listed, the children in small group enrichment benefit from looping which is defined as one teacher keeping the same students over time. For example, the researcher teaches the students in the program for more than one year beginning in the third grade and continuing to the fifth grade.

Fourth grade ethnicity and gender breakdown of the participants in the study were as follows: 35% male Caucasian, 20% female Caucasian, 25% male African American, 10% female African American and 10% male Asian Pacific Islander. Fifth grade ethnicity and gender breakdown of the study participants were as follows: 35% male Caucasian, 15% female Caucasian, 15% male African American, 30% female African American and 5% female Asian Pacific Islander. There were no participants classified as English as Second Language Learners (ESL).

Instruments Used In the Study

The Three Dimensional Survey of Science Attitudes (TDSAS; Zhang & Campbell, 2010) was distributed to all the students at the beginning of the study, and then again at the completion of the FOSS science investigations (see Appendix A). Only the treatment groups completed the drama questionnaire (see Appendix B). The TDSAS was distributed to both the treatment and control groups and collected by the researcher in order to determine if there were any significant differences in student attitudes toward science.

Two science investigation modules from the Full Options Science System (FOSS; The Regents of the University of California, 2005) were selected to teach the conceptual science investigations used in the study. Email correspondence by the researcher to Nicole Medina, FOSS Project Manager, asking for the FOSS pretest survey for use as a valid pretest and posttest in physics of sound and solar energy was obtained and used in the study.

Pearson's correlation of test and retest reliability of the FOSS pretest and posttest in sound physics and solar energy revealed a large correlation ($r = 0.713$) where the p value is equal to $p < 0.001$. Correlation is significant at the 0.01 level.

The TDSAS from pre-survey to post-survey yielded a moderate to large correlation and an acceptable reliability where $r = 0.613$ and p is determined at $p < 0.001$ level. Kaiser-Meyer-Olkin (KMO) demonstrated sampling adequacy at .624. The degrees of freedom as revealed by Bartlett's Test of Sphercity equaled 66.

The TDSAS developed for elementary students, was administered to the participants in this study (Zhang & Campbell, 2010). The TDSAS was collected from both treatment and control groups at the beginning of the study, and then again at the completion of the FOSS investigations to measure any differences in the participant's affective attitude toward science, cognitive beliefs about science, and motivation to learn science.

An open-ended drama survey, developed by the researcher, was administered to the drama treatment group, and was used to help the researcher understand how students perceived the use of the creative drama treatment in helping them to learn science (see appendix C). The open-ended drama questionnaire was completed by the treatment group respondents in order to determine student's affective feelings toward creative drama, student behavioral tendencies and motivation to learn science using creative drama and student cognitive judgment of how creative drama helped them to learn science. The drama questionnaire was used to answer the first research which states: What do students think about the use of creative dramatics in helping them to learn science? The drama questionnaire employed in the study is driven by tripartite theory and consisted of questions with three categories: enjoyment of creative drama, cognitive judgment of how creative drama helps to develop understanding in science, and students' perceived motivation to learn science using the additional support of creative drama. The tripartite theory of attitudes aligns linked dimensions of attitudes with the following three constructs: affective, cognitive and behavioral (Zhang & Campbell, 2010).

In addition, each belief statement in the drama questionnaire was developed on the ideas of social-cognitive psychologist Albert Bandura. Based on Bandura's assumption that of all the human traits, none is more basic than the individual's capacity for reflective thought, the questionnaire was determined to be child-respondent friendly by an expert in the field of science education. In item 4, it was determined that by providing a list of all the drama activities the students engaged in, the treatment groups completing the survey at the conclusion of the FOSS investigative modules would be better prompted to reflect back on the drama, and how its inclusion helped to understand the science. It was determined that a listed choice of items would invite more descriptive detail in the children's written responses.

Item 9 in the drama survey was constructed based on Albert Bandura's ideas about the nature of self-efficacy which states that among the types of thoughts that affect action, none is more central than people's judgments of their capabilities to exercise control over motivation and behavior (Bandura, 1986). People's conceptions of what they think, believe, and feel, affect how they behave. The use of the drama open-ended written response questionnaire allowed the researcher to gain a deeper understanding of how the child perceived and reflected upon learning science with the inclusion of creative drama.

Rationale for TDSAS Survey Selection

The TDSAS is a science attitude survey based on the tripartite theory of attitudes and consists of three constructs: student affective feeling about science, student cognitive judgment of science based on values and beliefs, and student behavioral tendencies in learning science (Zhang & Campbell, 2010). The decision to use the TDSAS in the proposed study was based on acceptable internal consistency and internal reliability measures. Also, the decision to use the TDSAS was based on several research findings that suggest student science attitudes are linked to student achievement and motivation in taking science courses and pursuing science related careers (Alsop & Watts, 2003; Haladyna, Olsen & Shaughnessy, 1982). This has indications for teaching practices in the elementary years in fostering the mindset for conceptual learning development of future scientists (Zhang & Campbell, 2010). Cronbach's Alpha Coefficient was used to evaluate the survey's internal consistency and each construct's internal reliability. The internal consistencies (0.65 to 0.83) for the TDSAS were considered acceptable (Zhang & Campbell, 2010).

The decision to use twelve of the survey's statements to measure affective feeling toward science, cognitive understanding about the value of science, and motivation to learn science was based on the researcher's judgment of how the children would be able to handle completing the survey with regards to the time it would take the participants to complete the twenty-eight item survey during instructional time. Although using the complete twenty-eight item survey can make claim to appropriate internal consistent reliability and concurrent validity as demonstrated by its developers, Zhang and Campbell, in this study, it is reasonable to apply value validity to the survey but not construct or structure validity.

Creative Drama Implementation

The creative drama activities implemented in the study were designed to be introduced after the students have had some experience with the content presented in the FOSS module. The creative drama activities were developed by the researcher and by the students through improvisation and relate to the science content of the investigations.

After modeling how dialogue could be created using personification in storytelling, students were invited to improvise and then write their own stories to act out about sound. For example, after completing the investigations on sound and vibrations, participants acted-out the teacher model of the dramatic narrative *The Real Story of Sound* (see appendix C). Later, the students were encouraged to develop their own role playing stories based on the content inquiry and science investigations outlined in the FOSS modules. The initial use of the adult modeled story prompted additional student created science scenarios integrating science content with reading, language arts skills, and creative drama skills in the context of extending and enriching the investigations presented in the FOSS Physics of Sound Module.

The use of a “science theatre” in the form of role playing and story writing supported the investigative conceptual learning presented in the FOSS modules which developed the concept that in order to produce sound, a vibration or sound wave must occur. This science concept is a major theme of *The Real Story of Sound*. As students listened to the story, which lent itself to the physical action that dramatic storytelling requires, students brainstormed and experimented through improvisation and through the story’s text ways to act out the action and storyline of the science story.

Desiring that the study’s drama activities concentrate on using student generated inventions and ideas allowed the class to work as a team to produce their own scripts and scenarios. In one improvised activity, students engaged in a pretend dialogue that a vibration might have with air molecules. In another activity, use of the classroom piano keyboard demonstrated how sound waves can travel through liquids, solids and gases. Students selected and correlated piano music to reinforce that sound needs a medium to travel through. They asked the question: What would a sound wave look and move like if it were traveling through solids, liquids and gases? The keyboard and the use of music played by a fifth grade participant in the study enriched the science by allowing the students to pretend to be sound waves traveling through these mediums. The integration of music helped the students to move and imagine sound waves in a moment of traveling through different states of matter.

In the teacher story example, using the skills and movement of pantomime and invented dialogue, the science characters in *The Real Story of Sound* resolve a series of obstacles in the story in order to understand how sound travels. This activity was used to develop understanding for four tested concepts contained in the FOSS Pretest/Posttest Survey. The first concept is that in order to have sound, a vibration must occur. This concept is acted out in the story through the imaginary Prince Vibration who warns the citizens of impending doom by moving rapidly back and forth. Another example, which is tested in item three of the Pretest/Posttest Survey, was the concept of sound amplification. In the text the citizens pantomime cupping their hand to their ear in order to amplify the warning sound coming from the shore. To expand this concept further, a megaphone constructed in an earlier investigation was used as a theatre prop to help tell the story. This was tested in item three as gathering and directing sounds in order to amplify a sound wave. An additional example of how the story enhanced the concept of how air molecules vibrate and form a sound wave was developed and acted out in the character of Grand Duchess Molecule. In the story, the Grand Duchess orders the gases to vibrate causing the sound wave to move out in all directions. She declares in triumph, “Sound is a vibration that travels through all matter—liquids, gases and solids”. The concept of a sound wave being able to travel through a medium such as a gas molecule was tested in item six and thirteen in the FOSS test instrument. The remaining concepts of pitch, volume, rate of vibration, tension, the effects of size and length of string activities can be found in the FOSS Sound and Solar Matrix with creative drama integration in Appendix B.

The use of the narrative *The Real Story of Sound* as a preliminary story model, and the Solstice Home TV Show Model to extend the Physics of Sound and Solar Energy Investigative Modules, respectively, encouraged students’ to develop their own ideas in generating improvised drama. As the researcher listened to the treatment group ideas about how to best improvise the concept of how molecules might vibrate in different mediums, the researcher was able to determine if they understood the concepts presented in the FOSS Modules. As the drama students created a commercial on the science of buying a solar home, the researcher was able to determine if they understood the best materials to use for a heat sink, or the best position to place the windows in a solar heated home based on the science of the investigative modules. When one group of students created the original skit, "The Cave Man's Story," which centered on where the sun rises and sets, and how the length of a shadow changes from sunrise to noon on a sunny day, the researcher was able to assess and verify if the students were experiencing conceptual learning as opposed to memorizing a fact. Including this concept in their role playing, and building a story to explain their FOSS shadow investigations led the researcher to believe that the concept was understood at a deeper level. This was accomplished by actively listening and clarifying the concepts as the improvisational role playing occurred. As both the creative drama teacher and science teacher, the researcher employed what Bonnie Shapiro (1994) describes as "sensitive listening" to what children's prior ideas and experiences in science reveal in an "authentic encounter" (p. xix).

Data Analysis

A Mixed Design ANOVA 2x2x(2) method was used to make analysis of the quantitative learning outcomes of the creative drama treatment and non-creative drama control groups in this study, and was administered using Statistical Packages for the Social Sciences (SPSS; version 19.0) computer software. This analysis was used to determine any significant differences in the learning outcomes of Group A (the creative drama treatment group) and Group B (the non-creative drama control group) in learning outcome and science attitude as measured on the FOSS Module tests and the TDSAS respectively. The dependent variables of this study are defined as learning outcome and science attitudes. The independent variables were group and grade over time.

Learning outcomes were measured using the FOSS Pretest/Posttest Survey. The Pretest/Posttest Survey was given to students at the beginning of the investigations, and then again at the conclusion of the investigations in both modules. Science attitudes were measured using the TDSAS, and were given to students at the beginning and then again at the conclusion of the investigation.

The researcher scored the coded student Pretest/Posttest Survey test knowing only if the tests were part of the treatment or control group. Names of the students were whited out prior to evaluation by an outside source. The test was assessed based on the scoring guide supplied by the FOSS teacher's guide. No letter grades were given to the students in the context of conducting this study nor were the results used to determine science grades in homerooms.

The Pretest/Posttest Survey in both modules contain coding guides for each science concept taught in the FOSS Investigations. The coding guides contain model student responses. The higher numbers are connected to a more complete student answer. Numerical values for *The Physics of Sound* have a possible total of twenty points and numerical values for *Solar Energy* has a possible of twenty-five points.

The Three-Dimensions of Science Attitudes Survey (TDSAS), developed for elementary students, was administered (Zhang & Campbell, 2010). The TDSAS was collected from both treatment and control groups prior to the beginning of the study, and then again at the completion of the FOSS investigations. It was determined by the researcher after reviewing two science surveys suggested by an expert in the field of science education that the Zhang and Campbell Three Dimensions of Science Attitudes Survey be used for the study. The decision to use the TDSAS was based on the researcher's opinion of the ease of readability that the survey afforded to the students in the study (see Appendix A). The decision to use 12 of the items of the TDSAS survey was based on consideration for the length of time that students would engage in taking a survey.

The analysis of the data collected from the TDSAS consisted of three parts. The first part described the demographics of the students. This included gender and grade level. The second part of the collected data described the results yielded from the three categories or constructs from the respondents. The data for this section consisted of twelve statements with four statements from each three categories: cognitive judgment of science based on values and beliefs, student affective feelings about science, and behavioral tendencies (motivation) in learning science. The respondents scored the items using a five point rating scale as follows: 5 = strongly agree, 4 = agree, 3 = neutral, 2 = disagree, and 1 = strongly disagree.

Student's affective feelings about science were measured using items 1, 2, 8 and 9. Cognitive judgment about science based on beliefs and feelings was measured using statements 5, 6, 10 and 11. Behavioral tendencies and motivation to learn science was measured using statements 3, 4, 7 and 12. All items were completed by the students.

The drama open-ended questionnaire, developed by the researcher, was completed by the treatment group at the completion of the investigations. The open-ended drama questionnaire was also driven by tripartite theory and consisted of questions with three categories: enjoyment of creative drama, cognitive judgment of how creative drama helps to develop understanding in science and students' perceived motivation to learn science using the additional support of creative drama. The tripartite theory of attitudes aligns linked dimensions of attitudes with the following three constructs: affective, cognitive and behavioral (Zhang & Campbell, 2010).

The open-ended drama questionnaire was given to the treatment group at the end of the modules and made analysis using qualitative research methods. Fitzpatrick, Sanders, and Worthen (2004) contend that when the researcher identifies emerging themes from the answers to open-ended questions, there is a potential to yield additional insights and understandings of the phenomenon under study (Fitzpatrick, Sanders & Worthen, 2004). The questionnaire was used to identify common themes and insights that emerged as respondents provided meaning to the process of engaging in creative drama to learn science. The questionnaire informed and provided understanding to the research question which states: What do students think about the use of creative dramatics in helping their learning of science concepts?

As in a mixed mode study, two kinds of analysis were used to infer meaning of the data collected. The quantitative data was used to inform conclusions toward the second and third research questions, and the qualitative data was used to provide additional insight in order to answer the first question of the proposed study. The open-ended questionnaire was implemented using content data analysis. Schwandt (2007) defines this as a research methodology that examines ideas, words, and phrases within a text in order to look for patterns of meaning. This method involves comparing, contrasting and categorizing data in order to test a hypothesis (Schwandt). The researcher looks for meaning in sentences, texts, and phrases and determines thorough inference if there is a relationship between the words and concepts (Schwandt).

Limitations of the Study

Despite critics who place limitations on the credibility of teachers making analysis of their own practice in authentic classrooms, viewing the teacher as a researcher of his or her own classroom practice has become an acceptable form of participant-action research. Understanding how science conceptual learning can be helped by the inclusion of creative drama was important to my growth and practice as a professional teacher. As both the teacher and researcher of this study, maintaining researcher and teacher objectivity was an issue, and this fact is acknowledged as a limitation of the study. In the undertaking of this study, several strategies to reduce teacher-researcher bias and student coercion have been identified previously by the researcher in this chapter.

Summary of Methods

The quantitative analysis of this study was employed using a Mixed Design ANOVA 2x2x(2) design method and was administered using Statistical Packages for the Social Sciences (SPSS; version 19.0) computer software. The Mixed ANOVA method was used to make analysis of any significant differences in the learning outcomes of Group A (treatment group) and Group B (control group) and made comparative analysis using the pre- and posttest means and standard deviations to answer the second and third research questions in the study. The design analysis was used to determine if there were possible changes in students' conceptual understandings of science based on the inclusion of creative dramatics in conjunction with the FOSS program. The TDSAS survey of science attitudes was used in the research to determine changes over time in science attitudes among students in the study. The drama questionnaire was used to determine how students in the study perceived the use of creative drama as an effective learning strategy.

CHAPTER FOUR. THE EFFECT OF CREATIVE DRAMA ON STUDENT SCIENCE ACHIEVEMENT AND ATTITUDE

The increasing time demands of standardized testing still permeate American school culture in the twenty-first century. Yet, as early as 1935, A.W. Stewart, of Kent State University, wrote of the need for educators to develop tests and strategies that could be implemented to measure the ability to *apply* [italics added] science principles rather than just memorizing the facts and content (DeBoer,1991). Posner, Strike, Hewson and Gertzog (1982) explain conceptual science:

> Learning is concerned with ideas, their structure, and the evidence for them. It is not simply the acquisition of a set of correct responses, a verbal repertoire or a set of behaviors. We believe it follows that learning, like inquiry, is best viewed as a process of conceptual change. (p. 212)

Despite the wealth of research literature which supports application of science learning through conceptual-based models, the No Child Left Behind Act of 2001 demands, year after year, higher standardized test scores from every student in every grade in every subject until the school year 2013–2014 when all students will meet proficiency levels as determined by the states in which they reside (NCLB, 2001). The “one size fits all mentality” of these standardized tests, and the time preparation by the teacher to get the elementary child ready to be “good little test takers” across several subsets of skills is costly to practices that would otherwise assist teachers to develop science conceptually, and to assessments in science that invite application of science principles learned.

The American Evaluation Association (AEA) in its position on high stakes testing in pre-K–12 education reports that 30% of teaching time is swallowed up in preparing students for testing (AEA, 2002). The American Evaluation Association (AEA) supports all accountability and assessment measures that empowers education, but believes the use and impact of high stakes testing demonstrates it to be an assessment practice where the greater harm outweighs the benefits (AEA, 2002). The practice of using high stakes testing as a quick fix to treat teaching and learning in a simple and fair manner has serious problems in a culture where education is complex with inequities of opportunity among its stakeholders (AEA, 2002). The practice has become a narrow way to assess children's learning at the expense of models of teaching that stress application rather than memorization of science principles (AEA, 2002; Bransford et al., 2000).

Set against this greater student achievement backdrop, as measured by standardized testing, is the same incessant demand for teacher application of better and more effective teaching practices in science at all levels (NSF, 2008). In fact, the National Science Foundation Board (NSF) believes that the nation is in danger of failing to meet the needs of U.S. students in science and math (NSF, 2008).

In addressing the critical need of the nation, the NSF calls for a "roadmap" of national and state support outlining programs, and incentives that can provide better trained teachers along with properly aligned curricula objectives in science and better assessments of student learning (NSF, 2007, p. 22). A better trained teacher at all levels of education includes a plan that provides for the communication, dissemination, and identification of best practice research in science (NSF, 2007).

Research into using creative drama as a strategy of best practice method to teach, and authentically assess science, mirrors the process of teaching conceptually. This occurs as emphasis and attention is given over to knowing and understanding the student's prior understanding and personal ecologies about science. The practice of creative drama has been defined by Davis and Behm (1978) as an improvisational, non-exhibitional, process-centered form of drama in which participants are guided by a leader to imagine, enact, and reflect upon human experience. In the very young, creative drama becomes a way to learn about the grown-up world as they are seen pretending or role playing the adult driving the car or using the stove to prepare dinner (Davis & Belm, 1978). In science, creative drama becomes the structured lesson tool that allows for student exploration into the abstract and sometimes difficult concepts of science in order to learn science (Kamen, 1991). To illustrate the role playing power of creative drama to learn science, teacher-researcher Linda Perkovic explains how her students came to learn about electric current in order to build further understanding:

> The room was quickly rearranged, students became electrons. These electron-students walked around as if in a circuit. Chairs (resistors) were then added into the circuit and students had to slow down to climb over them. Therefore, they quickly obtained the image of electric current as moving electrons and resistors as things which slow down the flow of electrons. They then proceeded to act out what happens when the dial on the transformer was turned up. The function of the ammeter was then introduced by having one student take on the role of an ammeter and count the number of electrons (students) that passed a point in time. (Aubusson, Fogwill, Barr & Perkovic, 1997, p. 570)

Moving beyond the models and diagrams often used in science texts, the students in this scenario were able to grasp and understand electric current in a more personal and affective way, involving physical movement and role playing to create the analogy of moving electrons in a circuit (Aubusson, et al., 1997). The educational implications for using creative drama as demonstrated in this classroom event appear to support its use to strengthen deeper understandings “where laboratory space is restricted” (Metcalfe, et al., 1984, p. 80). Although not superior to other, more traditional ways of learning science, the use of creative drama has demonstrated that practical work in science and other content subjects can be carried out “effectively in non-laboratory conditions” (Metcalfe, et al., 1984, p. 80).

As the general elementary science teacher continues to manage less instructional time for science in favor of time to prepare students for high stakes testing, there is an instructional need to examine the impact of specific practices such as creative drama on student understandings in science. As the NSB (2007) calls for infrastructures that support research and centers of excellence in science teaching effectiveness, there is a need to establish science learning environments in the elementary classroom where the use of effective teaching methods nurture and reflect inquiry, debate, creativity, and the principles of conceptual change models in science teaching. Thus, the purpose of this research study was undertaken to investigate if science learning could be enhanced with the inclusion of creative drama into an inquiry-based science curriculum. More specifically, it was instigated with these objectives in mind: (1) to determine if there were differences in science learning outcomes between treatment and control groups when creative drama is included in an inquiry based science program, (2) to determine differences in science learning between grade levels when creative drama is included in an inquiry based science program, (3) to determine if there were differences in learning outcomes between group and grade levels when creative drama is used in the science program, and (4) to determine if any differences in attitude toward science occurred when drama is used in an inquiry-based science program. Struck by the long supported idea that there is no one right way to teach all subject matter (NSB, 2007), the invitation by the NSB to seek innovation in science curricula, while providing research into effective models of teaching, shaped the goal of this study in making analysis of whether the practice of using creative drama to teach conceptual science helped students to learn science significantly better than science without creative drama.

Theoretical Framework for Creative Drama

Noted pioneer in the field of creative dramatics for children, Winifred Ward wrote that the art of playmaking with children begins with action (Ward, 1957). Children in the cyber-space video world of today still, as Ward emphasized, “glory in action” (Ward, 1957, p. 1).

More recent research available in the domain of creative drama has suggested that drama may help individuals in realizing their potential in that it tends to support multi-intelligence theory by appealing to the kinesthetic learner (Aubusson, et al., 1994). Approaching Ward’s idea of children learning through activities that are not drilled, or “poured in”, for memorization to activities that challenge children’s curiosity, interests, and various domains of intelligence, is strikingly similar to Gardner’s ideas of developing and recognizing human potential through an individual’s strengths or multiple intelligences (Gardner, 1983; Ward, 1957).

For the kinesthetic learner of today who “glories in action”, as Ward termed, creative drama has the potential to assist the science learning process as a personally relevant avenue to develop deeper meaning in science (Aubusson, et al., 1997). For children whose intellectual strengths lie in the verbal linguistic domain of Gardner’s Multi-Intelligence Theory, Winifred Ward also wrote of the value of creative drama as the opportunity to express ideas as children obtain experiences in “thinking on their feet” (Ward, 1957, p. 8). Ability in oral communication and debate of one’s ideas as one engages in expressing ideas in creative dramatics is generally needed by citizens living in a democracy (Ward, 1957). This ability to “think on one’s feet”, as Ward expressed, would also be an important process skill for world scientists, as well as elementary students in conceptual based science classrooms where debate and communication of findings are encouraged based on evidence and inquiry. According to the NRC publication *Taking Science to School*, “genuine scientific argumentation and debate is rarely observed in classrooms” (NRC, 2007). According to the National Research Council publication, *Taking Science to School*, science is typically taught with the teacher doing all, or most, of the talking, diligently transmitting and convincing students of the validity of a scientific world view of knowledge (NRC, 2007). These conversation sequences are intended to “find out if the student can provide the answer expected by the teacher, not to communicate anything previously unknown, put forth a claim, justify or debate a point, or offer a novel interpretation” (NRC, 2007, p. 187).

Ward (1957) long ago related the idea that creative drama is an activity for the whole child that grows from “not having knowledge poured in by the teacher, but rather from participating in activities that challenge his deepest interest and highest powers” (p. 17). Today, the NRC is calling for best practice methods that facilitate the learner’s highest powers promoting the language of science through debate and argument based on theory and evidence (NRC, 2007). Without intervention, the NRC contends, students will not be able to “think on their feet” in adopting the specific language skills in conducting productive debate and defense of ideas based on evidence and inquiry (NRC, 2007).

Accordingly, this participant action research investigation was conducted to examine the effectiveness of teaching science as an extension to a well-known science inquiry program. It was hypothesized that an activity such as creative drama could be used to help children plan ideas, solve problems, expand ideas, broaden attitudes and build new knowledge based on prior knowledge. It was further theorized by the researcher that the process of doing creative drama shared many of the same objectives of teaching science based on conceptual models which stress discourse, inquiry, problem solving and the interchange of student ideas about science.

Conceptual Change

Conceptual change models have been shown to be effective models in science teaching by encouraging scientific discourse among teachers and students. According to Hewson and Hewson (as cited in Beeth, 1998) conceptual change models engage the teacher in diagnosing student ideas in science with assessment procedures aimed at changing misconceptions and building on prior understandings. Hewson and Hewson (as cited in Beeth, 1998) state that using meta-cognition strategies such as personal relevance and prior knowledge, the expectations for students in conceptual change science models are that students can clarify their own thoughts through individual work, or in group discussion guided by well-planned questioning. Park (2007) has further defined authentic assessment in science as the understanding of student ecologies that includes a students' past experience, metaphysical beliefs, understanding of the nature of knowledge, affective domain, and epistemological commitments that influence conceptual change teaching.

When students participate in creative drama activities, Kamen (1991) has shown that creative drama becomes a model of authentic assessment revealing what a child is thinking in science. What a child is thinking in science and expressing aloud through role playing and improvisational drama creates a non-threatening avenue for both teacher and student to engage in science discourse of content in order to understand personal student ecologies (Kamen, 1991).

The literature in conceptual change theory states that the process of learning is not viewed as the process of identifying a science fact to be memorized, and then later retrieved for standardized testing purposes. In contrast, conceptual change models develop lectures, demonstrations and labs which can be implemented to create "cognitive conflicts" in students in order for accommodations to take place (Posner, et al., 1982, p. 225). Lectures, demonstrations, labs and the appropriate implementation of creative drama as an extension strategy to learn science can mirror conceptual change models. Sharing many of the ideas of conceptual models such as engaging the child in discussion, creative drama has the potential to develop the learning environments, and student-teacher interchanges needed to launch better understandings of science content.

Creative Drama and Social Constructivist Theory

Many writers, researchers and theorists have revealed the inner workings found in the principles and theoretical framework of educational drama. Vygotsky's socio-constructivist theoretical idea of MKO, or more knowledgeable other, can be clearly seen as one driving force in Aubusson's empirical investigation into the effects of using creative drama to teach science with students. In this mixed ability classroom investigation, it was found that creative drama provided experience which modeled scientific phenomena initially not understood by all the students in the investigation. The participants who understood the science phenomena had no trouble in relating the science to the creative drama activity. Later, the investigation claims, the creative drama experience provided "building blocks" for scientific understanding to those students who lacked the conceptual understanding in the beginning (Aubusson, et al., 1997,

p. 577). The students who failed to grasp the science initially had developed through participation in the creative drama with other, more knowledgeable students the foundation in which to build further understanding of the science phenomena (Aubusson, et al., 1997). In explaining how the use of creative drama in the classroom provided benefit to the students who failed to grasp the science concept, the researchers conclude:

> …These students mimicked others. They could play their part but could not relate the part to electricity or gaseous exchange at the time. In later discussions students were able to remember their part and it provided a link for their developing of ideas. (Aubusson, et al., 1997)

In mimicking the more knowledgeable others through a collective group activity such as creative drama, the students had acquired a connective link for further conceptual learning of the science phenomena. This conclusion made by the investigators lends support of the value and potential of creative drama to help students anchor and build upon ideas driven by the principles set forth in socio-constructivist theory.

Creative Drama and Active Learning

Much of what researchers have published about creative dramatics supports its use as an instructional strategy or available model in helping students to use higher level critical thinking skills in order to learn science subject matter at a deeper level (Arieli, 2007; Kamen, 1991). Kamen (1991) describes creative drama as a spontaneous group process that uses imaginative play acting to help students and teachers to actively explore, while applying meaning to many abstract science concepts. Much like the approach to science teaching inherent in concept based learning, creative drama can be a tool for deeper learning that seeks to involve the student in an active approach to explain evidence and to relate ideas to prior knowledge in order to develop important insights in science (Metcalfe, Abbott, Bray, Exley, & Wisnia, 1984).

Educational research literature supports the idea of using experiential learning approaches with elementary students, whether they are actual vicarious experiences, or ones that are created through drama to help students learn in the content areas (Dupont, 1992). In line with concept based models of teaching, Arieli (2007) explains that creative dramatics is a most appropriate tool to assist the learning process in science because it fosters the ability to adapt and apply acquired knowledge from hands-on lab experiences to new problems and settings. Much like conceptual models of science learning, creative dramatics helps students to clarify and monitor their learning through discourse and feedback because students, along with their teachers, are actively evaluating their understandings, seeking clarification and feedback from the teacher and each other as they engage in creating the science drama (Arieli, 2007; Kamen, 1991).

Creative Drama and Student Motivation

Researchers Aubusson, Fogwell, Barr and Perkovic (1997) found that students who had shown little interest in school science, and those that preferred a kinesthetic approach to learning, used dramatic role playing with effective results in science understanding. Additionally, the researchers found that in non-threatening, science-friendly classrooms, shy students, who would not otherwise engage in higher level thinking discourse, acquired a means to express and think aloud about science (Aubusson, et al., 1997; Ladrousse, 1989).

Aubusson's research supported the idea that opportunities to participate in the drama appealed to different learning styles, and different levels of understanding as might be found in classrooms that use conceptual model approaches to science teaching. The study's conclusion:

> …Students operated in three ways as the role play allowed students with different understanding and different aptitudes to learn in different ways. Firstly, for some students role play was a way of demonstrating understanding that they already had about science phenomena. These students, for example, already understood the electric current or gaseous exchange and they could apply this understanding in a role play. Secondly, it was a mechanism students could use to construct an understanding about science phenomena. The students discussed and refined their ideas as they developed better role plays. And thirdly, it provided experience which modeled scientific phenomena initially not understood. (Aubusson, et al., 1997)

In another research study, drama was found to provide an alternative science learning strategy to lower achieving, or less able students in developing deeper scientific understanding which is the arch support of all conceptual based models of science learning (Metcalf, et al., 1984). This study suggested that students were better able to relate ideas to previous knowledge and experience by relinquishing an egocentric viewpoint of looking at things while participating in creative role playing in science (Metcalf, et al., 1984). The study concluded that deeper meaningful learning, as opposed to surface learning, had occurred as demonstrated by student acquired expertise in explaining evidence and conclusions, while relating the ideas to previous knowledge and experience (Metcalf, et al., 1984). The deeper approach drama provided, Metcalf explains, is in stark contrast to surface rote learning in which students are expected to store science information for use at a later date (Metcalf, et al., 1984). It would appear from the investigations cited that creative drama offers both the teacher and student the pathway toward a finer meaning of having obtained science literacy. This participant-action research set out to determine if these findings could be duplicated.

Methods

Participants and Context of the Study

The participants in this study consisted of 38 students in four classes of fourth and fifth grade students, ages nine and ten. Twenty-two participants in the study were fourth grade students studying the physics of sound. Male students represented 72.7% of the students in the fourth grade talent pool classes while 27.2% of the participants were fourth grade females in the talent pool classes. Male students in fifth grade were represented by 37.5% of the students in the researcher's talent pool classes and female students were represented by 62.5% of the participants in the fifth grade talent pool classes.

The instruction took place in the fall semester of 2010 in one of two intermediate schools located in a small town in the southeastern region of the United States. The terms of the study required the students to take a pre- and posttest of the science content presented in the Full Option Science System (FOSS) Kits in the physics of sound and solar energy. The participants also agreed that the researcher would collect a pre and post science attitude survey for data analysis at the beginning of the study and at the conclusion of the study. All students completed the FOSS pre- and post-tests and the science attitude surveys. Only students in the drama intervention group completed a drama questionnaire at the end of the FOSS investigations.

The research setting of this investigation was located within a school system composed of one high school, a middle school, two intermediate level schools and three primary schools. Approximately 313 students make up the total student body of the intermediate school where the research occurred. Students designated as receiving free lunches comprise 54.3% of the student population while students approved for reduced lunches make up 7.3%. The intermediate school where the research took place is designated as a Title One school.

The researcher taught using the Full Option Science Investigations (FOSS) in sound physics and solar energy in a weekly pull-out, talented and gifted program. In the *Physics of Sound* Module, fourth grade students conducted four investigations that explored the content of sound physics by observing and manipulating materials in the science enrichment room utilizing simple tools. In the same manner, the FOSS *Solar Energy* module for fifth grade students supported the students in developing skills of investigation, in order to build and communicate science explanations based on knowledge and evidence.

Participants in Group A (treatment group) and Group B (control group) of the study were members of the small group pull-out enrichment classes and attended morning or afternoon classes based on the school's master scheduling of small group enrichment. Group A (drama) was composed of 19 fourth and fifth grade male and female pull-out small group enrichment students. Group B (non-drama) consisted of 19 fourth and fifth grade male and female small group pull-out enrichment students. Drama treatment groups consisted of one fourth grade class (n = 9) of small group enrichment students and one fifth grade class (n = 10) of small group enrichment students. The study's non-drama control groups consisted of one fourth grade small group of enrichment students (n = 12) and one fifth grade small group of enrichment students (n = 7). The design was non-random assignment.

All fourth grade participants were taught eight investigations in the physics of sound and all fifth grade participants were instructed in eight investigations in solar energy. Two investigations per class were taught in a seven week time frame to the treatment groups and the control groups. The FOSS lesson sequence procedure was the same for both the fourth and fifth grade treatment and control groups. Only the drama treatment groups received the creative drama integration after each FOSS investigation (see Appendix B).

The FOSS pretest assessment for sound physics was administered to the fourth grade treatment and control groups prior to the science instruction in the FOSS investigative modules. The same posttest was repeated at the conclusion of the eight FOSS investigations. The TDSAS survey measuring student attitudes toward science was given to the students at the beginning and then again at the end of the investigation. This pre/post design procedure was the same for the fifth grade treatment and control groups in the study of solar energy.

Researcher's Role

The researcher in the investigation taught the science content in the FOSS units on Sound Physics and Solar Energy, as well as the creative drama activities. The creative drama intervention, led by the researcher, was administered immediately following each FOSS investigative lesson module to the treatment groups of fourth and fifth grade students. The goal of leading the children in the creative drama activities was to determine if the intervention of creative drama would result in better understanding of the science taught in the Foss Modules in Sound Physics and Solar Energy as indicated in the pretest/posttest design of the study. To strengthen comprehension, the researcher used the creative drama activities to help the students remember and recall the science vocabulary.

The researcher's role in the study was to make certain that the creative drama activities were connected to the science concepts taught in the inquiry modules, and to make judgment if there was clear understanding by the students of the science taught. In addition, the researcher, through the exchange of ideas and through the questioning of students, served to clarify the drama intervention activity while guiding the students to connect the science to the role playing they were undertaking. The "drama coach as facilitator approach" was used by the researcher whenever students wrote skits, improvised raps, and in the case of the fourth grade treatment group, developed an original puppet play on how vibrations or sound waves need a medium to travel through. Otherwise, the students of the researcher improvised their own skits, puppet play, raps, creative movement, music, characters and props in revealing their understanding of the science phenomena investigated in the FOSS Units.

Quasi-experimental Design of the Study

The researcher employed a quasi-experimental, pretest/posttest design as the research method for the quantitative portion of this study. Quasi-experimental designs are often used in research studies in order to establish the needed experimental control in a study. Quasi-experimental designs are used in field research when it is not always possible to randomly assign participants to a control or treatment group in a study. Field notes were kept by the researcher to provide points of reflection in the process of carrying out the investigation and were used later to support experimental results.

Instrumentation

FOSS Tests

The instrumentation used in the study included the Full Option Science System (FOSS) Pre/Posttest, and the TDSAS (see Appendix A). FOSS is an ongoing, 20 year research-based science curriculum for grades K–8 developed for students and teachers at the Lawrence Hall of Science, University of California at Berkeley. The Physics of Sound Pre/Posttest survey analysis ($N = 307$) revealed Cronbach's Alpha at 0.73. Item separation reliability is reported as 0.944. The Solar Energy pre/posttest survey analysis ($N = 148$) showed Cronbach's Alpha as 0.74. Item separation reliability is reported as 0.978 (K. Long, personal communication, July 5, 2011). In the present study, Pearson's Correlation revealed test and retest reliability of the FOSS pre/post survey instrument as acceptable at 0.713 ($p < 0.001$).

The Pretest/Posttest Surveys in both FOSS kits used in this study contain coding guides for each science concept taught in the FOSS Investigations (see appendix A). The coding guides contain model student responses. The higher numbers are connected to a more complete student answer. Numerical values for *The Physics of Sound* have a possible total of twenty points and numerical values for Solar Energy has a possible of twenty-five points.

TDSAS Attitude Survey

The TDSAS developed for elementary students, was administered to the students in this study (Zhang & Campbell, 2010). The TDSAS is a science attitude survey based on the tripartite theory of attitudes and consisted of three constructs: student affective feeling about science, student cognitive judgment of science based on values and beliefs, and student behavioral tendencies in learning science (Zhang & Campbell, 2010). The data collected from the TDSAS consisted of two parts. The first part described the demographics of the students. This included gender and grade level. The second part of the collected data described the results of overall science attitude from the respondents. The data for this section consisted of twelve statements with four statements from each three categories: cognitive judgment of science based on values and beliefs, student affective feelings about science, and behavioral tendencies (motivation) in learning science. The respondents scored the items using a five point rating scale as follows: 5 = strongly agree, 4 = agree, 3 = neutral, 2 = disagree, and 1 = strongly disagree. All items were completed by the students. Questions 5, 6, and 12 on the TDSAS survey were reversed for consistency.

The decision to use the TDSAS in the present study was based on acceptable internal consistency and internal reliability measures. Also, the decision to use the TDSAS was based on several research findings that suggest student science attitudes are linked to student achievement and motivation in taking science courses and pursuing science related careers (Alsop & Watts, 2003; Haladyna, Olsen & Shaughnessy, 1982).

The TDSAS was collected from both treatment and control groups prior to the beginning of the study, and then again at the completion of the FOSS investigations. It was determined by the researcher after reviewing two science surveys suggested by an expert in the field of science education that Zhang and Campbell's Three Dimensions of Science Attitudes Survey be used for the study. The decision to use the Likert-style TDSAS was based on the researcher's opinion of the ease of readability that the survey afforded to the students in the study. The decision to use 12 of the items of the TDSAS survey was based on consideration for the length of time that students would engage in taking a survey.

Cronbach's Alpha for the three TDSAS subscales ranged from 0.65 to 0.83 which is considered moderate internal consistency (Zhang & Campbell, 2010). According to Bland and Altman (as cited in Zhang & Campbell, 2010), Cronbach's Alpha should optimally be above 0.7.

Procedure

A Mixed Design ANOVA method was used to examine the effects of drama, grade level and time. More specifically a 2x2x(2) Mixed ANOVA was used to examine differences in the learning outcomes between grade levels (4^{th} and 5^{th} grades) and groups (drama and non-drama) and over time (pre/post). All data were analyzed using the Statistical Packages for the Social Sciences (SPSS) computer software (version 19.0). Pretest and post-test scores of the treatment group and the control group were calculated using the Mixed ANOVA 2x2x (2) method. Comparisons were made between treatment and control groups, between grade levels, and between groups and grade levels overtime. A significant level of 0.05 was set for statistical analysis. The independent variables in this research are defined as group and grade. The dependent variables in the study are defined as science learning outcomes and science attitudes as measured by the FOSS pre and post-test in sound physics and solar energy, and the TDSAS, respectively.

Fourth grade study participants were taught using the FOSS investigations for the Physics of Sound Module and fifth grade study participants were taught using the FOSS investigations in Solar Energy. Only the drama intervention groups were taught using the creative drama activities (see Appendix B). The creative drama activities included improvised role playing which led to the organization and planning of science skit scenarios to communicate the science introduced in the FOSS science kit investigations. The role playing and the skits were developed by the researcher and the students. These creative drama activities were introduced after each investigation in the FOSS Kit. The pacing and length of time for the FOSS Investigations and creative drama intervention used in the study was based on enrichment classes meeting weekly for ninety-five minutes. Students were not taught the sound and solar energy information in the FOSS modules in the general classroom during the time of this study. The pre- and post- tests were administered to both groups of fourth and fifth graders at the beginning of the study and again at the end of the study as was the TDSAS measurement of science attitude.

The researcher scored the coded student Pretest/Posttest Survey test knowing only if the tests were part of the treatment or control group. Names of the students were whited out by an outside resource prior to evaluation by the researcher-teacher. The test was assessed based on the scoring guide supplied by the FOSS teacher's guide (see Appendix A). No letter grades were given to the students in the context of conducting the study nor were the results used to determine science grades in homerooms. Strict adherence to the FOSS scoring guide's exact wording and numerical rating values were followed by the researcher for consistency.

In order to insure greater validity to the results of the study, careful fidelity in the teaching of the FOSS investigations was addressed by following the exact sequencing of the FOSS investigations as presented in the teacher's guide for both modules. The adherence to following the sequence of the investigations as presented in the teacher's guide provided greater control that the teaching approach was the same for both the treatment and control groups in the study.

Results

The research focus in this classroom study examined the effectiveness of using creative drama to teach science as an extension to a well-known science inquiry program. The primary goal of the study was to determine if the inclusion of creative drama as an intervention into the science program helped students' understanding of science better than the science instruction without the creative drama intervention. The analysis also sought to determine if there were any significant differences in learning outcomes and science attitudes between groups, between grade, and between group and grade. The study included the additional aim of determining if the inclusion of creative drama in science instruction increased more positive attitudes toward science significantly better over time than inquiry-based instruction without creative drama.

The FOSS and TDSAS descriptive summary in Table 2 reports the changes in learning outcomes and the TDSAS attitude changes over time. In terms of learning, grade four scored higher than grade five and Group A (drama treatment group) is generally higher than the non-drama control group.

Table 2

FOSS and TDSAS Descriptive Summary

	FOSS		TDSAS	
	Pre	Post	Pre	Post
	Mean (SD)	Mean (SD)	Mean (SD)	Mean (SD)
Group A (Drama)				
4^{th} Grade	24.7 (4.4)	35.0 (3.0)	33.6 (2.9)	32.5 (5.9)
5^{th} Grade	21.9 (3.9)	31.1 (5.1)	32.6 (3.7)	31.3 (3.9)
Group B (Non-Drama)				
4^{th} Grade	25.4 (4.0)	32.0 (4.3)	33.7 (3.0)	31.7 (4.4)
5^{th} Grade	20.7 (3.4)	25.4 (2.5)	33.0 (3.3)	30.2 (5.3)

Learning (FOSS)

There was a significant main effect for grade level (F = 14.3, p < .001). More specifically, students in grade four reported greater learning outcomes (M = 29.2) than students in grade 5 (M = 24.8). There was also a significant increase in learning over time (F = 160.2, p < .001), increasing from a mean of 23.1 (SD = .67) on the pre-test to a mean of 30.9 (SD = .66) at the post-test. This difference over time, however, was dependent on the instructional group as evidenced by the Time X Group interaction effect (F = 11.3, p < .01). More specifically, students in the drama treatment group (Group A) increased their science learning more than students in the non-drama control group. Table 3 provides the effect summary of the ANOVA findings. In table 4, the results of the change in learning over time can be seen. The drama treatment group (Group A) increased their learning more than the non-drama control group (Group B) with the drama group reporting a 9.8 change versus the non-drama group change of 5.7.

Table 3

Summary of Mixed ANOVA Findings

Effect	Learning Outcome (FOSS)	Science Attitude (TDSAS)
	F	*F*
Group (Drama/non-Drama)	3.7	.07
Grade level (4^{th} /5^{th})	14.3***	.78
Group X Grade level	.93	.001
Time (pre/post)	160.2***	7.6**
Group X Time	11.3**	.77
Grade Level X Time	1.4	.13
Group X Grade Level X Time	.10	.03

P < .05,**p < .01, ***p < .001)

Table 4

Foss Test Summary

Group	FOSS Pre	FOSS Post	Change
A = Drama	23.3	33.0	9.77
B = Non-Drama	23.0	28.7	5.67

Science Attitudes

Science attitude data in this study reported a slight decrease over time from pre to post. The overall change from pre to post although small was statistically significant ($F = 7.5$, $p < .01$).

Table 5 summarizes the overall changes in pre and post attitudes indicating a 1.8 decrease in overall attitude scores.

Table 5

Attitude Outcomes (TDSAS)

	Mean	Standard Deviation
TDSAS Pre	33.3	3.1
TDSAS Post	31.5	4.8

Discussion

This study examined the effects of using creative drama as an extension to a well- known science inquiry teaching curriculum. The study's data analysis showed a significant main effect for grade level. Students in grade four reported greater learning outcome than students in grade five. There was also a significant increase in learning over time. This difference over time, however, was dependent on the instructional group. Students in the drama instructional group (Group A) increased their science learning more than students in the non-drama group.

Although not a big change, the science attitude data in this study revealed a slight decrease over time in student attitudes toward science. This was true across groups and grade level. While it is assumed that the students understood and answered the TDSAS based on their own individual views, the small decline revealed by the TDSAS could be influenced in part by other teachers who teach science. The students in this study receive science instruction with their individual homeroom teachers in self-contained classrooms often lacking in little to no time to fully engage students in the instructional style necessary to teach science conceptually. Yet, creative drama, as supported by previous researchers Kamen (1991) and Ariel (2007), and in the above study demonstrates the strategy to be an effective tool in providing the elementary teacher with a viable teaching approach that yields greater knowledge acquisition in science for students. Creative drama researcher Ariel offers this insight into drama's ability to improve learning for students.

> Creative drama is a tool that promotes understanding and does not emphasize memorization. Students remember process and vocabulary that they use in their skits or in the creative drama games because creative drama affects students through all senses and multiple intelligences. (Ariel, 2007, p. 133)

As Ariel suggests, strategies like creative drama that promote understanding rather than memorization in science reveals one layer of the inner core of teaching that aims for conceptual-based learning. In conceptual-based models of science teaching, students construct new knowledge from prior experience while seeking understanding of scientific phenomena (Davis, 2003). Specific creative activities in the drama formats of skit writing and improvised role playing performed by children can help teachers to uncover student ideas and understanding in science as emphasized in models of teaching that stress learning for conceptual change. In one classroom episode in this study, which was sequenced after the FOSS investigation of *Good Vibrations*, the conversations overheard by the researcher as the students planned and organized their skits on how sound travels revealed much of what the students were thinking and understanding about sound vibration investigations. The language of science was at full play when the abstract idea of a sound wave came up. As the children discussed what they were going to act out, they were reminded that a sound vibration and a sound wave were one and the same thing. One student declared, in all seriousness, that it was not the same kind of wave when you tell your mother good-bye. Rather, "it is a science meaning of the word sound wave!" The

NRC contends that to fully engage students in science, the emphasis on argumentation and debate should be additionally connected to the idea that science is a "style of language that does not match "everyday talk" (NRC, 2007). The NRC suggests that teachers provide opportunities for students to try on the role of language in science by talking science (NRC, 2007).

Talking the science by the children led to the application that a sound wave is a rapid back and forth motion that produces sound. From this idea came the realization that they could pretend to be sound sources and jump back and forth while shaking their arms which they promptly and joyfully demonstrated to each other. Listening to the conversation at this point, it was clear that teacher intervention could move the mental image of sound vibration further by asking "How could you act out a vibrating sound source being directed through air? As the children decided to role play air molecules they experimented the best way to present their model. This consisted of deciding on the best way they could use their bodies to show molecules being pushed on other role playing molecules (the students) causing the sound to travel out from the source in all directions. In another point of entry, it was asked of the students how they could visually demonstrate a slow moving sound source vibration. Without hesitation, one member of the class suggested that "our bodies could be vibrations and act out the slow rate of vibration by putting every body movement in slow motion like in a movie!" The children lowered the pitch of their voices to suggest the rate of a low pitched sound. They then proceeded to experiment with what a lower pitch vibration might look like (if you could see it) by slowing down and exaggerating the body movement of "running in place" while swaying the torso and arms as if in a slow motion movie. At this point in the process it was noted in the researcher's journal the importance of the teachable science moment in facilitating group discussion on how the rate of vibration affected pitch based on the observations of the FOSS tone generator. The children's reactions and conversation as recorded in the journal in this instance provided data for reflection and recall of the importance of intervention at such teachable moments in order to keep the role playing and “science talk” on task. In a subsequent lesson, the teachable moment came as a delightful surprise to the researcher when the students looked into the built-in speakers of the classroom electric piano keyboard and called out, “Look the dust in the speaker hole is jumping around and vibrating when Julia plays!” In conceptual models of teaching, priority is given to the value of exploration in science which precedes and supports children’s efforts to explain and make meaning of the science content either in concept discovery or elaboration supported through conversations between the teacher and student (Gallagher, 2007). Conceptual models also provide opportunities for the identification and resolution of alternative frameworks in science that may impede further development and growth in science (Georghiades, 2000). The language engagement of role playing, skit making and improvisation that define creative drama format provides additional opportunities between teacher and student for conceptual teaching and learning to take place. The result is a strategy that offers deeper science learning aimed toward fuller meaning and understanding.

The researcher of this study predicted that the group discourse and verbal interaction necessary to understand student science ecologies as outlined in conceptual-based learning models could be accomplished by engaging students in creative drama activities. The nature of what happens when students engage in role playing as a necessary component of making abstract science phenomena understandable is that students *and* teachers often engage in the conversations and language interchanges that uncover understanding as well as identification of any alternative misconceptions students may have in science (Kamen,1991).

Although greater gains in science learning occurred in the drama treatment group when compared to the non-drama group in this study, the research data showed a slight decline in student attitudes toward science across group and grade. This decrease in positive attitudes, although small was statistically significant. These results were not as expected and give cause for concern. Generally, science attitude statements remained closest to the top end of the TDSAS scale with five representing the highest positive rating a statement could be given. Analysis of paired scores showing slight declines in attitude from pre to post suggests possible outliers that could have skewed the data to an average decline. Considering the National Science Foundation's (NRC, 1996) appeal to keep America's future productive in science and math knowledge and innovation, it would appear that greater efforts to promote the status of science in education and society at large should be given urgent priority (NRC, 1996). Larger studies are needed to identify trends that may be occurring in schools and communities in how society perceives and views science. Attitudes are learned behavior, and because they are learned they can be subject to change (Kobella, 2011).

Implications

This study showed that when used as an extension to an inquiry based curriculum in science, creative drama can be implemented effectively to increase greater learning in science content. The call for using conceptual based models of teaching is a call to teach science for understanding and meaning, not memorization. Creative drama when used in conjunction with an inquiry-based science program is one such strategy that can empower the student and the teacher dialogues necessary for conceptual change to occur. Insights into what children feel, think and synthesize about science phenomena can shed greater light on prior knowledge, and alternative frameworks which chart the course for conceptual change models of teaching.

The globalization of world economies call out for a citizenry armed with the necessary knowledge that can produce the innovation and advancement needed for the United States to stay competitive in math, science and technology (NSF, 2007). The small decrease in student science attitudes reported in this study is cause for concern and reflection in favor of ways that teachers and educational systems can continue to reach out to students in science at the earliest level. The learning of all students in ways that allow maximum growth through personal strengths and multiple intelligences is a noble endeavor in building greater positive beliefs and attitudes toward science. Reaching out to students who have strong preferences for instruction that utilizes their kinesthetic ability to understand science taught conceptually through creative drama is one such example that has been especially effective in showing greater learning gains in science.

Success breeds success, and where there is greater science learning outcomes as shown in this study, there is the potential power to view science in more positive and different ways. With an intervention strategy like creative drama to teach science conceptually, students can build on their cognitive strength in science knowledge which can only lead to greater achievements in science understanding. Once that occurs, attitude change will follow. As teachers continue to examine practice, and continue to find ways that foster the conceptual learning of science through the central premise of practicing the language of scientific argument based on inquiry and evidence for students, then the potential for increased scores in standardized testing can occur, for science has the amazing power to broaden the world and inspire, even a standardized test.

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CHAPTER FIVE. CHILDREN'S PERCEPTIONS ABOUT USING CREATIVE DRAMA TO LEARN SCIENCE

Introduction

Somewhere, someplace, at any given time, or culture in the world, people come together for the purpose of engaging in some aspect of live theatre. Across cultures and language there can be found the very human desire to explore through self-expression what it means to be human, and thereby gain deeper personal knowledge of the world (McCaslin, 2006). This engagement with drama can be as basic as being an audience member in a sold-out house in a local community theatre, or as wonder-producing as children spontaneously engaged in using the body to act out natural phenomena such as the rapid back and forth motion of a sound vibration, or mimicking the movement of water molecules. Across centuries and time, drama and theatre have been used to entertain, teach, inspire, and persuade new ways of thinking and looking at the world. Making its appearance as a strategy into the science classroom, creative drama can be effective in helping students communicate their understanding of the world in useful ways through the human construction of knowledge (Eisner, 1998; Kamen, 1991).

Creative drama is by definition an informal drama that is created by the participants to explore, develop and express ideas through dramatic enactment (McCaslin, 2006). Appropriate to both children and adults, creative drama deeply personalizes learning, and its use can teach, motivate and extend learning across subject matter (Davis & Evans, 1987). Davis and Evans provide further clarification into creative drama's definition and use:

> The creative drama process is dynamic. The leader guides the group to explore, develop, express and communicate ideas, concepts, and feelings through dramatic enactment. In creative drama the group improvises action and dialogue appropriate to the content it is exploring using elements of drama to give form and meaning to the experience. (Davis & Evans, 1987, p. 262)

Much has been written praising drama's merits in educational settings since Plato's argument that dramas were mediums for learning. Today, creative drama proponents recommend its use in the elementary curriculum "extolling its aesthetic, psychological, social and language benefits" (Stewig, 1984, p. 27). Yet, state mandates in science along with high stakes standardized testing push many teachers to teach the facts first and "cover" the material quickly in order for students to score well on numerous pencil and paper assessments. Memorization is stressed while developing alternative teaching strategies that encourage creativity and conceptual understanding in science is overlooked (Polisini-Kase & Spector, 1992). In the age of American standardized testing, studies that continue to test drama's long embrace in learning subject content is important if it can help foster the classroom settings and authentic assessments that assist children in learning science conceptually**.**

The purpose of this article is to report the findings of how nineteen fourth and fifth grade science enrichment students viewed the experience of participating in creative drama activities in order to learn sound physics and solar energy developed through FOSS curriculum. In line with what British drama educator Dorothy Heathcoat describes in role playing as "working from the inside out", the survey questionnaire was developed by the researcher to encourage children's reflective perspectives and assessments of how creative drama enhanced their learning of science (Heathcote, as cited in McCaslin, 2006, p. 262). Working with children from the "inside out", and listening to what their inner voices have to tell us about the process of using creative drama to understand science can reveal much about the process of educational drama in the science classroom. To this extent, the following participant-action research is a follow-up discussion and summary of how these children who demonstrated significant gains in achievement through creative drama viewed their experience with it. The heart of this mixed-mode research asked: What do students think about the use of creative dramatics in helping their learning and understanding of science concepts?

Eisner has suggested that qualitative inquiry in education is about "trying to understand what teachers and students do in the settings in which they work" with the purpose of viewing students and teachers as sources of "interpretation and appraisal" (Eisner, 1998, p. 11). In the qualitative findings reported in this study, the assumption is made that there are multiple ways in which the world can be known" and that "human knowledge is a constructed form of experience" (Eisner, 1998, p. 7).

Literature Review

Nature of Creative Drama

In education, the use of drama to teach other subjects is not a new idea (McCaslin, 2006). Historically, drama and theatre have been used as a "potent means of education and indoctrination" (McCaslin, 2006, p. 257). During the golden age of theatre in Ancient Greece, Plato advocated in *The Republic* that plays were mediums for learning and argument (McCaslin, 2006). Long before John Dewy advocated for the arts in education, Aristotle clearly advocated the arts in education in Ancient Greece, "distinguishing between activities that were means and those that were ends" (McCaslin, 2006, p. 257). Later, the English miracle and morality plays which grew from the Greek practice of ritual worship to Dionysus was used by the Medieval

English Church to teach the masses in an era when very few people could read or write (Brockett & Hildy, 1999). Clearly, in the late 19th century, Norwegian playwright, Henrik Ibsen, the Father of Modern Western Drama, knew the power of using drama to prompt public opinion leading to an awareness of the need for social change (Brockett & Hildy, 1999).

Distinguished British drama educator and writer Dorothy Heathcote (1981) has written that creative drama for children is a means of making the world more understandable. Heathcote states: "It seems sensible to me that, if there is a way of making the world simpler and more understandable to children, why not use it?" (p. 78). In further explaining how creative drama is a tool for learning she explains:

> Dramatizing makes it possible to isolate an event or to compare one event with another, to look at events that have happened to other people in other places and times perhaps, or to look at one's own experiences after the event, within the safety of knowing that just at this moment it is not really happening. We can, however, *feel* that is happening because drama uses the same rules we find in life. People exist in their environment, living in a moment at a time and taking those decisions which seem reasonable in the light of their present knowledge about the current state of affairs. (pp. 78–79)

Heathcote suggests in these statements that drama is an activity people can engage themselves with in order to make events understandable. She has provided the educator with the essence of educational drama for children in that it can be used as an 'in the moment' form of expressive communication that takes into account present knowledge to explore environments or compare events while trying on meanings that create understanding in light of the individual's own knowledge and prior experience.

Creative Drama and Science Literacy

The literature supports creative drama's ability to increase students' reading literacy. DuPont's empirical study of the effectiveness of using creative drama with remedial readers showed that experiencing what is read through the use of creative dramatics is strongly correlated to greater gains in reading comprehension (Dupont, 1992). Creative drama is first and foremost a language *experiential activity*{italics added} in its own right, and incorporates the activity of play acting that encourages being in the moment, as Heathcote expresses, to the forming of mental pictures, analogies or models to increase understanding in science (Aubusson, et al.,1997; Heathcoate,1981). Research has suggested that effective readers make mental pictures in their minds before, during and after reading (Dupont, 1992). Dupont's investigation appears to suggest that the 'physical doing' of acting out a reading story assists in helping children to form better mental imagery which aids in comprehension (Dupont, 1992).

Dupont generalized in her study that the significant increases in story comprehension that students gained through acting out a story plot can be equally utilized into science for greater insights and deeper understanding (Dupont, 1992). In using drama, as Dupont suggests, the simulation role play process applies to both the animate world of being able to act out a character in a story after reading the story for greater understanding to the inanimate world, as in the case of using drama to act out the abstract principle of flowing electrons in electrical circuits or gas exchange in the human lung (Aubusson, et al., 1997; Dupont, 1992).

Braund (1999) has stated that students find the abstract terms and concepts in the physical sciences difficult to learn. His position is that acting out vocabulary, key terms and concepts in the physical sciences using the creative drama methods of mime, body movement and dance can help students develop better understandings. In his study, in order to demonstrate a battery charging electrons, two students acted out the ‘pit-a-cake, pat-cake’ movements with their hands” (Braund, 1999, p. 38). In another cooperative group role play simulation, the students acted out the energy levels of transformed voltages by “undulating movements of their arms as they traveled around the laboratory” (Braund, 1999, p. 38). Braund’s findings reveal that the creative drama approach helped the students understand difficult concepts and terms through the creation of mental imagery. Students used a variety of methods in the investigation to make the abstract understandable and explainable using primarily the communication modes of language, mime, movement dance and oral language. Braund (1999) recommends the following action if educators seek to broaden the science literacy of all students:

> Understanding the abstract nature of science and the many difficult ideas in physics demands considerable mental effort from our pupils. If science education is largely about tackling the abstract and solving problems, then drama should have its place in every science teacher’s ‘toolkit’ of approaches. (p. 40)

Along with developing a better science literacy for all through effective teaching methods designed to help students develop deeper understanding of key terms and concepts in science, there is a call from the American Association for the Advancement of Science (AAAS) that science literacy include the idea that teachers should improve their efforts to help students develop clear communication in science (AAAS, 2011). The AAAS, in *Benchmarks: Project 2061*, provides the vision of what elementary students should be able to do as testimony of support to educators seeking greater science literacy for students in the elementary years. They write: “Clear communication is an essential part of doing science. It enables scientists to inform others about their work, expose their ideas to criticism by other scientists, and stay informed about scientific studies around the world” (AAAS, 2011).

Creative drama is a language medium that allows children to communicate and explain science in useful ways that have meaning and purpose (Kamen, 1991). If we are seeking ways to improve science communication along with helping students to understand abstract concepts and terms in science conceptually, then the research supports creative drama as a language and problem solving strategy. Creative drama will never replace pure science inquiry in well-equipped elementary classrooms, but participating in an activity like creative drama allows children to build meaning in personal ways based on scientific world view. It is no surprise that creative drama by nature requires that communication is emphasized to the class as the form itself is an expressive medium that depends on the collective ideas and meaning constructs of the group. Drama, unlike the solidary act of drawing a picture, or reading a text depends on group interaction and discourse. In this way, creative drama as an extension strategy in science can support the call for a greater scientific literacy. The AAAS explains: "Investigations should often be followed up with presentations to the entire class to emphasize the importance of clear communications in science. Class discussions of the procedures and findings can provide the beginnings of scientific argument and debate" (AAAS, 2011).

In creative drama, when children plan, develop and organize 'science skits' developed from classroom investigations, they learn from each other. They are engaging in procedures much like what scientists do in the real world. They are involved in discourse, often coming to a consensus of how to best present the findings so that others in the class can understand the science. When the creative drama process involves children taking the step further with communication involving evaluation of how the skits presented the findings, students are learning the beginnings of argument and debate, as teachers have the opportunity to model the language and stance that civil debate and peer criticism require.

In *Taking Science to School,* the NRC (2007) provides a further vision in laying the foundation for what is needed to create better science literacy for students. Science literacy, they contend, encourages science discourse, and not merely as teacher and student dialogues intended to find out if the student can correctly give back the answer expected by the teacher (NRC, 2007). Instead, effective methods of science teaching should encourage teachers to explicitly teach students to learn the language of science in order to be able to "put forth a claim, justify or debate a point, or offer a novel interpretation" (NRC, 2007, p. 187). The creative drama process allows for discourse to occur, and if needed, the clarifications of the science in an authentic, motivating, and non-threatening way. When children communicate science, through the use of creative drama, they are constantly searching their own personal science bank of prior knowledge for the details and information needed to represent their models of understanding in science through the communication systems of oral language, dramatic pantomime, role playing, and skit construction.

Another facet of developing better science literacy for children is seeking to understand how an activity such as creative drama assists students in comprehension of abstract concepts in science. The use of analogies has been cited in the literature as a useful tool scientist use in explaining abstract and difficult concepts (Duit, 1991). According to Shapiro (as cited in Duit, 1991), analogies make new information more concrete and easier to imagine. Creating mental models through simulation role playing which Aubusson (1997) describes as the process of creating analogies can be effectively used in much of the subject instruction in schools including science (Aubusson, et al., 1997; Dupont, 1992). Implementing simulation role playing into the creative drama process encourages what Posner has characterized as the creation of metaphors, models, and analogies to make the science "intelligible and plausible" which in turn supports effective science instruction that is conceptually driven and meaningful to the learner (Posner, et al., p. 225). The use of analogy in science teaching provides "the analogical reasoning that underpins the development of ideas through simulation role play" (Aubusson, et al., 1997). Aubusson's investigation showed that simulation-role-plays in science learning appeared to improve student learning, create better classroom atmosphere and support of learning differences among students. Ladrousse (as cited in Aubusson, et al.1997) contends that when students role play, the process encourages the participation of shy students, and develops students' ability to interact. The creative drama activity of role playing in Aubusson's study assisted the students to visualize abstract concepts, and to verbalize ideas in terms the students could understand.

Glasson Learning Cycle and Creative Drama

Drawing upon the science and teaching literature, another view of creative drama's use as an effective teaching strategy is the adaptability it offered the researcher of this study in applying Glasson's Learning Cycle in the science instruction. Glasson (as cited in Tytler, 2002) has offered a learning cycle that is well- tuned to the principles of social constructivist theory as a guide to building effective science teaching. The important aspect of this model is that students' prior ideas are taken into account which invites the student to reflect on their understanding, to test their ideas and to change views if needed, based on evidence (Tytler, 2002). Lending support to concept-based learning theory, the Glasson model emphasizes classroom community discourse and teacher understanding of what Posner has termed as being aware of individual student ecologies in order to help students construct science knowledge through expert questioning (Posner, et al., 1982).

Glasson's Learning Cycle is divided into distinct phases and the preliminary stage of Glasson's Cycle is exploratory in nature (Tytler, 2002). The researcher in this study sought to understand student prior knowledge and science conceptions, or lack of science conceptions about sound physics and solar energy content through the group's discussion and language process while engaged, or being in the moment of carrying out the drama activities of role playing and skit creation. What was made clear to the researcher is that when children assemble to engage in creative drama activities such as skit construction, or role playing, the assessment process naturally occurs as Kamen (1991) maintains in the science discourse that happens. As children exchange ideas in the process of planning and organizing their role playing ideas into skit scenarios, they reveal what they understand or misunderstand. Tytler has characterized the Glasson model as one that stresses attention "to social constructivist insights into the importance of language in framing conceptions" (Tytler, 2002, p. 31). In this phase and throughout the cycle, the creative drama student using drama to learn science, reveals through language what is understood about the science investigated, including what Kamen calls providing authentic assessment in revealing to the teacher student understanding or misconceptions (Kamen, 1992). This process was a necessary requirement for the students in this study in order to be capable of acting out the science ideas and understanding of each FOSS investigations conducted. Introducing a creative drama activity into the preliminary phase of Glasson's Learning Cycle clearly describes Kamen's research claims of the effectiveness of creative drama's use when supported with other forms of science instruction especially discussion (Kamen, 1992).

In the focus phase of Glasson's model, concept introduction and the inclusion of a motivating activity to engage the student with science was primarily implemented through the FOSS investigations in sound physics and solar energy. In this stage of the model, student and teacher continue to be engaged in science discourse through oral language interchanges that may include motivating starting points such as "acting out" a science word as in the manner of the dramatic role playing of word charade games, or creating group improvised skits that demonstrate Newton's Laws prior to the actual investigations. In this stage it may be as fundamental as the sequencing of instruction so that students are afforded the opportunity to engage in hands-on activities before being introduced to new science explanations (Brown & Abel, 2007).

The challenge stage of Glasson's Learning Cycle stresses application not memorization (Tytler, 2002). This phase consists of bringing all the ideas together in the group process while modeling that everyone considers the views of others aligned with the accepted science views of what is being investigated in the science classroom (Tytler, 2002). In this phase and with the use of creative drama, children learn to *apply* their science understandings in a variety of symbolic forms, not just pencil and paper tests. As children engage in these "out of your seat" experiential activities, teachers are afforded the opportunity to engage with the children through language what the child is thinking in science. To create a skit or role play one must be able to synthesize what is learned into an expressive form of communication that demonstrates understanding.

Study Overview

The classroom investigation in this study examined the effectiveness of using creative drama to teach science as an extension to a well-known science inquiry program, Full Option Science System (FOSS). The goal of the study was to determine if the inclusion of creative drama into a FOSS science unit helped students' understanding of science better than science instruction without creative drama. Specific aims of the study were to determine any differences between treatment and control groups when creative drama is included in science instruction. Additionally, the researcher sought to determine if the inclusion of creative dramatics in science instruction helped increase positive science attitudes over time toward science learning significantly better than inquiry-based instruction without creative drama.

Fidelity in treatment to both the drama group (N = 19) and non-drama group (N = 19) was adhered to by the researcher who taught the investigations by following the exact sequence and format of the FOSS modules in sound physics and solar energy. Pre- and post-tests of the FOSS content in physics of sound and solar energy were given to both the drama group and the non-drama group using the FOSS Pretest and Posttest Survey (see Appendix A). The creative drama lessons and activities were developed by the researcher to compliment and extend the FOSS science content (see Appendix B) and were integrated into the teaching of the FOSS activities following the Glasson Learning Cycle. Only the drama students were taught using the creative drama activities.

Participants and Context of the Study

The setting of the research took place in one of two intermediate schools located in a small town in the southeastern region of the United States. The school system is composed of one high school, a middle school, two intermediate level schools and three primary schools. Approximately 313 students make up the study body of the intermediate school where the research occurred. Students designated as receiving free lunches comprise 54.3% of the student population while students approved for reduced lunches make up 7.3%. The intermediate school where the research took place is designated as a Title One school.

The drama intervention group surveyed in this study was composed of 19 students enrolled in the researcher's small group enrichment classes. The participants were members of the researcher's small group enrichment classes, and as participants in the study it was determined they could inform, and give meaning to the research topic. Males in the study represented 58% of the drama group and females in the study represented 42% of the drama intervention, the researcher employed a quasi-experimental, pretest posttest design as the research method for the quantitative portion of this study. Quasi-experimental designs are often used in social science research studies in order to establish the needed experimental control in a study. Quasi-experimental designs are frequently used in evaluation of educational programs when it is not always possible to randomly assign participants to a control or treatment group in a study (Gribbons & Herman, 1997).

In order to inform deeper insights and meanings to the quantitative portion of the study, a questionnaire's was given to encourage student reflection about the experience of participating in creative drama. The questionnaire was given to the drama participants at the conclusion of instruction (see Appendix B). Other qualitative data in the study consisted of the researcher's journal notes of direct observations of students engaged in creative drama activities kept during the course of the investigation. The study employed a mixed-mode analysis. For detailed information on the design see the previous chapter article.

The descriptive statistics in Table 6 provides a summary of the FOSS (learning outcomes) means and TDSAS (attitude outcomes) means showing overall learning and attitude changes over time. In terms of learning outcomes, grade four scored higher than grade five and group A (drama treatment group) is generally higher than the non-drama control group. More specifically, students in the drama treatment group (Group A) increased their science learning more than students in the non-drama group as evidenced by group interaction effect. For a complete summary of Mixed ANOVA findings, see previous article.

Table 6

Summary of Mixed ANOVA Findings

	FOSS		TDSAS	
	Pre	Post	Pre	Post
	Mean (SD)	Mean (SD)	Mean (SD)	Mean (SD)
Group A (Drama)				
4th Grade	24.7 (4.47)	35.0 (3.05)	33.6 (2.95)	32.5 (5.98)
5th Grade	21.9 (3.94)	31.1 (5.12)	32.6 (3.74)	31.3 (3.93)
Group B (Non-Drama)				
4th Grade	25.4 (4.05)	32.0 (4.30)	33.7 (3.01)	31.7 (4.45)
5th Grade	20.7 (3.48)	25.4 (2.55)	33.0 (3.31)	30.2 (5.37)

The TDSAS attitude outcomes in Table 6 show a slight decrease over time from pre to post. This decrease in positive attitudes, although small was statistically significant. These results in attitude were not as expected and give cause for reflection. Generally, the science attitude statements remained closest to the top end of the TDSAS scale with five representing the highest positive rating a statement could be given. Analysis of TDSAS paired scores showing slight declines in attitude from pre to post suggests possible outliers that could have skewed the data to an average decline. Considering the National Science Foundation's (NRC, 1996) appeal to keep America's future productive in science and math knowledge and innovation, it would appear that greater efforts by teachers and school administrators to promote and improve the status of science at the elementary level and society at large should be given urgent priority (NRC, 1996).

The Drama Questionnaire

Much of the theory that drove the questionnaire construction in this study was embedded in the thoughts of Vygotsky's theory of social constructivism which stresses the need, and importance of understanding learning through the learner's perspective (Vygotsky, 1978). Consideration of student views of a learning process such as creative drama to teach science is important for teachers in making enlightened, informed decisions about how to make instruction effective for all students. The importance of student views about what they experience in the science classroom cannot be overstated as children's language and ideas about the experiences teachers bring to them are a vital part of the teaching and learning interchange in science (Shapiro, 1994).

The drama questionnaire used in this study consisted of eight open-ended statements and four forced choice items. The open-ended items provided additional layers of meaning of how the creative drama experience helped the participants to learn science. The choice items in the questionnaire included two demographic statements relating to gender and grade level. Two choice items in the survey concerned recall of specific activities the children engaged in during the investigation. Expert advice from an educational researcher with experience in survey construction was sought in the construction of the survey. After review, it was suggested that the limited use of choice items in the survey would prompt a richer and thicker description of children's perceptions of creative drama in the open-ended portion of the survey. The forced items were deemed appropriate as reflection prompts due to the drama survey being administered at the end of the investigation. An additional educator provided insight and suggestions based on readability and comprehension of the drama survey for the children in the study. Group A, the drama intervention group, completed the questionnaire.

Qualitative Analysis

The qualitative portion of this mixed-mode study examined the beliefs of 19 fourth and fifth grade students in order to understand their perceptions of how creative drama helped them to learn science. The analysis approach in this study involved a process designed to condense the raw data collected from the students into categories or themes based on valid inference and interpretation by the researcher, and then coded inductively. Inductive codes are codes that are developed by the researcher directly. Schwandt (2007) defines this type of coding as "posteriori, inductive, context-sensitive scheme" (p. 32). In this study, the researcher worked with the written responses of the students who participated in the creative drama activities in order to generate codes or categories. After collecting the questionnaire and carefully reading the responses for meaning, statement by statement, the researcher transcribed an unordered typed list of the children's responses to the open-ended questions in the drama survey. These statements provided the researcher with a means of segmenting the data into meaningful analytical units. In this study, the coding consisted of looking for segmented phrases as analytical units and then marking the segments of data with category names. The coding process in qualitative research is defined as "a procedure that disaggregates the data, breaks them down into manageable segments and identifies or names those segments" (Schwandt, 2007, p. 32).

Miles and Huberman state that when a researcher identifies a theme or pattern the process of isolating the theme requires the act of counting. They state: "When we identify a theme or pattern, we're isolating something that (a) happens a number of times, and (b) consistently happens in a specific way" (Miles & Huberman, 1994, p. 253). Using the process of counting, the researcher counted the number of times the word "fun" was repeated in the children's written perceptions of how creative drama helped them to learn science. The higher count indicated that the children enjoyed participating in the creative drama activities which led to the formation of the category theme, enjoyment of creative drama. This method of frequency was again used with the counting of the words “remember”, “learn” and “understand” embedded in the data responses and then categorized as usefulness of creative drama to learn science. The phrases “getting out of my seat” and “move” were also interpreted by the researcher and categorized under the theme of usefulness of using creative drama to learn science. The final theme, confidence to communicate science, used the same inductive analysis with the phrases “confident” and “know”.

The journal notes used in this study employed the process of memoing. Memoing can record the thoughts of the researcher while engaged in the process of analysis (Schwandt, 2007). Memoing can provide a description or explanation of a particular aspect of a setting or phenomenon (Schwandt, 2007). The teacher’s journal in the form of field notes provided the observations and several quotes from student conversations during the course of the instruction with the purpose of providing recall of events and even possibly providing additional meaning to the responses in the questionnaire.

Several of the recorded quotes in the teacher’s journal about what the children were sharing about the experience were also revealed in their written reflections in the questionnaire. For example, one entry in the journal made note of the fact that on days when the class was pressed for time and the researcher decided to skip over the physical warm-up in order to complete the drama activity planned for that day, the students insisted on going back and doing the very physical skipping game of “Little Sally Walker.” This is a drama skipping game that provides a context for warming up the body and ‘breaking the ice’ with members of group before plunging into the dramatic role playing. The researcher noted that fourth and fifth graders were still active and demanded this activity after sitting for 90 minutes in a general classroom before coming to the small group pull out program. One student revealed in class conversation, “I like to do “Little Sally Walker” because I get to move around.” This observation was later compared to three student statements in the questionnaire indicating they liked creative drama because “you can get out of your seat and move.” Observation of how students seem to enjoy the “Little Sally Walker” warm-up, along with using their bodies to communicate the abstract concepts of how sound travels through different mediums, was appealing to the students. When referring to the application of science concepts to body and language communication inherent in drama, it gives additional meaning to the student who reported in the questionnaire: “You can do this in class on a test, but you remember it better when you actually do it.” This was also true when fifth grade students used body movement to communicate how water is slower to absorb heat and then release heat when compared to other earth materials. Using the constant comparative method, devised by Barney Glaser and Anselm Strauss (1969), the researcher made analysis of the movement phenomena children seem to enjoy when doing creative drama. This similar episode was then compared to the “get out of your seat” category for relevance in the questionnaire.

The qualitative data in this mixed mode study was then used to inform the quantitative findings. Linking qualitative data to quantitative data in a mixed mode study is often used to give additional insights into the phenomena being studied (Miles & Huberman, 1994). Rossman and Wilson (1984, as cited in Miles & Huberman, 1994) state the following reasons for connecting quantitative data to qualitative data:

a. To enable confirmation or corroboration of each other via triangulation

b. To elaborate and develop analysis, providing rich detail

c. To initiate new lines of thinking through attention to surprises or paradoxes, providing fresh insight (p. 41).

Summary Findings

The student responses on the drama survey were arranged into the following thematic categories: 1) enjoyment of creative drama; 2) usefulness in learning science through creative drama; 3) confidence to communicate science.

Theme 1: Enjoyment of Creative Drama

The qualitative data from the open-ended questionnaire in question three indicated that all of the 18 students surveyed in this study enjoyed participating in the various creative drama activities, and generally perceived drama as a fun way to learn science. Only one student wrote in the open-ended response as “neutral”. In essence, from the questionnaire the majority of the students enjoyed the creative drama because they reported the activities as fun and entertaining to do. Along with the idea of fun, the students expressed that creative drama was a way to use their own ideas with one student revealing much about the experience of a transmission style of teaching:

> “It is fun and we are learning at the same time. I feel like I’m in control to say whatever, and I’m not just sitting there listening to the teacher. I get to tell it in my own way with humor and science.”

In another view, the transmission style of teaching entered into the children’s voices along with the contrast of seeing drama and science as “fun learning” as one student declared:

> “It helps me learn more because I am a kid, and kids learn fun better than a teacher telling them.”

Additional descriptors used by the children as they shared their feelings about liking the experience were “understandable”, “entertaining,” and “creative”.

Theme 2: Usefulness of Creative Drama to Learn Science

From the questionnaire, students expressed that the drama activities were useful in learning science because it was challenging, requiring them to think about the science and the investigations completed in class. One student in the drama treatment group as recorded by the researcher and noted in the researcher’s field notes indicated he would rather just “do the experiments today.” Later, after the investigation, he seemed content to participate in the role playing activity about pitch in “*Alien Voices: Take Me to Your leader*.”

Overall, the children shared creative drama’s usefulness as helping them to remember and understand science as something that is fun and allowed for movement in the classroom. From the questionnaire, phrases such as “remember it better” and “stuck in my head” reappear in the responses lending additional support to viewing creative drama as an activity that helps the children to remember. The following statements illustrate:

“You can do this in class on a test, but you remember it better when you actually do it.”

“I really liked getting out of my seat!”

“We did something fun that is stuck in my head and my parents usually ask me what I did that day and I liked it.”

In another written response, a hint of conceptual change learning is rendered as one fourth grade child employs a metacognitive awareness describing the extent of her science knowledge about the abstract concept of amplification in sound science.

“It helps me because I remember fun things and this is fun so I remember easily when I do creative drama! It also changed because the first day I came, I really didn’t know about sound then Mrs. --------- introduced me to creative drama then it got more fun and a lot easier!! Now I know what amplification is. To me then—I was like—what in the world does that big word mean, but now I know."

Another fourth grade student wrote metacognitively of her lack of prior knowledge at the beginning of the study to her final assessment of how she gradually began to think about how sound energy works through the use of creative drama as an extension to the FOSS investigations. This response is familiar to conceptual change models of science teaching which stress the need for building metacognitive awareness in students:

"At first, I didn't really understand sound. I didn't think about how it works, but now I think about things (sound, carefully). Also, the vocabulary is amazingly understandable to me now—such as sound source (what makes the sound) and sound receivers (what receives the sound) and much more. So, I'm very glad I signed up."

On the first day of administering the FOSS pretest, the journal notes indicated that the students were nervous about their lack of knowledge in taking the FOSS pre-test. Many of the students felt stressed that they did not know the answers to the questions. They were reassured that they would learn more as the investigations proceeded. The students were encouraged to think about each question and write what they already knew in terms of prior knowledge. They were reminded that the test was not a test for a grade but a way to help all of us to learn more about science and learning. This worried concern occurred in both fourth and fifth grade classes. Later, the posttest did not cause any undue stress, and the children seemed confident and sure in taking the test.

Fifth grade responses also indicated approval of using the creative drama to learn. Students stated that they enjoyed improvising the solar energy commercials which had as one objective the selling of a solar water heater to an imaginary television audience. Working in small cooperative groups, the drama students improvised a panel of science experts who based the "new and improved" solar water heater on the energy storing power of "basic black" and powerful "evapo container lids" that minimized the solar heat loss experienced through evaporation. One student impersonated the character of "Sham-Wow to pitch the sell, but changed the name to Sham-Now! The added bonus, according to Sham Now is: "Bam! Water is a great heat sink because it can absorb and store energy. Bam! Water can release heat slower than other earth materials!" One student response that was noted during the course of the activity was that "science is hard but this is easy."

Children seemed to prefer the spontaneous and improvisational aspect of creating and using their own ideas to communicate the science learned as opposed to writing and organizing the science learned into a script for the projects required by the school enrichment program. In discussing and planning a puppet play idea about what happens to sound on the moon, the children needed much encouragement to write their dialogue down for purposes of remembering their ideas and dialogue when presenting the skit to parents and teachers.

Generally, there was not an activity the students did not like, although some of the statements from fifth grade indicated that it was sometimes hard to come up with their own ideas to show the science. One fifth grade student who indicated that she enjoyed the creative drama wrote this response:

> "The shadow puppetry activity really helped me to understand more about shadows. I'm not really a "stage" person. I didn't like to present things. I did like the ideas though. I really liked getting out of my seat!"

Other comments described positive attitudes toward the creative activities in order to extend the science content of the FOSS investigations. The idea of humor embedded in some of the activities the students carried out was noted in the journal. One skill in implementing creative drama was keeping the science on task as some students bordered on what the researcher describes as “getting the extreme case of the sillies”. Careful thought was given in how to encourage the creativity while keeping the role play and skit construction moving forward with the science content of the investigation for that day. This was accomplished with five short hand claps in a pattern that children later copied. The meaning was clear: Stop what you’re doing and talk science! Students knew to freeze and get back into control. This approach worked and still allowed the children to have fun, but allowed for the researcher to direct the children to stay on task using the energy to focus on the construction of the science content through the creative drama activities. The idea of humor was later reported in the questionnaire as a way to assist in learning the material. Being able to use one’s own ideas was reported as a positive plus for using creative drama to learn. One child wrote:

“I learned way more because of humor and I get to use my own ideas.”

Other students were specific in which activities were the most fun and provided information in what they learned as a result of the engagement with the creative drama.

“I liked making the voice sound weird and walking like aliens.”

“I liked it when we made different animal noises to see if the pitch was low or high.”

Theme 3: Confidence to Communicate Science

Students in fourth grade generally felt confident in communicating science to others outside of the enrichment class, and those that held this view of the experience saw it as a way to collectively help each other to understand science. One of the fifth grade students reported that they did not like making up lines to say, but they liked the ideas. The children also reported that they felt confident about communicating science because they knew and understood the science. As mentioned earlier, students from both the treatment and control group showed an anxious concern about their level of knowledge when given the FOSS pretest survey on the first day of the investigation. However, by the end of the study, as indicated in classroom field notes, the students in both groups were eager, confident, and assured of their growth in understanding the science content.

From the questionnaire, general feelings and beliefs were expressed by the children, giving insight into the student's affective feelings about the confidence they felt in communicating science learning. The fourth and fifth grade students in these responses are referring to the skits on sound and solar energy improvised in class, and later presented as a class project to parents, teachers and students.

> "I feel happy because I'm helping people learn science in fun ways. I feel confident because I know a lot about it."
>
> "Yes, because I know what I can do."
>
> "Yes, because if you make them laugh or smile it makes you get confident in yourself that you can do it."
>
> "Yes, because we all learn, and we enjoy that part of drama."

Children seemed to prefer the spontaneous and improvisational aspect of creating and using their own ideas to communicate the science learned as opposed to writing and organizing the science learned into a script for the projects. From the entry in the journal notes, the students in the study enjoyed working together as a group with very few needing extra help in accomplishing this task. In discussing and planning a puppet play idea about what happens to sound on the moon, the children needed encouragement to write their dialogue down for purposes of remembering when they present the skit to parents and teachers. The children perceived the drama as a useful way to learn science, yet needed extra reinforcement in seeing how useful it would be to take their improvisational dialogue and record it on paper so as not to forget.

Although fifth graders reported enjoying participation in creative drama and thought it helpful in learning science, some students expressed some reservations about their confidence in performing the skits and improvisations to communicate to other students in the school outside of the talent pool class.

> "My friends that are not in talent pool wouldn't even talk about this science. I feel confident because everybody else does it." (in talent pool)
>
> "No. I don't. I get nervous and feel stupid making up the lines myself. I like theatre, though. Like I said before, I love the ideas. Science is my hardest subject and the drama helped me to understand."

The students reported confidence in that they felt they could communicate to teachers, parents and friends about science because of their science knowledge.

> "I can talk to them because I remember the science. I can tell them the science behind things."
>
> "Some friends are curious about the things we do in here and I could explain to them about the science. Some teachers ask questions about the science and I would be able to answer it off the top of my head."

Discussion

Creative drama is a highly social and experiential activity that was viewed by students in this investigation as a fun and enjoyable way to learn, and *think* about science. Drama has been shown to develop deeper understanding in science because learners have higher levels of engagement with the science ideas through collaboration with other learners (Braund, 1999). Braund (1999) found that students generally valued using creative drama, and suggests wider dissemination of it benefits in education.

Students also described the creative drama activities as useful because the activities helped them to remember the science better when used as an extension to an inquiry based science program. The research in science and creative drama integration shows that role playing, and the creation of analogy embedded in creative drama activities when combined with an inquiry-based program in science, allows students to develop mental pictures and create analogies much like what good readers do in the act of reading for better understanding and comprehension (Aubusson, et al., 1997; Dupont, 1992). According to Shapiro (as cited in Duit, 1991) analogies are important in learning because analogies have the potential to make the learning more concrete and easier to imagine. In suggesting how creative drama increases reading comprehension in students, Dupont states that one possible explanation is that children may gain valuable practice in creating "clear mental images of written words they have acted out" (Dupont, 1992, p. 50).

Although children reported that creative drama was useful because it allowed them to use their own ideas to communicate science, they were specific in which activities were useful in helping them to remember and learn the science. In the activity, "Take Me to Your Leader", the children reported that they enjoyed pretending to walk and talk like aliens in order to understand two properties of pitch, high and low. Much of the discourse in this activity focused on what was observed in the classroom investigations of how tension and the rate of vibration affected pitch. Combined with the mental imagery of aliens, not to mention the symphony of high pitched and low pitched aliens, this activity encouraged the personal construction of the understanding of pitch as high and low as opposed to loud and soft which is often confused in sound studies.

It was further revealed in this study that creative drama is useful because it appeals to the psychomotor or kinesthetic domains of the still active elementary child. Children indicated that they liked getting out of their seats to create movement closely associated with dance by acting out sound vibrations traveling through different mediums. Bentley and Watts state (as cited in Braund, 1999) that creative drama experiences can be useful to teachers in order to help students whose talents are not typically used in science classrooms.

In this study, students were allowed the freedom of creative movement to support their learning. Walking like aliens to explore alien voices of high and low pitches is such an example. As children explored the science of heat sinks, the students were allowed to get out of their seats and use their linguistic abilities to create television commercials to convince an audience to use and buy solar water heaters based on the science learned. As children explained how earth surfaces heat up faster than water, they used their motor abilities and body movement to show water molecules, slowly moving from a balled position to a full upright position indicating how water molecules heat up absorbing the sun’s energy. Using a swaying and resisting motion, the children illustrated through movement how water makes a good heat sink because the water molecules are slower to release their energy, holding on to the heat longer than other earth materials. The children’s responses support a greater need for science teachers to focus attention on how the affective and psychomotor domains can be utilized in the learning of science.

Learning communities that give children a variety of communication systems such as dance, movement, mime improvisational role playing and skit making are examples that provide children a way to learn that moves away from a transmission style of teaching to an approach that touches the affective domains of learning (Hoyt, 1992). The value and usefulness of using creative drama is that drama personalizes and internalizes a connection between what is new learning and what is already known (Hoyt, 1992).

The students in the study reported great self-efficacy in their ability to communicate the science learned as a result of the creative drama activities. Wells (1986) states (as cited in Hoyt, 1992) that children should be given authentic opportunities to talk about what they are learning. There is even a call to action from the NRC committee for teachers to provide opportunities to the elementary student to engage in discourse and to present findings in science presentations (NRC, 2007). Creative drama provides "a variety of communication systems that facilitate learning in ways that stimulate the imagination, enhance language learning and deepen understanding" (Holt, 1992). Perkins (1991) concurs (as cited in Kase-Polisini&Spector,1992) and recommends that teachers stress understanding so that children are able to not only retrieve information, but also to be able to communicate explanations, provide examples, form generalizations and create analogies to learn Science programs that strive to teach conceptually can benefit from creative drama's use in the classroom (Braund, 1999).

Implications

Several implications can be drawn from what the children revealed in the qualitative findings of this study which may be helpful to teachers who are seeking additional strategies to help children learn and communicate science. The following implications could be considered significant:

1. Much of creative drama is fun and its appeal and proven effectiveness to teach science is that it is a strategy that makes use of children's creativity, oral language, affective feelings, and motor abilities to communicate the science learned.
2. Creative drama provides the teacher an authentic means of assessment in a non-threatening manner that moves beyond the countless pencil and paper tests that accountability in public education demands.
3. Creative drama provides a way to listen sensitively to what the students are thinking in science in order to understand individual personal ecologies in science.
4. Creative drama can be useful to students whose learning style may be kinesthetic or linguistic in nature.

Effort and support to provide extension and enrichment strategies like creative drama to understand science has continuous meaning for parents, teachers, educational researchers and supporting local communities who are seeking understanding of a method of learning that is experiential, useful, effective, and fun for the student. What worked in this study is that students' valued the opportunity and focus creative drama presented for personal expression of their own ideas, affective feelings, and thoughts about the science investigations. Children enjoyed improvising and communicating the science presented in the investigations using creative movement, dance, pantomime, and role play. They viewed it as a way to help them understand. When used as an extension to compliment a valid science inquiry program, students learned not only the language of science but they learned to communicate science in different ways while planning, organizing and problem solving of how best to present their science scenarios so that others could learn. It goes beyond doubt that we not only learn from the teacher, but that we learn from each other, and what we learn can be shared with our parents, families, friends and the community at large.

For teachers who wish to implement and engage children in using creative drama, its integration is useful in acquiring deeper understanding of students' personal ecologies about science while assessing the science knowledge in an authentic and non-threatening way. As a method of instruction, creative drama has the ability to make difficult concepts in science concrete which is useful in laying a solid foundation for all children to reach a better science literacy for the future.

It has also been suggested that creative drama is a pragmatic way for teachers to teach science inquiry and content conceptually while tapping in on student ability that may never be used in science classrooms. This may be the case for the highly creative, kinesthetic or linguistic students of science. Creative drama's ability to increase deeper conceptual learning which has been documented in the literature and in this study is a call for its wider use and application in education.

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CHAPTER SIX. CONCLUSIONS

Introduction

The purpose of this study was to examine how the inclusion of creative dramatics improved student achievement and attitudes toward science when used in conjunction with a hands-on science inquiry program. The researcher also explored student perceptions to gain additional insights into how students viewed creative drama as a tool for learning in science. The intent of this study was to establish an understanding as to the benefits that may be gained from using an extension strategy such as creative drama to help students better understand science and whether the use of creative drama could help improve student attitudes toward science learning. The researcher used the following questions to guide the study:

1. Does the inclusion of creative dramatics in inquiry-based science instruction help students' understanding of science concepts significantly better than inquiry-based instruction without creative dramatics?

   1a) Are there significant differences between treatment and control groups when creative dramatics is included in an inquiry based science program?

   1b) Are there significant differences between grade levels when creative dramatics is included in an inquiry based science program?

   1c) Are there significance differences between group and grade levels when a creative dramatics approach is included in an inquiry based science program?

2. Does the inclusion of creative dramatics in inquiry based science instruction help students' attitudes toward science learning significantly better than inquiry-based instruction without creative drama?

3. What do students think about the use of creative dramatics in helping their learning of science concepts?

Two groups participated in this mixed-mode study. Both quantitative and qualitative research methods were used. The treatment group was composed of 19 fourth and fifth grade students and the control group consisted of 19 fourth and fifth grade students. Only the treatment group received the drama intervention in this study. All students in the study were taught using the Full Option Science System (FOSS) (University of California, Berkley). Two FOSS investigative units were used. The fourth grade students were taught using the Physics of Sound Module and fifth grade students were taught using the Solar Power Module. A Mixed ANOVA 2x2x(2) research design was used for analysis in the quantitative portion of the study. The Three-Dimensions of Student Attitudes Toward Science Survey (TDSAS) was used to measure student attitudes. All students in the study completed the TDSAS. Only the drama treatment group completed the open-ended drama questionnaire. In the following pages each research question will be addressed followed by the outcomes of the findings.

Outcomes

Creative Drama Inclusion Increases Student Achievement

The first research question in this investigation inquired: Does the inclusion of creative dramatics in inquiry-based science instruction help students' understanding of science concepts significantly better than inquiry-based instruction without creative dramatics? The data in this study reported a significant increase in learning over time ($F = 160.2$, $p < .001$), increasing from a mean of 23.2 (SD = .670) on the pre-test to a mean of 30.9 (SD = .657) at the post-test. This difference over time was dependent on the instructional group as evidenced by the Time X Group interaction effect ($F = 11.3$, $p < .01$). The first outcome of this study is that creative drama implementation in a science inquiry program can increase student achievement and student understanding in science more than science instruction without the added benefits of an extension activity such as creative drama. Students in this study who received the creative drama intervention scored significantly higher than the students in the study who did not receive creative drama intervention.

Significant Differences Between Treatment and Control Groups

Research question one consist of three parts. In part 1a), the research question asks: "Are there significant differences between treatment and control groups when creative dramatics is included in an inquiry based science program?" The outcome in this investigation showed significant differences between the treatment and control groups. As stated, there was a significant increase in learning over time from the FOSS pre-test to post-test and this difference over time was dependent on the instructional group as evidenced by the Time X Group interaction effect. The results of this research showed that students in the drama treatment group increased their science learning over time more than students in the non-drama control group.

Differences Between Grade Levels and Instructional Groups

Part b inquires: Are there significant differences between grade levels when creative dramatics is included in an inquiry based science program? The outcome of the analysis is that there were significant differences. The data indicated a significant main effect for grade level ($F = 14.3$, $p < .001$). The analysis revealed that students in grade four reported greater learning outcomes (M = 29.3) than students in grade five (M = 24.8). However, there was also a significant increase in learning over time from pre-test to post-test and this factor was dependent on the instructional group with the drama instructional group increasing their science learning more than the non-drama group. Logical reasons as to why grade four scored higher than grade five may be connected to a possible limitation of the study in comparing two different grade levels, and two different curricula, sound physics and solar energy. Two distinct and separate units of study were taught to each grade. Fourth grade students were taught from the FOSS Physics of Sound Module and fifth grade students were taught using the FOSS Solar Energy Module. Although proficiency bias could have occurred, efforts by the researcher to teach the two modules as prescribed was implemented by following the exact sequencing of the FOSS teacher's guide in order to provide more control in the study. Additionally, expectation bias was minimized by blinding the pre- and post-tests in order to prevent errors in measuring the data toward expected outcomes. Also of note is the fact that the FOSS modules in sound physics and solar energy had not been taught in the general education classroom prior to the implementation of this research study. Finally, the FOSS instrument used to measure learning outcomes is well-known and well researched with acceptable reliability rates and internal consistency measures. (For more detail about the FOSS instruments used in this study refer to Chapters Three and Four.)

The final outcome of 1c asks: Are there significant differences between group and grade levels when a creative dramatics approach is included in an inquiry based science program? The data showed that there were significant differences between group and grade levels as stated. Grade four scored higher than grade five, but the Time X Group Interaction Effect indicated that greater learning over time occurred, and that was dependent on the instructional group. The outcome of this study showed that there were differences in grade and group with the drama group scoring higher than the non-drama group and grade four scoring higher than grade five.

Student Attitudes Toward Science

Question two of this study sought to understand if student attitudes toward science could be improved with the inclusion of creative drama. The research question asked: "Does the inclusion of creative dramatics in inquiry based science instruction help students' attitudes toward science learning significantly better than inquiry-based instruction without creative drama?" Both groups and grade levels in this study showed a slight decline in science attitudes from pre to post survey. Although the overall change was small it was statistically significant. This result is reported accordingly. The conclusion from this data is that the inclusion of creative drama in a science inquiry science program does not increase student's attitudes toward learning science any better than inquiry based instruction without creative drama. Although the results of the attitude survey were not as expected, there is much to be learned from this information. Analysis of the science attitude statements revealed that the statements on the TDSAS scale generally remained closest to the top end of the TDSAS scale with five representing the highest positive rating a statement could be given. It is a reasonable argument that the TDSAS paired scores showing slight declines in attitude from pre to post suggests possible outliers that could have skewed the data to an average decline. The overall decline in attitudes although small could possibly reflect trends in American society as a whole with regards to the status and value of science education. However, findings should not be generalized based on this study alone. In light of the National Science Foundation's (NRC, 1996) appeal to keep America's future productive in science and math knowledge, efforts by teachers, school administrators and the community at large to improve the status of science at the elementary level should be given urgent priority (NRC, 1996)

The final outcome of this study is discussed as it relates to the research question that asks: “What do students think about the use of creative dramatics in helping their learning of science concepts? The results of the drama questionnaire indicated that all children in the study believed creative drama helped them to learn science. Children in the creative drama group generally indicated that they liked doing creative drama with one child marking the open-ended questionnaire with the word “neutral”. The consensus reported in the questionnaire is that creative drama is a helpful addition to remembering the science because the science can be acted out in ways that are entertaining. The students in this study reported that creative drama is a fun, active and an enjoyable way to think, learn and talk about science. The students expressed great self-efficacy and personal empowerment in being able to communicate the science learned with the added bonus of being able to use their own ideas in a creative way to learn about science.

Limitations and Assumptions

There are a number of important limitations to this study. This study was limited to 38 fourth and fifth grade students in a small-group pull-out enrichment program (N = 38) in a school system located in the southeastern region of the United States. Based on the relatively small sample size, generalization beyond the students in the study and the intermediate school where the data was collected should be undertaken with caution. The study was also limited to only the information gained from the responses of the researcher’s created drama questionnaire. In the same manner, the study was limited to the results of the FOSS pre- and post-tests and to the TDSAS survey of science attitudes. Therefore, as stated previously these findings cannot be generalized based on this study alone.

In addition, there are critics who place limitations on the credibility of teachers being the lone investigators in classroom studies aimed at examining teaching and learning. When the teacher becomes the researcher, objectivity becomes an issue and some would argue that bias can be a limiting factor into claims of the study's validity. In this study the teacher was also the researcher, and this may be viewed as a limitation imposed upon the study. However, it should be noted that bias can be present in any study. In this study, great efforts were made to minimize bias while increasing objectivity. These methods have been stated previously. It has also been stated that this study is defined in part as participant action research which is viewed by many as a valid and accepted form of research which aims at improving teaching and increasing achievement in students by teachers who teach and examine practice.

There were several assumptions made by the researcher in the course of this investigation. The researcher assumed that students who responded to the survey and questionnaire understood the directions and answered truthfully. It was further assumed that students did not collaborate on test questions, survey items or the drama questionnaire. Finally the assumption was made that the children who responded to the TDSAS survey and drama questionnaire reflected their own individual views and perceptions and reported these accordingly.

Summary

Creative drama will never replace a valid and conceptually taught science inquiry program. Creative drama's strength however, is that it can be used as an effective science tool to help students increase their knowledge about science and the world around them. Creative drama as a strategy has the potential to tap into the talents and abilities of many children that may never receive the attention and recognition normally reserved for students in a science lab.

The facilitation of the activities associated with creative drama such as creative movement, dance, pantomime, role playing and skit making has a wider appeal to different learning styles and preferences of learning. There is no denying of the endless opportunities creative drama offers to students in realizing science belongs to them, and with the use of their own ideas both personal and relevant, the study of science phenomena will open up worlds of meaning and amazement. In a nation that continues to call for a greater science literacy at all levels of education, a teaching approach that can foster conceptual learning deserves our attention and efforts as we prepare students for a better world.

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Appendix A

FOSS Test Instruments/Coding Guides and TDSAS Survey of Science Attitudes

PHYSICS OF SOUND
Survey/Posttest

Name ______
Date ______

1. Kate said, "An object has to move back-and-forth to produce sound." What is this back-and-forth movement called? ________________

2. Which of the following words can be used to describe pitch?
(Mark an X next to all that apply.)

   ______ loud ______ low
   ______ high ______ soft

3. • Give an example of an object that can be used to amplify sound.
   ____

   • Explain how the object amplifies sound.
   (Circle the one best answer.)
   A. It amplifies by changing the pitch.
   B. It amplifies by gathering and directing the sounds.
   C. It amplifies by increasing the tension.

4. When the rate of vibration increases or decreases, what changes?
(Mark an X next to all that apply.)

   ______ pitch ______ volume

PHYSICS OF SOUND

Survey/Posttest

Name

5. Below are pictures of wind instruments. You blow air through them to produce sounds.

- Circle the wind instrument that plays the lowest sounds.

- Why does it make the lowest sounds?

____

____

6. Besides air, what types of materials can sound travel through?

____

7. When the strength of vibration increases or decreases, what changes?

(Mark an X next to all that apply.)

_____ pitch _____ volume

Name ______________________

8. Ken started to cross a street. He heard a horn honk and jumped back to the sidewalk.

   a. What was the sound source? ______________________

   b. What was the sound receiver? ______________________

9. Darla tied one end of a string around a doorknob and held the other end in her hand. When she plucked the string, she heard a sound.

   a. How would the pitch change if Darla pulled the string tighter?

   ____

   b. How would the pitch change if Darla made the string longer?

   ____

10. Which of the following words can be used to describe sound volume?
(Mark an X next to all that apply.)

_____ loud _____ low

_____ high _____ soft

11. • Name a property of the sound of a fire engine's siren.

   ____

   • Why was the siren's sound designed to have this property?

   ____

   ____

12. A class set up an investigation using glass bottles and a wooden mallet to strike them. Below is the table students made of their observations.

Size of bottle	Sound made
large	low
medium	medium
small	high

What question were they investigating?

(Circle the one best answer.)

A. How does the color of a bottle affect its pitch?

B. How does the thickness of the glass affect the pitch?

C. How does the size of a bottle affect its pitch?

D. How does the wooden mallet affect pitch?

13. Blowing into a bottle can produce a sound because

(Circle the one best answer.)

A. air in the bottle vibrates.

B. air is absorbed by the bottle.

C. air is cooled by the bottle.

D. air is warmed from a person's breath.

SURVEY/POSTTEST CODING GUIDES—1 OF 4

1

Code	If the student...
2	writes "vibration."
1	provides any other answer.
0	makes no attempt.

2

Code	If the student...
3	marks only high and low.
2	marks only high *or* low.
1	marks any other combination.
0	makes no attempt.

3

Code	If the student...
4	provides a reasonable example (e.g. megaphone, tube, ear, microphone, stethoscope, etc.); circles B.
There is no level 3 for this item.	
2	provides a reasonable example *or* circles B.
1	provides any other answer.
0	makes no attempt.

4

Code	If the student...
2	marks only pitch.
1	marks volume (with or without marking pitch).
0	makes no attempt.

SURVEY/POSTTEST CODING GUIDES—2 OF 4

5

Code	If the student...
3	circles the saxophone (third from left); explains that it has the longest (widest, largest, biggest) tube.
2	circles the saxophone *or* provides a correct explanation.
1	provides any other answer.
0	makes no attempt.

6

Code	If the student...
3	states that sound can also travel through liquids (or water) and solids; may include (other) gases.
2	states that sound can also travel through liquids (or water) *or* solids; may include (other) gases.
1	provides any other answer.
0	makes no attempt.

7

Code	If the student...
3	marks only volume.
There is no level 2 for this item.	
1	marks pitch (with or without marking volume).
0	makes no attempt.

FOSS

SURVEY/POSTTEST CODING GUIDES—3 OF 4

8a

Code	If the student...
3	states that the horn is the sound source.
2	states that a car (truck, bike, etc.) is the sound source.
1	provides any other answer.
0	makes no attempt.

8b

Code	If the student...
2	states that Ken's ear is the sound receiver.
1	provides any other answer.
0	makes no attempt.

9a

Code	If the student...
3	states that the pitch would get higher.
There is no level 2 for this item.	
1	provides any other answer.
0	makes no attempt.

9b

Code	If the student...
2	states that the pitch would get lower.
1	provides any other answer.
0	makes no attempt.

10

Code	If the student...
3	marks only loud and soft.
2	marks only loud *or* marks only soft.
1	marks any other combination.
0	makes no attempt.

11

Code	If the student...
3	identifies a property (such as loud volume or changes in pitch); says something about the property's conveying information (e.g. "get out of the way").
2	identifies a property *or* says something about the property's conveying information.
1	provides any other answer.
0	makes no attempt.

SURVEY/POSTTEST CODING GUIDES—4 OF 4

12

Code	If the student...
2	circles C.
1	circles A, B, D, or more than one answer.
0	makes no attempt.

13

Code	If the student...
2	circles A.
1	circles B, C, D, or more than one answer.
0	makes no attempt.

SOLAR ENERGY
Survey/Posttest

Name	
Date	

1. A shadow is

(Circle the one best answer.)

A. a dark reflection of an object made by the Sun.

B. an outline of an object made by light.

C. part of an object, but it only shows when light shines on the object.

D. a dark area made when light is blocked by an object.

2. Amber predicted that a black-covered box would heat up faster than a white-covered box.

She took two identical shoe boxes and wrapped one with white paper and the other with black paper. She punched a hole in each box, stuck a thermometer into each hole, and put both boxes in the sun. Every 5 minutes, Amber recorded the temperature in each box.

- Will the data support Amber's prediction? _______
- Explain your answer.

____

____

____

____

____

3. What causes the 24-hour cycle of night and day?

____

Name

4. Betty was puzzled. In the morning, the shadow of the bus sign is in the street. In the afternoon, the shadow of the bus sign points the opposite direction.

   Explain to Betty why the shadow is one place in the morning and a different place in the afternoon.

   ____

   ____

   ____

   ____

5. In designing a model solar house, how would you orient the house to keep it as warm as possible?

   (Circle the one best answer.)

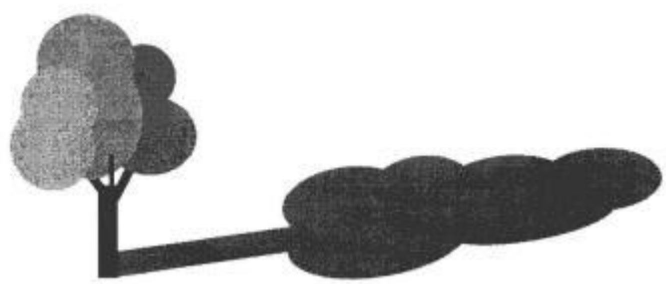
   A. Place the house in the shade.

   B. Face the windows toward the north.

   C. Face the windows toward the afternoon sun.

   D. Face the back of the house (with no windows) toward the afternoon sun.

6. Look at the picture.



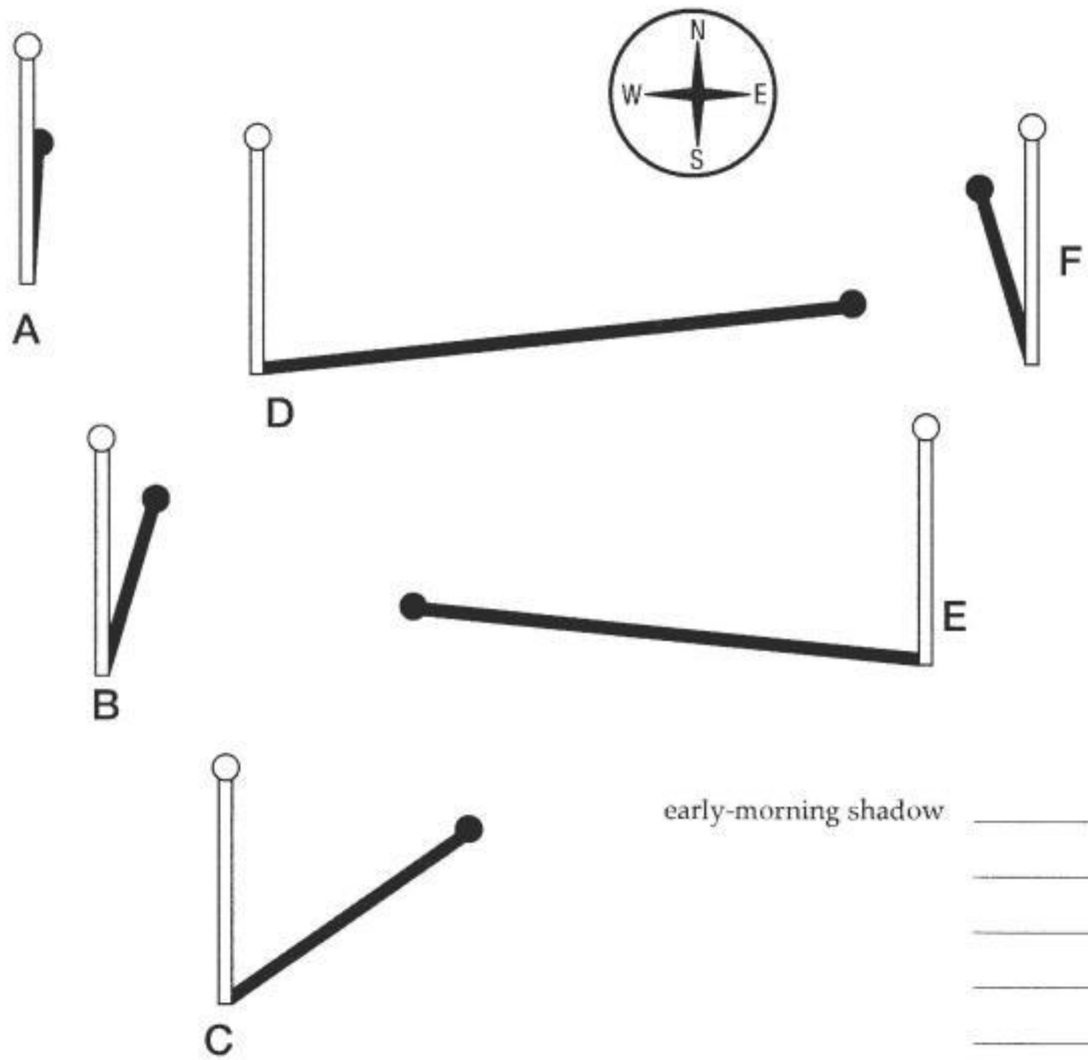
- Is the Sun directly overhead or closer to the horizon? ____________
- Explain how you know the position of the Sun.

  ____

Name

7. Below are the shadows of a flagpole at different times of the day. The top of the flagpole is identified by the round ball.

Order the shadows so that they are in sequence from early morning to late afternoon. Record your answers below.



early-morning shadow ________

____

____

____

____

late-afternoon shadow ________

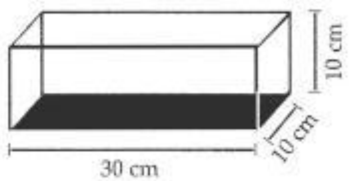
SOLAR ENERGY
Survey/Posttest

Name

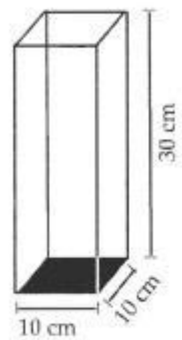
8. Julie and David each built a solar water heater. Both solar water heaters were 10 cm × 10 cm × 30 cm. Both water heaters were painted black on the inside bottom and filled to the top with 3 liters of room-temperature water. Julie and David set both water heaters in the sun.

They checked the temperatures every 5 minutes and recorded them on the table shown below.

A



B



Elapsed time (minutes)	Temperature change	
	Julie	David
0	0°C	0°C
5	6°C	4°C
10	13°C	7°C
15	19°C	11°C
20	25°C	14°C

a. Make a graph of Julie's and David's temperature-change data on the next page. Be sure to label which line shows Julie's data and which shows David's.

b. Which solar water heater did Julie build, A or B? _______

Explain how you know which solar water heater is Julie's.

____

____

____

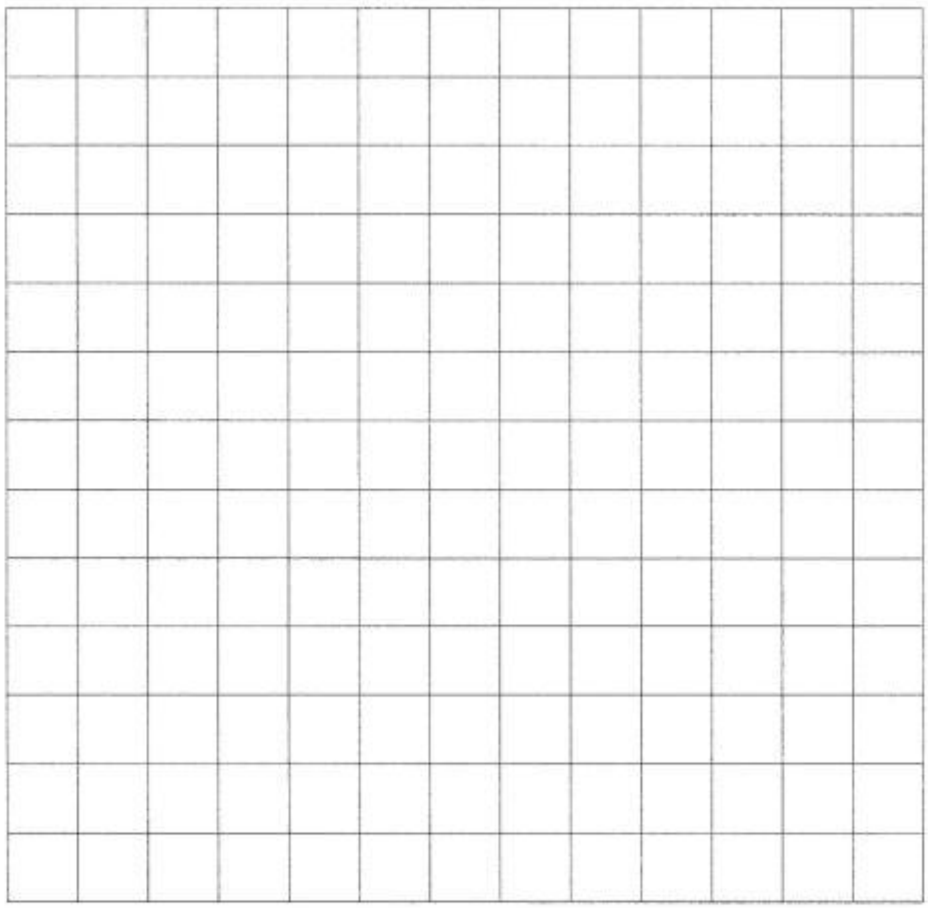
____

____

Name

8a. Graph Julie's and David's data on this sheet.

Elapsed time and temperature change for solar water heaters



Name

9. Look at the picture of the boy and his shadow.

   The Sun is

   (Circle the one best answer.)

   A. behind the boy.

   B. in front of the boy.

   C. directly above the boy.

10. Kira wants to show how shadows change during the day using a globe (Earth), golf tee (a person standing on Earth), and flashlight (the Sun). Which of the following would be correct?

    (Circle the one best answer.)

    A. Keep the flashlight in one position and rotate the globe.

    B. Keep the globe in one position and move the flashlight around in a circle.

    C. Rotate the globe and move the flashlight around the globe in a circle.

    D. Keep the globe in one position and move both the golf tee and the flashlight.

11. The Sun rises in the

    (Circle the one best answer.)

    A. north.

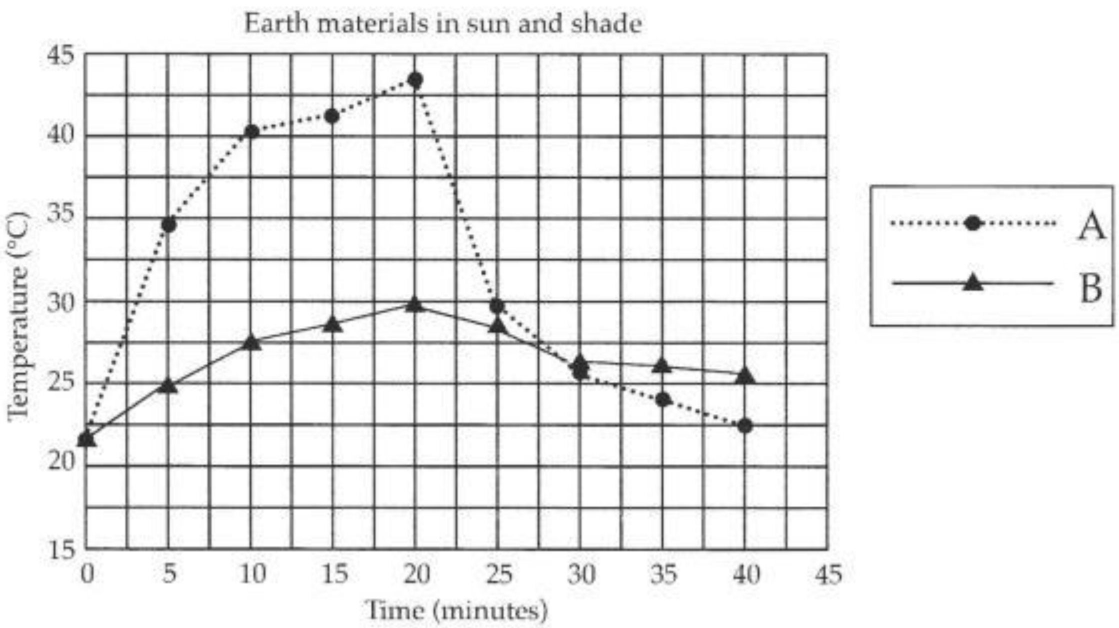
    B. south.

    C. east.

    D. west.

Name

12. The graph shows temperature data from two containers. One container had 100 mL of water, and the other had 100 mL of dry soil. Each container was placed in the sun for 20 minutes and then in the shade for 20 minutes.



Which container, A or B, had the water? ______

Explain how the graph helped you decide which container had the water.

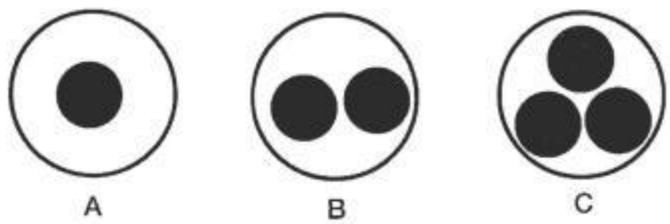
______

______

______

Name

13. Maggie wanted to find out if surface area affected temperature change. She had three white cake pans. She filled each with 300 mL of water. She put one small black plastic disk in pan A, two in pan B, and three in pan C. Then she put all three pans in the sun.



- When Maggie measured the water temperature in each pan after 15 minutes, which pan do you think held the hottest water?

  (Circle one.) A B C

- Explain your answer.

SURVEY/POSTTEST CODING GUIDES—1 OF 8

1

Code	If the student...
2	circles D.
1	circles A, B, C, or more than one answer.
0	makes no attempt.

2

Code	If the student...
3	answers yes; explains that black absorbs more heat (or that white reflects more heat), therefore black will heat faster.
2	answers yes and indicates that black absorbs heat *or* that white reflects heat, but does not relate that to heating faster; may also say only that black heats faster.
1	provides any other answer (e.g. "black attracts heat").
0	makes no attempt.

3

Code	If the student...
2	indicates the rotation of Earth causes the 24-hour cycle of night and day.
1	provides any other answer.
0	makes no attempt.

SURVEY/POSTTEST CODING GUIDES—2 OF 8

4

Code	If the student...
4	indicates that the Sun is in the east in the morning so the shadows point west and that the Sun is in the west in the evening so the shadows point east.
3	indicates that shadows point west in the morning and east in the afternoon; does not include information about the shadow's relationship to the position of the Sun.
2	indicates only that the position of the Sun or the direction of shadows changes during the day but does not explain why or how.
1	provides any other answer.
0	makes no attempt.

5

Code	If the student...
2	circles C.
1	circles A, B, D, or more than one answer.
0	makes no attempt.

6

Code	If the student...
2	indicates that the Sun is closer to the horizon; explains that shadows are longer when the Sun is closer to the horizon or low in the sky.
1	provides any other answer.
0	makes no attempt.

FOSS

SURVEY/POSTTEST CODING GUIDES—3 OF 8

7

Code	If the student...
3	correctly orders the pictures: E, F, A, B, C, D.
2	reverses the order of the pictures: D, C, B, A, F, E; orders the pictures by changing length but not direction.
1	orders the pictures any other way.
0	makes no attempt.

SURVEY/POSTTEST CODING GUIDES—4 OF 8

NOTE: Item 8a answer and coding guide are on pages 20 and 21.

8b

Code	If the student...
3	chooses A; indicates that Julie's solar water heater heated up faster and hotter; relates this to the greater surface area of the black collector in A.
2	chooses A but gives vague explanation (e.g. says that heater A had "more black" or "it got hotter faster").
1	provides any other answer.
0	makes no attempt.

SURVEY/POSTTEST CODING GUIDES—5 OF 8

8a

Code	If the student...
3	has the independent variable on the x-axis and the dependent variable on the y-axis; uses equal intervals to label axes; has origin in proper place; plots ordered pairs correctly; draws line of best fit; and labels graph and axes, including units.
2	makes one or two errors, including not using the conventions listed above.
1	needs further instruction on graphing conventions.
0	makes no attempt.

SURVEY/POSTTEST CODING GUIDES—6 OF 8

9

Code	If the student...
2	circles B.
1	circles A, C, or more than one answer.
0	makes no attempt.

10

Code	If the student...
3	circles A.
There is no level 2 for this item.	
1	circles B, C, D, or more than one answer.
0	makes no attempt.

11

Code	If the student...
2	circles C.
1	circles A, B, D, or more than one answer.
0	makes no attempt.

SURVEY/POSTTEST CODING GUIDES—7 OF 8

12

Code	If the student...
3	chooses B; explains that water is a better heat sink than dry soil; relates this to the graph—line B took longer to heat up and cooled off slower.
2	chooses B; states only that water does not heat or cool as fast as dry soil (or vice versa).
1	provides any other answer.
0	makes no attempt.

SURVEY/POSTTEST CODING GUIDES—8 OF 8

13

Code	If the student...
3	circles C; indicates that C has more black disks (or greater black surface area) to absorb heat (energy), so the water will heat up faster.
2	circles C; indicates C has more disks, more dark, or more black, but does not relate this to more heat energy being absorbed (e.g. states that three disks produce more heat).
1	provides any other answer.
0	makes no attempt.

TDSAS Survey of Science Attitude

The Three-Dimension Elementary Science Attitude Survey (TDSAS)

Read each sentence carefully. After reading the sentence, please circle the number below the sentence that tells to what extent you agree or disagree with the sentence about science. Use the following scale to rank the extent to which you agree or disagree.

5 = Strongly Agree 4 = Agree 3 = Neutral 2 = Disagree 1 = Strongly Disagree

---

1. **I think it is very important to learn science**.
   5 = strongly agree 4 = agree 3 = neutral 2 = disagree 1 = strongly disagree

2. **I think learning science is fun.**
   5 = strongly agree 4 = agree 3 = neutral 2 = disagree 1 = strongly disagree

3. **I always ask my parents science questions.**
   5 = strongly agree 4 = agree 3 = neutral 2 = disagree 1 = strongly disagree

4. **I like to help others to solve the problems by using science knowledge I have learned.**
   5 = strongly agree 4 = agree 3 = neutral 2 = disagree 1 = strongly disagree

5. **I think people pay too much attention on science.**
   5 = strongly agree 4 = agree 3 = neutral 2 = disagree 1 = strongly disagree

6. **I do not think science will be very useful to me for my future job.**
   5 = strongly agree 4 = agree 3 = neutral 2 = disagree 1 = strongly disagree

7. **I like to find out why something happens by doing experiments rather than by being told.**
   5 = strongly agree 4 = agree 3 = neutral 2 = disagree 1 = strongly disagree

8. **Learning science will help me to learn other subjects.**
   5 = strongly agree 4 = agree 3 = neutral 2 = disagree 1 = strongly disagree

9. I do not think I will pursue a science related career in the future.

5 = strongly agree 4 = agree 3 = neutral 2 = disagree 1 = strongly disagree

10. Team work is often needed for solving hard science problems.

5 = strongly agree 4 = agree 3 = neutral 2 = disagree 1 = strongly disagree

11. I want to be a scientist when I grow up.

5 = strongly agree 4 = agree 3 = neutral 2 = disagree 1 = strongly disagree

12. I do not like to spend much time doing science.

5 = strongly agree 4 = agree 3 = neutral 2 = disagree 1 = strongly disagree

Thank You For Your Time In Completing This Survey!

Appendix B

FOSS Physics of Sound Matrix with Creative Drama Integration

FOSS Solar Energy Matrix with Creative Drama Integration

FOSS PHYSICS OF SOUND MODULE MATRIX

CREATIVE DRAMA ACTIVITY INTEGRATION

INVESTIGATION	SCIENCE CONTENT	THINKING PROCESSES	CREATIVE DRAMA ACTIVITY
1. Dropping In	Objects can be identified by the sounds they make when dropped. Sounds have identifiable characteristics. Sounds convey information. Sound is caused by vibrations. A sound source is an object that is vibrating. A sound receiver detects sound vibrations.	Observe sounds made when dropped. Communicate with others making a code. Compare sounds to develop discrimination.	Science Theatre: Students act out the dramatic narrative, The Real Story of Sound" using pantomime, improvisation and created dialogue with action accompanied by baritone ukulele.
2. Good Vibrations	Sound originates from vibrating sources. Pitch is how high or low a sound is. Differences in pitch are caused by differences in the rate at which objects vibrate. Several variables affect pitch including size (length) and tension of the source material.	Observe that sound originates from a vibrating source. Compare high, low, and medium pitched sounds. Record observations on sound. Relate the pitch of a sound to the physical properties of the sound source.	Students observe tuning of baritone ukulele using tuning pegs of the instrument. Sing simple song accompanied by teacher. Students explore and observe plucking of strings on classroom autoharp. Students observe tension applied to a dulcimer instrument. Observe and describe strings in school piano when instrument is played. Science Theatre: Students pretend to be strings of a cello , vibrating slowly with improvised body movements (kinesthetic/learners) Students pretend to be strings of a smaller instrument (example: violin or ukulele with short strings) vibrating faster producing higher sounds. Students pretend to be aliens using voices with slow moving vocal chords that have big spaces between the chords to produce a lower sound. Aliens with fast moving vocal chords and smaller spaces between the vocal chords produce higher sounds. Body warm-up and movement accompanied by CD music and classroom keyboard

(continues)

Investigation	Science Content	Thinking Processes	Creative Drama Activity
3. How Sound Travels	Sound travels through solids, water, and air. Sound vibrations need a medium to travel. Sound that is directed travels better through air. Our outer ears are designed to receive, focus, and amplify sounds.	Sound travels through solids, water, and air. Sound vibrations need a medium to travel to travel. Sound that is directed travels better through air. Our outer ears are designed to receive focus, and amplify sounds.	When a sound source is demonstrated and called out (example: banging cymbals together, shaking a rain stick, striking finger symbols, a tuning fork) Students pretend to be sound waves moving out in all directions. Students pretend to be sound waves using their energy to pass through a medium. Students pantomime passing through a solid, liquid and a gas. Students pretend to be molecules in the medium being pushed (Gently) on the molecules next to them. The molecules cause the sound to travel out from the source in all directions. A cooperative sound wave can be made using students as molecules compressing together then spreading apart as they travel across the floor of the activity building.
4. Sound Challenges	Several variables affect pitch, including size (length), tension, and thickness of the source material. Sound can be directed through air, water, or solids to the sound receivers. The medium that sound passes through affects its volume and the distance at which it can be heard.	Observe that the outer ear is designed to receive sounds Compare different ways of amplifying sounds and making them travel longer distances. Record observations of how sound travels. Report findings in a class presentation	Students pretend to be tones of sound (e.g. A live Rock Band) all wanting to be measured through air at the Decibel Gym (Activity Building) Here are the teams of sound: Rustling Leaves (10), The Whispers (20), The normal Conversations, (65) The Cars Without Mufflers (100), The Live Rock Concert Trio (120). Sound volume or intensity (how soft or loud) is measured in decibels. After pretending to be tones of sound and using pantomime, the students must then come up with a method using the medium of a solid in order to decrease the volume of the decibel level of the teams of sound. Examples: rustling of leaves (a blanket over the leaves, mulching the leaves for the compost pile, raking the leaves and placing them in a burlap bag that can be carried

			as mulch to the compost pile), Whispers and conversations (putting your hand over your mouth) Cars without mufflers, (pantomime building a fence sound barrier on the interstate, pantomime a mechanic getting under a car to attach an automotive muffler) rock concerts (putting ear plugs in your ears, pantomime turning down the intensity on the amplifier, pantomime a teenager and create dialogue explaining to your parents why you are deaf.) Other ideas will be acted out by students as they brainstorm scenarios of ways to make sound waves travel further. Students improvise a script of dialogue that has the main character, Dr. Heargood, accompanying several tourists through the human ear. Each child, after outside research, will play the ear parts. Each ear character presents a "This is your Life" biography of the ear part's life. (theatre concept -- Personification of ear parts and how they work in the human body told as a story (play) written by the children.

SOLAR ENERGY MODULE MATRIX

CREATIVE DRAMA ACTIVITY INTEGRATION

Investigations	Science Content	Science Processes	Creative Drama Activity
1. Sun Tracking	Shadows are the dark areas that result when light is blocked. The length of shadow depends on the position and orientation of the Earth relative to the sun. The length of shadows on earth change as the sun's position in the sky changes during the day.	Observe and compare shadows over time. Organize information and communicate results. Relate the position of the sun to a shadow's shape and direction.	Body warm-up and movement accompanied by CD music and classroom keyboard Students will act out "Grandmother Spider Steals the Sun" a Cherokee fictional adventure in which the main characters experience the sun's energy and the position of the earth relative to the sun. (FOSS Module Story)
2. Heating The Earth	Change of energy from one form to another or the movement of energy is called energy transfer. Energy from the sun is absorbed and released by different materials at different rates. A heat sink is a material that can absorb a large amount of heat for its volume and release the energy slowly.	Observe and compare temperature change of different materials over time. Organize and communicate results of investigations. Relate the rate and amount of temperature changes to properties of materials	Students research shadow puppetry. Perform a shadow play based on Grandmother Steals The Sun." Students develop and improvise original Caveman's Story: A Debate About the Power of the Sun: Objective: communicate the results of investigations In skit form
3. Solar Water Heaters	The color of the collector in a solar water heater affects the change in temperature. Placing a clear cover on a solar water heater Affects the change in water temperature. The surface area of the collector in a water heater affects the change in the water temperature.	Observe and compare the effect of different colors and covers on solar water heaters. of a collector to energy Science Processes Organize data and communicate results on graphs. Relate the surface area of a collector to energy transfer.	Body warm-up and movement accompanied by CD music and classroom keyboard

Investigations	Science Content	Science Processes	Creative Drama Activity
4. Solar Houses	The change of energy from one form to another or the movement of energy is called energy transfer. A heat sink is a material that can absorb a large amount of heat for its volume and release the energy slowly. Insulation can be used in a solar house to maintain its inside temperature. Solar energy is energy from the sun that comes to Earth in the form of light. Space heating is the transfer of heat energy to air in an enclosed space.	Observe and compare variables on solar house heating efficiency. Use information to build an efficiently solar-heated model house. Investigate insulation as a means of holding in heat in a space.	Students will write, act, direct and produce a television commercial advertising the efficiency of solar heated homes.

Appendix C

Science Experience Story Drama Questionnaire

The Story of Sound

A Science Experience Story

To Be Acted Out By Children

Becky Hendrix

Once upon a time in a place called Silentapolis, several silent citizens began to wonder what life would be like if they all had sound. Life in Silentapolis had become unbearable, a boring and mundane existence living in a boring and mundane vacuum. Since they could not speak or hear, the citizens knew they were missing something. So, with great determination, the citizens decided to build a boat to the powerful ruler of Silentapolis, The Mighty Silent Eggoknowo. The Mighty Silent Eggo would know what to do.

At last, when the citizens had finished building the boat, they pushed the boat into the blue foaming waters of the ocean and set sail to find the Mighty Eggoknowo in the Sound Palace.

On the way to the island where Eggoknowo lived, a tremendous and dangerous ocean storm came out of the east to rock the citizen's boat. Wave after wave, after wave of ocean water pounded and tossed the vessel toward the jagged rocks and cliffs surrounding the Sound Palace. The citizens were tossed about as if they were rag dolls---wet and miserable.

The citizens of Silentapolis were in great fear for their lives, as they had good reason to be. Not having the gift of speech or the knowledge of sound, all the citizens could do was scream and wail in silence as they were tossed and knocked about in the boat. They gnashed their teeth in fear and terror. They pounded silent chests in despair. They stretched their arms to the sky and pleaded for mercy. It looked bleak for the citizens of Silentapolis. Bleak, indeed.

From the shoreline, Prince Vibration, known as Sound Wave, was calling out, and excitedly moving back and forth. Upon seeing the citizen's boat near the jagged rocks and hearing the Prince's cries, The Grand Valmir of the Palace Guard sounded the island's ship distress signal by striking the golden triangle. Immediately, Prince Vibration began to move quickly back and forth more rapidly, calling out, "Danger!" The prince waved his arms to the citizens but they did not see or hear his attempts to lead them to peaceful waters, for sound waves cannot be seen directly.

The Grand Valmir of the Palace Guard saw at once the need to strike the Golden triangle again. In quick motion he provided the energy to make the triangle vibrate sending Prince Vibration into a frenzy of back and forth motion, again calling, "danger." It was a desperate situation.

All seemed hopeless until suddenly, Grand Duchess Molecule appeared.

"Never fear, Prince, dear, my molecules of gases — oxygen, nitrogen and water vapor — will also vibrate for when the Grand Valmir strikes the triangle he sets the energy in motion to make the molecules in the air vibrate too."

"Cool," shouted Prince Vibration breathlessly. Could you hurry up because I am running out of energy with all this vibration!"

"Ok girls, let's go!" commanded the Grand Duchess Molecule.

One by one the molecules of oxygen, nitrogen and water vapor started to vibrate in order to produce a sound wave in all directions that would travel to the citizens in the boat — for sound is a vibration that travels through all matter—liquids, gases and solids!

"Prince Vibration, quick, come here and help us," shouted Mary. Gaining his strength from the surface of the vibrating Silver Chromium Triangle, Prince Vibration ran in place and quickly jumped back and forth, back and forth. Other vibrations joined in until the molecules of gases in the air next to Prince and the vibrations started to vibrate. The molecules of gases knew what to do. The molecules closest to the vibration squeezed together and then other vibrations spread apart to form a sound wave.

“Stay close to the vibration and keep moving back and forth”, commanded Prince Vibration to the gases of air molecules. You must vibrate, too.

The molecules in the Compression Family in the sound wave squeezed and stayed close together doing its part to make a sound wave. The Rarefaction Family of molecules spread apart and did its job to make the sound wave.

The sound wave and its molecules of gases carried the energy from the vibration outward in all directions staying close to the vibrations.

Suddenly, the citizens of Silentapolis cupped their hands to their ears as they tried in vain to steady their legs in the boat. Something was happening. The citizens of Silentapolis had created a sound receiver in order to direct the sound waves to their ears!

“What is this strangeness in our ears?”

“Yes,” they all cried, “What is this in our ears?”

“Is it a trick?” cried another.

“No, it’s coming from shore—Look!” cried a citizen.

“It must be sound, one citizen shouted, listen.”

Upon hearing the warning vibrations from the shore, the tiny hairs in the citizens’ inner ears started to vibrate. The sound had traveled, warning the citizens in the boat of the jagged rocks. The sound waves alerted the citizens of the powerful motion energy that was ready to rip the boat apart with deadly force. Quickly and without hesitation, Citizen Kane sensed the meaning of the warning sound as he steered the boat from danger. The winds ceased at that moment as the boat slipped effortlessly toward the shore. Molecules, vibrations and even the wise Eggoknowo led the enlightened citizens in a splendid parade of thankfulness and cheering, as they repeated the cause effect litany of the meaning of sound:

> If someone strikes a triangle's surface, then the triangle vibrates. If the surface of the triangle vibrates, then the vibrations cause the molecules of gas in the air to vibrate. If the molecules of gas in the air vibrate, then they squeeze together and then spread apart. If a vibration spreads away from a vibrating object, then it becomes a sound wave. Vibration is the beginning and end.

So be it, The END!

STUDENT ATTITUDES ABOUT CREATIVE DRAMA

Drama Questionnaire

Dear Student,

Your opinions about the creative drama we did in class are very important to me. Please answer each question below, and tell me what you thought about the creative drama activities. Please do not put your name on the paper. The information you write will not be graded. Remember, there is no right or wrong answer. The information will be used to improve teaching and learning.

Thank you for your help in telling me what you think about the activities.

Mrs. Hendrix

1. Please circle if you are a boy or girl: BOY GIRL

2. Please circle what grade you are in. FOURTH FIFTH

Read the sentence carefully. Use the spaces below in order to tell me some information about your thinking.

3. Do you like doing creative drama? _____________________________________

4. Look at the list below: Circle the creative drama activity or activities you liked best. Please explain why you liked doing these creative drama activities in science class in the space below.

FOURTH GRADE ACTIVITIES

1. "Acting out "The Story of Sound"
2. Acting out "Animal Barnyard "
3. " Tighten Your Strings Theatre Chant"
4. Musical Strings Pantomime Activity
5. Alien Voices: "Take Me To Your Leader"
6. Muffle that Sound!
7. Molecule Method Acting Activity
8. Sound Waves Will Travel!
9. Dr. Heargood Travels The Ear

FIFTH GRADE ACTIVITIES

1. " Gifts From the Sun'' An Exploration in Shadow Puppetry:
2. The Solstice Home Network Show
3. The Vana White Demonstrators
4. Solar Assembly Line
5. Morris Ave. Green Earth Water Heater

5. Was there a creative drama activity that you did not like? If so, please explain why.

6. Do you think that creative drama is useful to you in understanding the investigations we did in science? Please explain why you think it helps you to understand the science investigations in science.

7. Do you feel that after doing the creative drama activity in science class that you could explain the science to another person? Circle the person or persons you believe you could explain the science to:

My teacher My parents My friends

Can you tell me why you could talk to that person about science?

8. Do you think participating in creative drama will help you learn in other subjects? Circle the subjects you think it will help you in: Social Studies Spelling Writing Reading Math Art Music Science? Can you explain why you think creative drama helps you in other subjects? Please use the space below.

9. Do you ever feel happy and confident when you do creative drama about science in front of friends? Why?

10. Do you think you would like to do more creative drama activities in science class? Why?

Thank you for taking the time to fill out this questionnaire.

Appendix D

Parental Permission Letter and Student Assent Letter

Auburn University

Auburn University, Alabama 36849-5212

Curriculum and Teaching
College of Education
5040 Haley Center

Telephone (334) 844-4434
Fax (334) 844-6789

(NOTE: DO NOT AGREE TO PARTICIPATE UNLESS AN APPROVAL STAMP WITH CURRENT DATES HAS BEEN APPLIED TO THIS DOCUMENT.)

PARENTAL PERMISSION/CHILD ASSENT
for a Research Study entitled
"Using Creative Dramatics to Foster Conceptual Learning In An Elementary Science Enrichment Program"

Dear Parents/Guardians,

Your child is invited to participate in a research study as a part of the science instruction offered in small group (talent pool) enrichment at Morris Avenue Intermediate School. The purpose of this study is to see if the inclusion of creative dramatics as an instructional supplement to the classroom's science inquiry program can significantly help student's understanding and learning of science. The study is being conducted by Mrs. Rebecca Hendrix, enrichment teacher, under the direction of Dr. Charles Eick in the Auburn University Department of Teaching and Curriculum. Your child was selected as a possible participant because he or she is a student in the talent pool class at Morris Avenue Intermediate School. Since your child is age 18 or younger we must have your permission to include him/her in the study.

What will be involved if your child participates? If you decide to allow your child to participate in this research study, your child's results on a science survey (pre and post) and science unit tests (pre and post) will be submitted as data for this study. The instruction in the Full Option Science System (FOSS) Science Investigations are part of the regular teaching activities that would normally occur in talent pool on the days your child is scheduled to come to the enrichment room. Your child may be in one of the classes where creative dramatics is used as an instructional supplement to the FOSS program. A post-questionnaire on this supplement will also be used in these classes as data for this study. If you decide that your child would like to be in the study, you will be giving Mrs. Hendrix and Dr. Charles Eick permission to use your child's collected data (pretests, posttests, surveys and/or questionnaires) as part of the research study. The results of the study will be used in Mrs. Hendrix's dissertation work toward her Ph.D. The collected data may also be used for publication or professional presentations. Your child's total time commitment will be approximately 90 minutes once a week. The science would be taught by Mrs. Hendrix using the FOSS Program. This classroom instruction meets the standards of the Alabama State Course of Study in science and The National Science Foundation's Goals for achieving science literacy for all students.

Are there any risks or discomforts? There are no discomforts associated with this study. The risks associated with participating in this study are very few, but it is possible that a breach of confidentiality or coercion could occur in that a child's test or survey might be identifiable. To minimize these risks, Ms. Hendrix will not know which parents have consented for their children to be a part of this study during the teaching of the FOSS unit and study. Consent forms will be returned to Dr. Eick. A self-addressed envelope is provided for you to mail this consent form (letter) along with the student assent form to Dr. Charles Eick at 5040 Haley Center, College of Education, Auburn University, Auburn Alabama, 36849. A signed form to Dr. Eick will mean that you give permission for your child to be in the study. An unsigned form means that you have decided that your child will not be in the study. Either way, be sure to mail both forms to Dr. Eick. A follow up letter will be sent to all parents reminding them to return the consent and assent forms. In addition, each test, survey and/or questionnaire will be coded by Dr. Eick with a numbering system that will be kept confidential by Dr. Eick. Ms. Hendrix will not know the names of the students who participated. No student names will be used in data analysis or in research publications.

Parent/Guardian Initials______
Participant Initials_______

The Auburn University Institutional Review Board has approved this document for use from 10/14/10 to 10/13/11
Protocol # 10-279 EP 1010

Are there any benefits to your child or others? If your child participates in this study, your child can expect to benefit by doing hands-on science investigations and/or creative drama which engage his or her higher level conceptual thinking skills and processes. Through the implementation of The FOSS Science Modules, children will practice, teamwork and conduct experiments while learning to value the process of doing science in order to learn. We cannot promise you that your child will receive any or all of the benefits described.

Will you or your child receive compensation for participating? To thank your child for participating and mailing in the letters, all children will have the opportunity-- even if they choose not to be in the study-- to be a part of a raffle drawing to receive a science book on experiments. At the conclusion of the study, all students will join the researcher-teacher, Mrs. Hendrix, in a "Science Everyday Pizza Celebration!"

Are there any costs? If you decide to allow your child to participate, there are no costs to you as a parent.

If you (or your child) change your mind about your child's participation, your child can be withdrawn from the study at any time. Your child's participation is completely voluntary. If you choose to withdraw your child, your child's data can be withdrawn as long as it is identifiable. Your decision about whether or not to allow your child to participate or to stop participating will not jeopardize you or your child's future relations with Auburn University, The Department of Teaching and Curriculum, Morris Avenue Intermediate School or The Opelika School System.

Your child's privacy will be protected. Any information obtained in connection with this study will remain confidential. The data collected will be protected by Mrs. Rebecca Hendrix or Dr. Charles Eick. Information obtained through your child's participation may be used to fulfill an educational requirement or published in a professional journal. No names will be used.

If you (or your child) have questions about this study, contact Mrs. Rebecca Hendrix at 745-9734. A copy of this document will be given to you to keep.

If you have questions about your child's rights as a research participant, you may contact the Auburn University Office of Human Subjects Research or the Institutional Review Board by phone (334)-844-5966 or e-mail at hsubjec@auburn.edu or IRBChair@auburn.edu .

HAVING READ THE INFORMATION PROVIDED, YOU MUST DECIDE WHETHER OR NOT YOU WISH FOR YOUR CHILD TO PARTICIPATE IN THIS RESEARCH STUDY. YOUR SIGNATURE INDICATES YOUR WILLINGNESS TO ALLOW YOUR CHILD TO PARTICIPATE. YOUR CHILD'S SIGNATURE INDICATES HIS/HER WILLINGNESS TO PARTICIPATE.

______________________________	Rebecca Hendrix 10-20-10
Participant Child's signature Date	Investigator obtaining consent Date
______________________________	Rebecca Hendrix
Printed Name	Printed Name
______________________________	
Parent/Guardian Signature Date	
______________________________	
Printed Name	

The Auburn University Institutional Review Board has approved this document for use from 10/14/10 to 10/13/11
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Auburn University
Auburn University, Alabama 36849-5212

Curriculum and Teaching
College of Education
5040 Haley Center

Telephone (334) 844-4434
Fax (334) 844-6789

MINOR ASSENT
For a research study entitled
Using Creative Dramatics to Foster Conceptual Learning in a Science Enrichment Program

Dear Students,

You are invited to be in a research study to help me understand how some children learn science using a hands-on science program supplemented with creative dramatics. You were chosen for this study because you are in the talent pool enrichment classes at Morris Avenue Intermediate School.

If you decide you want to be in this study, you will give permission for your teacher, Ms. Hendrix, to use the results of your science surveys, FOSS science tests, and/or drama questionnaire for her study. This semester all students will complete four hands-on science experiments to learn about either the physics of sound or solar energy, and you may be asked to be involved in creative drama activities. When the study is over, all of the fourth grade and fifth grade talent pool students will participate in some very special creative drama activities that we will perform for our parents.

If you sign this letter, and your parents sign this letter, you will be giving me permission to use the pretests and the posttests, the science surveys, and/ or the drama questionnaires for use in my research work at Auburn University. Your name will not be used in the dissertation written from this study or any other publications or presentations from it. If you and your parents do not sign this, you will not give me permission to use the above data. Either way, I will need you and your parents to mail this letter in the self- addressed envelope along with the parent permission letter letting Dr. Eick, my professor, know what you have decided to do.

To show how much I appreciated your help in mailing back the letters, even if you decide not to be in the study, we will have a drawing for a chance for you to win a book on science experiments. At the end of the study, even if you chose to participate you are invited to join me in a celebration "Science Everyday Pizza Party!"

If you have any questions about what you will do or what will happen, please ask your parents or guardian or ask me. If you have decided to help me, please sign or print your name on the line below and have your parents mail the letter to the address on the self-addressed envelope.

Thank You!
Mrs. Hendrix

Child's Signature	Printed Name	Date
Parent/Guardian Signature	Printed Name	Date
(Parent/Guardian must also sign Parent/Guardian Consent Letter!)		
Rebecca Hendrix	Rebecca Hendrix	10-20-10
Investigator obtaining consent	Printed Name	Date

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October 27, 2010

Dear Parents,

Recently your child brought home two permission letters requesting your approval of your child's participation in a research study in my talent pool classes. This study concerns the use of creative dramatics in helping students learn science, and is part of my work on my dissertation in teaching and curriculum. If you have not signed these forms, this letter is a reminder to return the forms in the self-addressed envelope addressed to Dr. Charles Eick, Department of Teaching and Curriculum, Auburn University. The letters should be returned whether you have given your consent or not, to confirm that you have received them. If you need additional letters and/or self-addressed envelopes, please let me know. Thank you for taking the time to respond to the letters. If you have any questions regarding this study or the consent letters, please call me at 745-9734.

Sincerely,

Rebecca Hendrix

Rebecca Hendrix

Enrichment Teacher